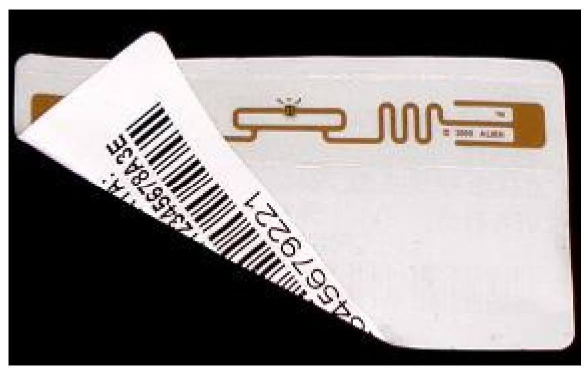
MEAT & LIVESTOCK AUSTRALIA

The Red Meat Industry Undergraduate Program 2007/2008

Review of RFID (EPC) Technology for Potential Use in Meat Processing and Distribution

5th June 2008



AMPC

The Red Meat Industry Undergraduate Program 2007/2008

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4th June 2008

Section 1 of 9: Executive Summary

Executive Summary

Over the last decade, automated identification and data capture (AIDC) has revolutionised the supply chain management process. The aim of most automated identification and data capture systems is to increase efficiency, reduce data entry/errors and free up staff. Automated identification and data capture comprises of such systems as optical character recognition (OCR), magnetic stripe (e.g. credit card), biometric, voice recognition, radio frequency identification (RFID) and of course the most well known, bar codes.

While bar codes are widely used in Australian red meat processing and distribution there is currently limited use of RFID. There are a number of reasons for this including limited knowledge of the technology, the challenging nature of the processing and distribution environment and uncertainty regarding the cost benefit of the technology.

Due to the interest shown by a number of industry participants the current project was undertaken to:

- Highlight current processes, products, id methods and environments from lairage through to distribution where RFID might operate
- Give an overview of generic RFID technology
- Highlight areas within the processing supply chain and the generic RFID technologies that could be implemented within these areas
- Define specific testing and performance protocols for RFID technology
- Outline the future of RFID in the processing supply chain and related recommendations

Two of the main reasons why Red Meat Industry companies need to take a realistic approach to RFID are the current cost and environmental constraints in which RFID are required to operate. To date the return on investment from RFID has shown mixed results. Part of the reason for this is because companies are requiring RFID systems to be 100% accurate in their data read rates. This has been difficult to achieve due to the numerous environmental variables that occur from processing through to distribution.

A RFID system in the right area, for the right reasons, can result in a company gaining a significant return on investment. This project did, however highlight that as with any emerging technology RFID is not a fix all or a “plug and play” technology. In the right setting RFID can offer a significant return on investment but as with any technology used in the wrong setting or for the wrongs reasons the results may be a costly mistake

Due to the current lack of scientific investigation future independent research needs to be based on analytical quantifiable empirical methods. To date, this type of in depth scientific investigation has been very limited on RFID technology. It remains a difficult process to separate fact from fiction when reviewing the information currently available on RFID technology.

As a result of this RFID technology review the recommendations and findings were:

1. Highlighted current possible RFID application points as hooks, cartons, pallet labels, employees, cutting boards, primal bags, totes and assets e.g. plant equipment.

2. To date 100% read rates with RFID have been difficult to achieve or maintained.

3. Environmental variables in which RFID systems will be required to work have a major impact on whether a system will deliver the required results.

4. Empirical research into what type of specific technology is best suited for each stage of processing needs to be conducted e.g. slaughter, chilling, boning, packaging, people, distribution and stock control of consumables such as cartons.

5. Industry wide investigation into implementation of smart labels and what the possible return on investment could be on both a company level and whole supply chain level.

6. If RFID smart labels are shown to be of value the industry needs to publish the related results. Then through industry consultation an action plan needs to be developed that would clear the way for the use of Electronic Product Code compliant smart labels across the industry. This would allow for track forward and track back on an industry wide scale.

7. RFID technology should be empirically compared so that companies can decide which vendor's technologies best suit their applications.

8. Continue to review and develop test/performance protocols and publish the related findings.

9. MLA need to publish all relevant empirical studies and allow them to be accessible to all interested parties. This will allow for feedback from a variety of interested parties and therefore help shape future research.

10. Publish MLA recommendations associated with RFID relating to all companies along the processing supply chain.

This report has been written so each document is a stand alone paper so as to allow for separate distribution of each section and is aimed at readers with various levels of knowledge relating to RFID.

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4th June 2008

Section 2 of 9: Processing Overview

Executive Summary

The following document is designed to give the reader an overview of procedures within a processing plant. It identifies the current ID method, packaging, products and environments that can be found within each of these procedures. This Overview has been written as background to highlight where RFID systems may operate. The photos for this section have been taken at a beef processing plant. It should be noted that Sheep processing differs but not in a significant manner.

Table of Contents: Processing Overview

IMPORTANT NOTICE

1 *Processing Matrix*

Process/Products	2.1 Lairage	2.2 Knocking	2.3 Shackling to Splitting Saw	2.4 Offal Processing/ Offal Packing	2.5 Weighing/ Carcase Grade	3.1 Chiller/ Grading	3.2 Quartering, Loadout/ Boning Room in	4.1 Boning	4.2 Carton (tote etc) Put Away
Information collected or added	Ear tag scanned, visual inspection	NLIS tag and ear tag recorded	Visual inspection, body number, mob/kill lot noted	Visual, carton scanned	Body no., carcase no., age, sex, fat depth etc	Body no., carcase	Carcase ticket	Visual, scan bar code	Scan bar code
Carcase		X	X. H		H	H	H	H	
Render		X	X	X	X			X, C	
Offal			X	X, T, C, RRP, P					X,C
Hide			X						
Waste		X	X		X			X	
Trim								X, CB, C, BC	X,C,T, BC
Primal								X, PB, CB, C	X, C, T

Table continued:

4.2 Chilling/ Freezing	4.2 Carton Picking	4.2 Palletising	4.2 Pallet/ Carton Loadout	5.1 Value Adding	5.1 Packing labelling	5.2 Carton put away	5.2 Chilling/ freezing	5.2 Picking	5.2 Pallet	5.2 Container
Scan bar code	Scan bar code	Scan bar code	Scan bar code		Scan bar code	Scan bar code	Scan bar code	Scan bar code	Scan bar code	Scan bar code
			X							
X,C	X,C	X,C	X,C	X,C,T, RRP	X,C, RRP	X	X	X	X	X
			X							X
										X
X,C,T, BC	X,C, BC	X,C,BC	X,C, BC, P	X,C	X,C, RRP	X,C	X,C,	X,C	X,C,P	X,C,P
X,C,T	X,C	X,C	X,C,BC,P	X,C, RRP	X,C RRP	X,C	X,C	X,C	X,C, P	X

Legend: X denotes that a product is produced
Within the table carton can stand for CB7 or tub/tote etc.
Packaging:- H= Hook , T=Tote/tub, C= Carton, CB= Chopping Board, PB= Primal bag, BC= Bulk carton/CB7, P=Pallet, RRP=Retail Ready Pack

The preceding matrix is designed to give a quick visual reference to the process order, products, packaging, environment and information collection points that occur within a processing plant. The numbers correspond to the accompanying detailed literature and allow for quick reference between the two. It should be noted that throughout every stage above, the environment in which system components have to operate is considered to be harsh. The reason for this is such environmental variables as temperature differences, electrical noise, mechanical, handling damage and chemicals that are used in cleaning/disinfecting.

2 *Lairage to Carcase Weight Station*

2.1 *Lairage*

Process: The animals are off loaded from a truck into holding pens (photo 1) into the lairage area. The cattle are sorted by cleanliness and lot number and placed into the appropriate pens. Once in the pens the cattle are hosed down and visually inspected for any abnormalities (e.g. lumps or lame). The animals are then taken a mob at a time (according to the kill sheet) from the pens and put through the wash pen and herded on up through to the final holding area (photo 2) where they get funnelled (photo 3) one at a time into the knocking box.

Product/s: Animal
Packaging: N/A
Id Method: Visual inspection of the ear tag (feed lot number,), pen lot and NVD. This forms a Kill Lot
Environment: Cattle moving around, water, dirt and dust

Photo 1: Holding pens

Photo 2: Final holding area

Photo 3: Funnel into knocking box

2.2 *Knocking*

Process: The animal comes in to the knocking box and the NLIS tag is read and entered along with the animal's lot number and ear tag information into a work station (photo 4) which allows this information to be cross referenced against the kill lot. The animal is then stunned (photo 5) and rolled down onto a conveyer belt where it is sticked, rod weasand, and electrically stimulated (400-700amps @ 200volts) before being shackled (Photo 6).

Product/s: Carcase, waste, product to render (blood)
Packaging: N/A
Id Method: NLIS tag, ear tag (feed lot number etc), kill lot code
Environment: Electromagnetic interference (EMI), water, blood


Photo 4: Information input


Photo 5: Knocking


Photo 6: The animal is sticked, rodweasand, stimulated and shackled

2.3 *Shackling to Splitting Saw*

At any point in this process a carcase can be tagged; this denotes that it needs to be checked by a government official (a carcase can be tagged for reasons such as hair or faeces contamination or for any abnormalities).

Process: The animal is hung up by one leg using a shackle and placed on to the over head rail (which transports the animal through the slaughter room). Then the animal passes through a stimulation process (photo 8) which involves electric current (300-600amps @ 200volts) being conducted through the body.

Then at first leg the fore hocks and horns are removed along with a small piece of hide (these go to render). At the 1st leg changeover stage an operator starts to remove the hide from one rear leg and cuts off the hock from the same leg. Once this is done the animal is hung (on a hook) via the de-hided leg and the shackle is returned to the shackling area (photo 9). Also a paper ticket body number (the same body number as the one at knocking) is applied to the leg just below the hook. At this point non halal and non export are denoted through the use of a tag being placed on the carcase.

At the second leg stage an operator will place an anti mortem tag on the carcase (this denotes the start of a particular kill lot and also that the mob (NVD) have been inspected/approved by the government inspector) and also enters the sex of the animal into a work station (photo 10). The second hock is then removed and goes down a pipeline (to render) (photo11). The body number, matching the one put on at the first leg changeover area, is applied to the second leg at the bung station.

At the hide removal station the carcase is once again stimulated (30-120volts) before the hide is removed and sent to a sorting area where the head flap is taken off. The hide is then put into a metal skip/bin and stored in a cool room awaiting pick up. After hide removal the head is removed and placed on to the head chain (photo 12). At this point the head gets a body number put on it (the same no. as the carcase) and also the number of teeth is entered into a database in accordance with its respective body number. Once on the head chain the tongue and cheeks are removed and sent to the offal room and the head skeleton goes to render.

Next is the brisket saw, where the brisket is opened up and the fore-legs are removed (and sent to render). Fronting out is next and is where the carcase is eviscerated (photo 13). The offal goes onto the eviscery table for inspection and processing. Offal is either rejected in which case it goes to render or accepted and therefore goes to the offal processing room. The co-products go down a separate shoot and are dealt with in the co-products area.

Next is the splitting saw which is where the carcase is cut in half (photo 14). Following this is the government inspection point (this is where the retain rail is positioned) and following this is the final trim (goes to render) and thin skirt removal (which goes to the offal room).

The totes/tubs that are used in this are washed in temperatures up to 82˚ and with varied chemicals depending on specific company operating procedures. In day to day use the totes receive a large amount of rough handling.

Product/s: Offal, waste (blood hosed off the floor etc), carcase, product to render, hide, co-products
Packaging: Hook
Id Method: NLIS tag, ear tag (Feed lot number), body number, carcase number (paper number stuck to the legs and head), visual (e.g. eviscery table)
Environment: Direct electrical current into carcase, water, blood, chemical cleaners used in the clean down process, vibration, shock (on hooks), electromagnetic interference

2.3.1 Hooks

Process: Carcase hooks are cleaned in hot water (90˚) for around 20 minutes (sometimes with chemicals) (photo 7). They then get returned to the slaughter floor ready for use at the 1st and 2nd leg changeover stations.

Several companies within the industry use a process called tender stretching. This process requires the carcase to be hung by the h-bone and the hook that was through the leg is taken out. The normal process is to start with one extra hook and to use this hook to hang the carcase by a piece of string through the h-bone and then take out the original hook (and use it to hang the h-bone of the next carcase). This process is then repeated except when the hook is noticed to be defective in which case a spare hook is used.

Regardless of whether a company uses tender stretching the hooks continue to stay with the carcase (through the chiller) and at quartering another hook (or two new hooks depending on company procedure) is used to hang the now quartered carcase. Once the quarter carcase is boned the hook is returned to a cleaning station.
Hook Environment: Chemical, hot water, mechanical shock, electromagnetic interference


Photo 7: Hook cleaning area


Photo 8: Direct electrical stimulation

Photo 9: 1st leg station

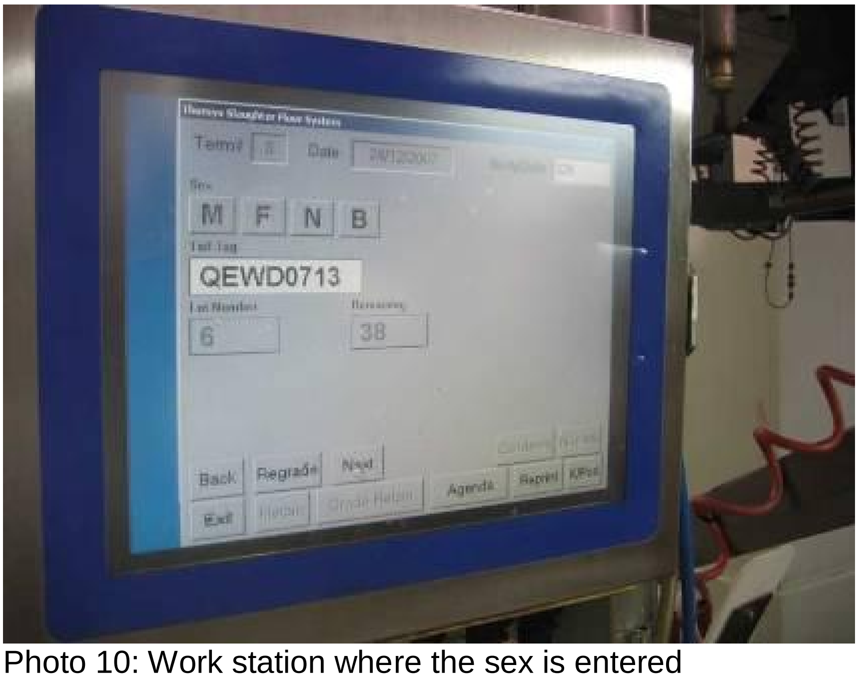


Photo 10: Work station where the sex is entered

Photo 11: 2nd leg rear hock removal

Photo 12: Head chai

Photo 13: Evisceration

Photo 14: Splitting saw

2.4 *Offal Processing*

Process: The offal comes in from the evisceration table and is sorted into totes for the days order requirements (e.g. quality, weight etc). The totes then go to the packing room where the offal is transferred into a carton or retail ready pack (which ends up in a carton). Then the carton is visually inspected (to make sure the right product is in the right box) by an operator who weights and enters the contents of the carton into a work station. A printer then produces the relevant barcode label which is placed on the carton before it goes to storage.

Product/s: Retail ready packs, product to render
Packaging: Plastic bags, totes, cartons, retail ready packs, pallet
Id Method: Visual, stickers, order sheet, colour coding totes, carton label
Environment: Temperature (4˚ - 15˚), electromagnetic interference, vibration, water, blood, shock (on totes)

2.5 *Weighting/Carcase Grade*

Process: An operator measures the fat depth (photo 15) and takes note of any bruising and enters these into a work station. Then a carcase ticket is printed and attached to the carcase (photo 16). The carcase ticket can depict such information as weight, kill date, dentition, fat, sex, lot number, Australia Inspected (AI) stamp, hot grade, company name/address and body number (which is visually checked against the body number on the carcase leg).

Product/s: Carcase, render
Packaging: Hook
Id Method: Body number (checked against carcase paper label), carcase ticket
Environment: Electromagnetic interference, vibration (for hooks), blood, water


Photo 15: Fat depth measuring


Photo 16: Carcase ticket attached

3 *Chillers to Boning*

3.1 *Chiller/Grading*

Process: The carcase comes down the hot meat passage (photo 17) and is washed and stimulated (250-3500amps @ 150volts) and depending on company practise is hung for tender stretching (photo 18). An operator then reads the carcase ticket (and any other appropriate tickets e.g. non halal or retain) and directs the carcase into the appropriate chiller (photo 19). Segregation can consist of: non halal, non export, different grades, veal and E.coli samples (ESAM). Retain, non export and suspect carcases go into a separate chiller.

The carcases are usually graded (to MSA and AUS MEAT standards and this information is entered into a grading terminal along with the scanned carcase ticket information) whilst they are in the chiller (usually over night). From the chiller the carcases are then separated into their boning groups (e.g. non halal and retains are put through to the boning room last) and moved to the marshalling area.

Product/s: Carcase
Packaging: Hook
Id Method: Carcase tickets
Environment: Warm to Cold (9˚to -2˚), vibration (for hooks), electromagnetic interference, water, blood, direct electrical current

Photo 17: Hot meat passage

Photo 18: Hanging for tender stretching

Photo 19: Chiller

3.2 *Quartering Loadout/Boning room in*

Process: After the marshalling area the carcase ticket is scanned and the cold weight of the carcase and date and time (of carcase entering the boning room) is entered into a weight station. This is done to enable traceability and to double check that the right carcase is in the right boning group. The carcases are then quartered (as per order) (photo 20) one at a time and proceed to be entered into the boning room. At this point the quarter carcases can be sent to the boning room (photo 21), load out area or straight into awaiting trucks.

Product/s: Quarter carcase
Packaging: Hook
Id Method: Carcase ticket
Environment: Vibration (for hooks), cold, shock (on hooks)

Photo 20: Quartering

Photo 21: Quarter carcase entering boning

4 *Boning to Distribution*

4.1 *Boning*

Process: The boning room setup and conveyance method of the meat varies across the industry but in essence a quarter carcase enters the boning room and is de-boned (photo 22) and sliced to order (photo 23). At the end of this process the three main products, cuts, trim and product to render are achieved. The cuts or trim are then packed in both inner (e.g. cryovac, tray packed etc) and outer packing (e.g. carton, CB7 or totes) (photo 24, 25). At this stage the reciprocal (carton, CB7etc) will be lidded (final visual check of correct product in correct box) and labelled with a bar code (photo 26) and sent to freezing or chilling. The label on the box will/can show such information as generic identification of product, date of packaging, country of origin, net weight statement, Australian Inspection stamp, establishment number, company name and address.

Chopping boards are subject to cold (4˚-10˚) and hot (82˚) temperatures as well as shock. Also they are exposed to harsh washing environments.
Product/s: Cuts, trim, primal cuts, product to render
Packaging: Hook, chopping board, primal bag, carton, tote/tub, CB7
Id Method: Visual, bar code
Environment: Temp cold and hot (chopping board cleaning), vibration, electromagnetic interference

Photo 22: De-boning

Photo 23: Sliced into trim and primal

Photo 24: Cryovac and loose packed meat


Photo 25: CB7 being packed

Photo 26: Creating label for carton

4.2 *Carton (CB7, tub, tote) Put Away to Load out*

Process: Once the product is in its respective reciprocal (carton, tote etc) it is sorted, via bar code scanning, before heading into either a freezer or chiller. The temperatures in the freezer can be as low as $^{-}35^{\circ}$ and the product can spend up to 40 hours freezing. Similarly the chiller can be as low as $^{-}4^{\circ}$ and the product can be in there for up to 20 hours. The cartons then go in to a unistore/buffer until they are picked (via bar code scanning) and palletised. Once the product is palletised it is stored awaiting direct loading on to a truck or hand packing into a shipping container. Either way every carton on the pallet is scanned before being loaded to a truck.

Product/s: Cartons, pallets
Packaging: Cartons, pallets, CB7
Id Method: Bar code
Environment: Vibration, shock, cold, electromagnetic interference

5 *Value Adding to Distribution*

5.1 *Value Adding*

Process: The pallets arrive at the de-boxing area (the room temp is around 8˚) where each pallet and carton is scanned (and also hand written down onto a delivery sheet as a hard copy record). Depending on how many cartons (30-42) are on the pallet and on how easy the barcodes are to read (e.g. could be scratched, soiled, cut or cupboard deformity) each pallet takes between 2-8 minutes to scan. The cartons are either emptied into a CB7 (photo 27), tote or put into a buffer as they are (photo 28). From the buffer the carton/tote/CB7 is taken to the cutting room and goes into the appropriate cutting line (depending on the orders for the day) (photo 29).

Once in the cutting line the product can be either human or machine cut to order. From the cutting line the product either gets put back into a tote and goes back into the buffer awaiting transport to the packing room or goes directly to the packing room. Upon entering the packing room the product is placed at the appropriate packing line (depending on daily orders etc). The product (e.g. porterhouse, lamb cutlets etc) is then packed into retail ready packs, labelled and placed into cupboard boxes (which get a bar code label also) and transported to storage (photo 30).
Product/s: Retail ready, product to render
Packaging: Pallet, carton, CB7, tote, retail ready pack
Id Method: Bar code, visual inspection
Environment: Totes get washed in hot water (82˚), room temp (8˚- ¯2˚), rough handling (e.g. forklift), blood, water, vibration, electromagnetic interference

Photo 27: CB7

Photo 28: Palletised cartons being put away in the buffer

Photo 29: Meat being unpacked for cutting

Photo 30: Label about to be applied to carton before transport to storage

5.2 *Carton (CB7, tub, tote) Put Away to load out*

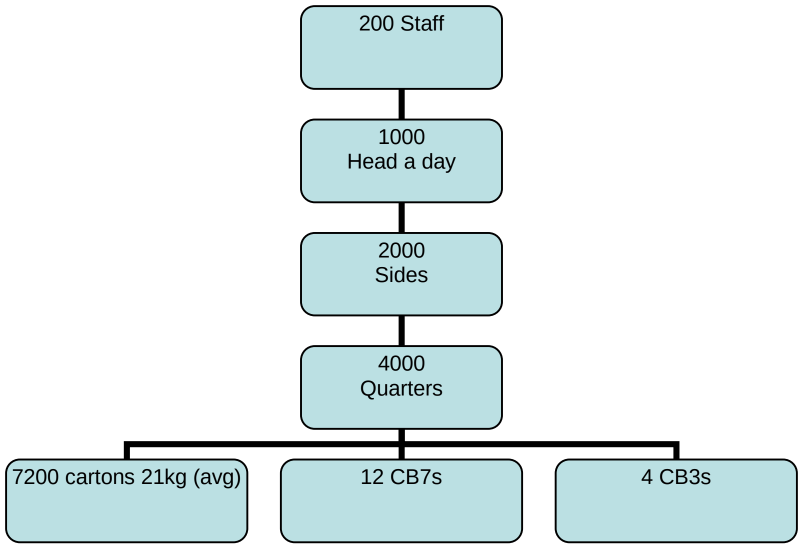
Process: Once the product is in its respective reciprocal it is taken to either a chiller or freezer. The item is scanned before entering the chiller/freezer. The temperatures in the freezer can be as low as $^{-}30^{\circ}$ and the product can spend up to 40 hours freezing. Similarly the chiller can be as low as $^{-}4^{\circ}$ and the product can be in there for up to 20 hours. The cartons then go in to a unistore/buffer until they are picked (via bar code scanning) and palletised. Once the product is palletised it is stored (in either a chiller or freezer) and waits to be either directly loaded on to a truck or hand packed into a shipping container. Either way every carton is scanned before leaving the distribution centre.

Product/s: Cartons, pallets
Packaging: Cartons, pallets, CB7
Id Method: Bar code, visual inspection
Environment: Vibration, shock, cold, electromagnetic interference

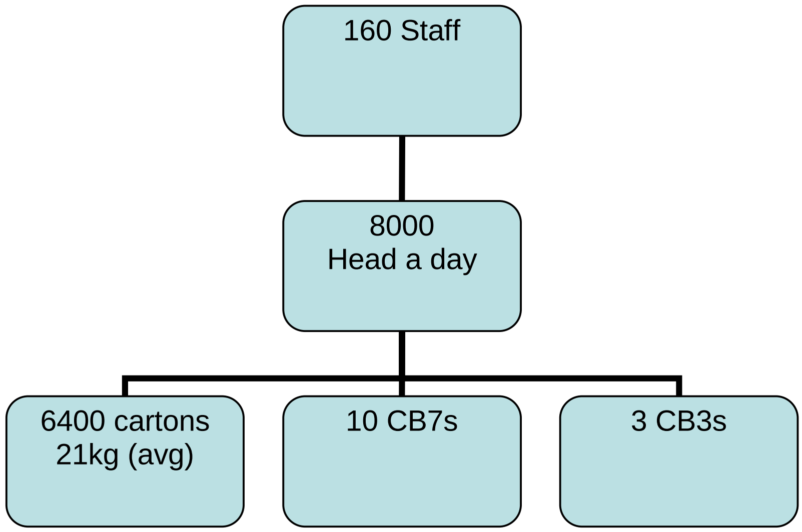
6 *Volumetric Representations*

The following diagrams illustrate an average volumetric flow for both a beef and sheep processing plant from lairage through to packaging. On average a beef processing plant will require 200 staff and a sheep plant will require 160 to achieve their respective head numbers processed per day (1000 & 8000). From these figures the quantity of RFID tags (only) that are needed can be estimated.

Volumetric representations for Beef



Volumetric representations for Sheep



For example working off the beef figures a company will have 4500 hooks (on average) for which they'll need 4500 tags plus spares for non readers etc. Also if a company wished to use an access control RFID system for their employees they will require a minimum of 200 tags plus spares. The same rules apply for any of the reciprocals (e.g. cartons, CB7s and totes) a company would use. Keeping in mind that any tags used on pallets, cartons or CB7s are for single application use only. So even if a company only applied smart labels to their cartons (and taking into consideration no other RFID associated costs) they would spend (7200x.30c a smart label=) $2160 a day compared to what they are currently spending on bar codes which is (7200x.024c bar code=) $172 a day.

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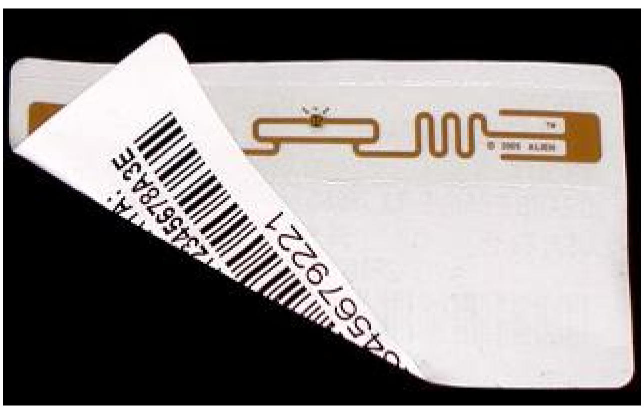
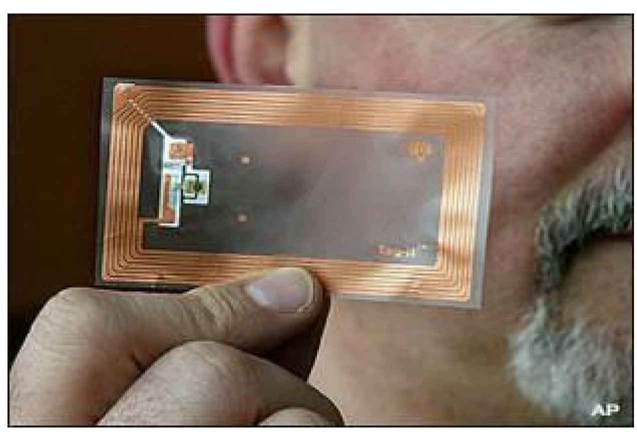
Section 3 of 9: RFID Explained





Executive Summary

Over the last decade, automated identification and data capture (AIDC) has revolutionised the supply chain management process. The aim of most automated identification and data capture systems is to increase efficiency, reduce data entry/errors and free up staff. Automated identification and data capture comprises of such systems as optical character recognition (OCR), magnetic stripe (e.g. credit card), biometric, voice recognition, radio frequency identification (RFID) and of course the most well known, bar codes.

RFID was first developed in the 1940s as a way to identify allied and enemy aircraft in World War II, since then RFID has been applied to a myriad of applications from clothing, paper documents, toll collection, access control, baggage handling, animal tagging, people monitoring through to tracing assets/products along a production line. A typical RFID system consists of tags (encapsulated chip and antenna), readers (and their antennas), middleware and a backend data base that collects and collates all the appropriate data. The data transmitted contains the electronic product code (EPC) or other similar information, which includes various details about the tagged product. A RFID reader (sometimes called an interrogator) interrogates the tags via antennas to either obtain or transmit information to a tag. Software, called savant or middleware, is required to control the reader and to collect and filter the information so it can then be passed onto the company's computer network (backend database).

In general the cost of a RFID system depends on the application, the size of installation, the type of system and many other factors, so it is difficult to give an exact figure. However the cost of an RFID system can be broken down into four key areas:

- Hardware
- Software
- Service
- Miscellaneous

When enquiring into RFID systems vendor selection is a very important procedure due to the ever evolving nature of the technology. Vendors can be broken up into three classes: Manufacturers, Original Equipment Manufacture (OEM) and Implementers.

Prior to the development of standards for tags and readers, companies primarily developed propriety RFID systems so that readers from one vendor often only read tags from the same vendor. For a long time, and even now to a certain degree, the lack of standards within the RFID industry has been a major sticking point in terms of wide spread adoption. However now, thanks to the ISO and EPCglobal (a subsidiary of GS1) standards RFID systems are becoming more interoperable (both between companies and internationally).

An RFID system can improve on, or complement, a barcode system by capturing larger amounts of data and more specific information about items. RFID is not necessarily "better" than bar codes rather the two are different technologies and have different applications, which sometimes overlap. Two significant differences between bar codes and RFID are

1. That bar codes require direct line of site to be read
2. RFID has the ability to uniquely identify each individual product via item specific Electronic Product Codes (EPC).

RFID is a technology that can provide considerable value in a business world in which operating costs are often dominated by labour and the inability to accurately trace stock in real time. The interest in RFID as a solution to further optimise the supply chain is

gathering momentum at an ever increasing pace, with more and more companies announcing trials and mandates to their suppliers.

A word of caution is that despite publicity to the contrary RFID is not a “plug and play” technology. Companies need to take time to conduct research and make appropriate decisions based on sound company business strategies which will allow for the maximum return on investment.

Table of Contents: RFID Explained

1 *RFID Overview Matrixes*

1.1 *Tag Power Source*

Tag Type	Advantages	Disadvantages	Application	Cost
Passive = Powered from reader	Longer life, wider range of form factors e.g. glass, plastic, paper, tags are more mechanically flexible	Shorter range than active	Case & pallet applications	Low
Semi-passive = Dormant until woken by reader	Greater read range, longer battery life, can be used to manage other devices like sensors (temp°, pressure etc)	Battery wear and cost (more than passive tags)	Reusable containers and asset tracking	Medium
Active = Transmitting all the time using its own power supply.	Greater read range, memory capacity, continuous signal, can be used to manage other devices like sensors (temp°, pressure etc)	Batteries require maintenance, larger size, expensive	Used with high value asset tracking (e.g. container tracking), temperature logging tags.	High

1.2 *Tag Memory Function*

Tag Type	Advantages	Disadvantages	Application
Read only (RO)	Simple communication protocol	Identification only, no tracking updates, difficult to generate on demand and integrate data.	Animal ID, cartons
Write Once Read Many (WORM)	Programmable	Write once	Asset tracking, reusable totes
Read/Write (R/W)	Erasable and programmable	N/A	Supply chain, reusable items

1.3 *EPCglobal Classes Summary*

Class	Memory	Power	Frequency	Cost AUD
1 (Tag)	R/O	Passive	LF,HF	$0.50 per 1000
			UHF	$0.25 Per 1000
2 (Tag)	R/W	Passive	LF,HF	$0.50 per 1000
			UHF	$0.25 Per 1000
3 (Tag)	R/W	Semi-Passive	UHF	$30 Per 100
			Microwave	$40 per 100
4 (Tag)	R/W	Active	HF,UHF	$50 per 100
			Microwave	$70 Per 100
5 (Reader)	R/W	Mains Power	LF	$1200-1800
			HF	$1800-2400
			UHF	$2400-3200
			Microwave	$2800-3500

All costs are Australian dollars and are representative costs only.

Legend:
R/O= Read Only, R/W= Read-Write
Source: Personal communication with EPCglobal

1.4 *RFID System Overview*

RFID Components	Function	Cost LF	Cost HF	Cost UHF	Cost microwave
Tag	Data carrier	$3.00 to $20.00	$1.00 to $3.00	<$1.00	$10.00 to $100.00
Antenna	Transmits signals between tags and readers	$10-$10,000			
Reader	Sends and receives data from tags	$500 - $1000	$100 - $1000	$1500-$3500	$2000 - $10,000
Printer/Encoder	Encodes data onto smart label	N/A	$1,500-$5,000	$1,500-$5,000	N/A
Middleware	Collects and filters data	$25,000 - $200,000 Dependent on size of RFID system			
Hardware	Turns data into understandable business information				
Commissioning/ Integration	Installation and up keep of RFID system				

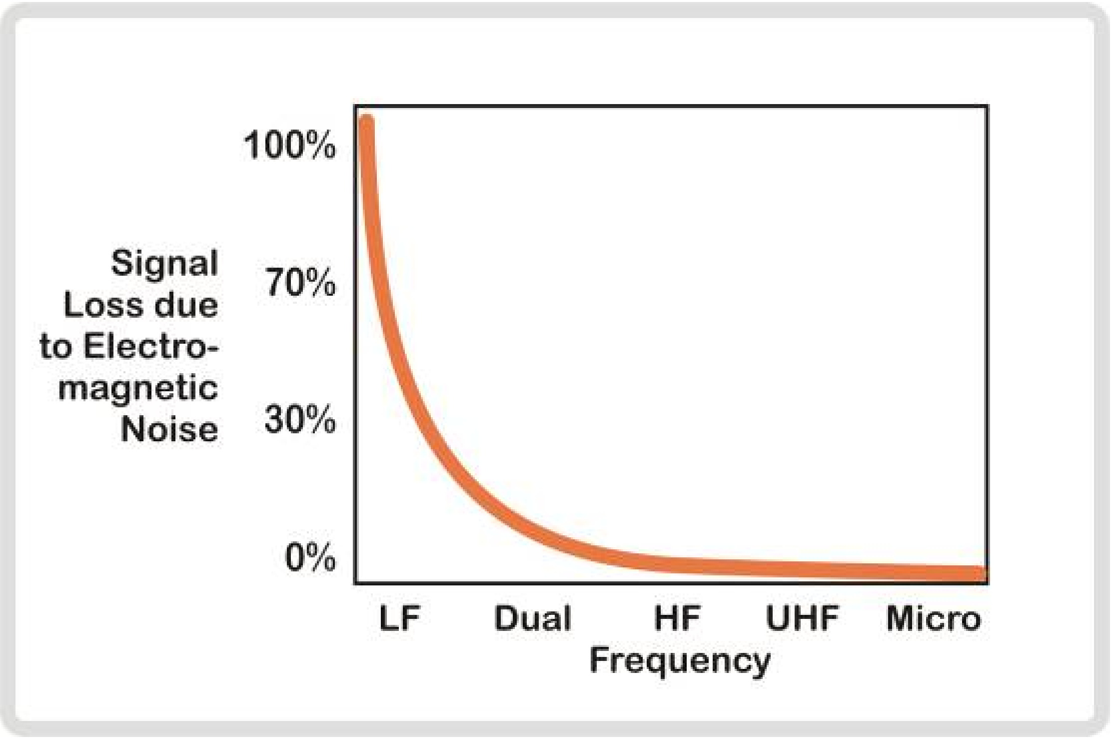
All costs are Australian dollars and are representative costs only.

1.5 *RFID Frequency Overview*

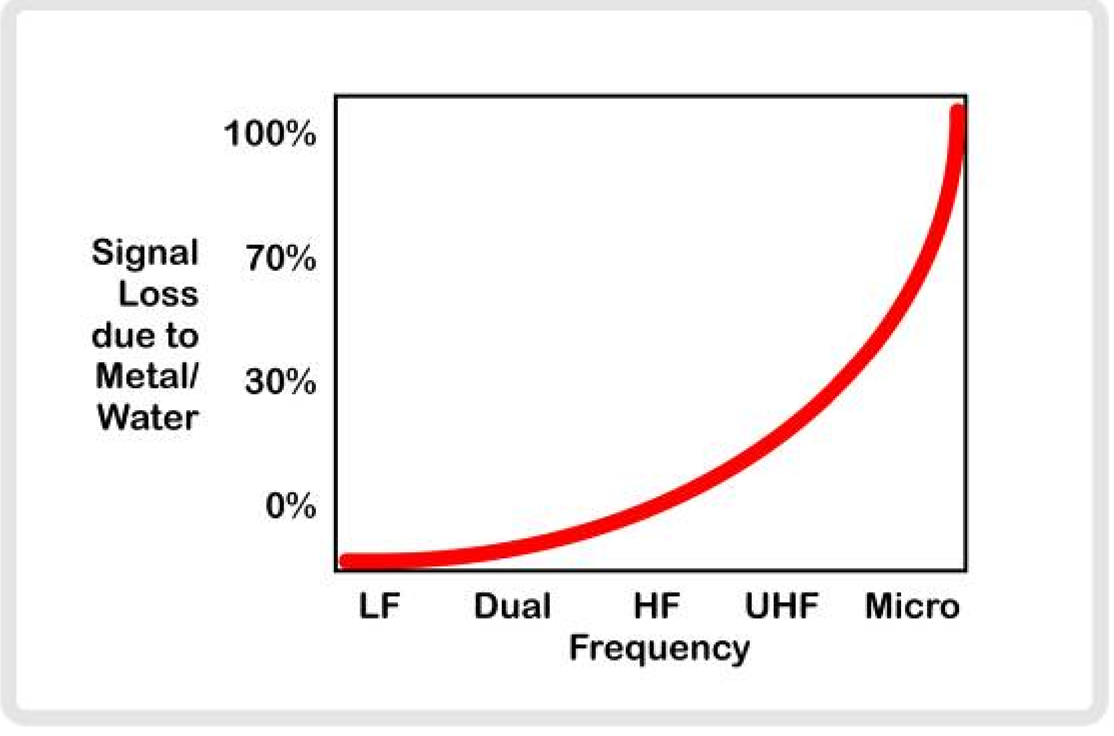
Band	LF Low Frequency e.g. AM Radio	DF Dual Frequency	HF High Frequency e.g. FM Radio	UHF Ultra High Frequency e.g. mobile phones	Microwave	Smart labels (HF and UHF only)
Frequency	30–300kHz	100kHZ-13MHz	3–30MHz	300 MHz–3GHz	2–30 GHz	–
Typical RFID Frequencies	125–134 kHz	Transmit 125kHz / Receive 6.8MHz	13.56 MHz	433 MHz or 865 – 956MHz	2.45 GHz	433 or 865 – 956MHz or 13.56 MHz
Approximate read range (m=metres)	less than 0.5m	Up to 1.4m	Up to 1.5m	433 MHz = up to 100 metres 865-956 MHz = 0.5 to 5m	Up to 10m	Less than 0.5m or up to 1.5m
Typical data transfer rate (kilobit per Second=kbit/s)	less than 1 kilobit per second (kbit/s)	Up to 125 kbit/s	Approximately 25 kbit/s	approximately 30 kbit/s	Up to 100 kbit/s	Less than 1 or up to 25 kbit/s
Characteristics	Short read range, low data transfer rate, larger tag size, little signal loss	Read range similar to HF, possible high read rates. Can work in environments with metal and liquids	Higher read range, reasonable data rate, small signal loss, good read range in noisy environments, anti collision	Long range, high data transfer rate, concurrent read of <100 items, cannot penetrate water or metals	Long range, high data transfer rate, very high signal loss	Combines both human readable and RFID data, size, scope of use
Typical use	Animal ID, car immobiliser	Tote boxes, returnable assets	Smart labels, contact-less travel cards, access & security	Specialist animal, baggage handling, tracking, logistics	Vehicle toll, item tracking	Carton and pallet tracking
Tag Cost (AUS)	$3-$20	$3-$10	.50c- $5	.10c -$3	$20-$100	.20c to $2
Multiple tag read rate	None ◄────► Faster					
Ability to read near water or metal	Better ◄────► Worse					
Signal loss due to electromagnetic interference	Worse ◄────► Better					

All costs are Australian dollars and are representative costs only.

1.6 *Example of Tag Reading Loss Due to Electromagnetic Interference*



1.7 *Example of Tag Reading Distance Due to Presence of Metal and Water*



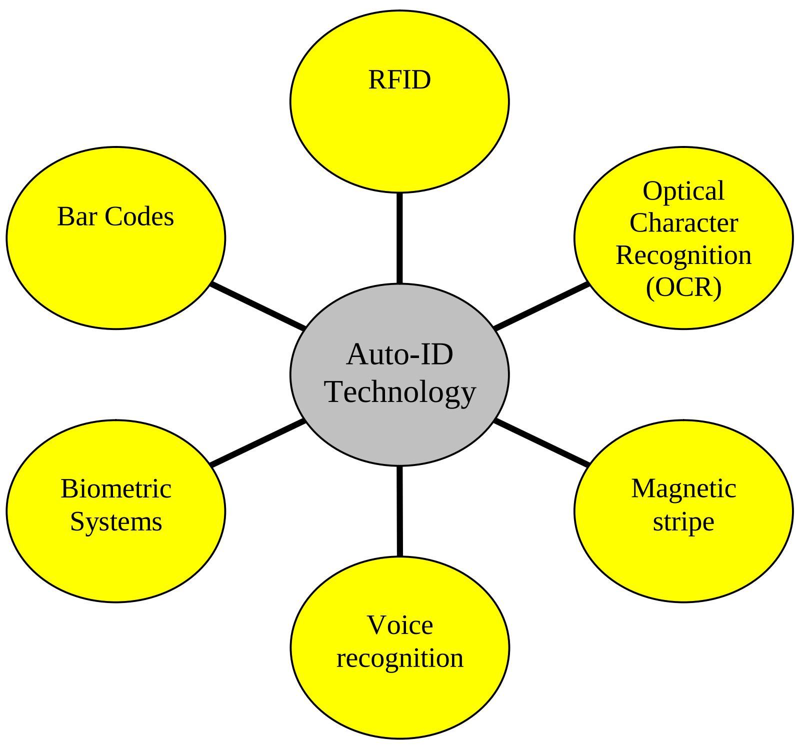
2 *Introduction to RFID*

2.1 *Automated Identification Data Capture*

Over the last decade, automated identification and data capture (AIDC) has revolutionised the supply chain management process. The aim of most automated identification and data capture systems is to increase efficiency, reduce data entry/errors and free up staff. Automated identification and data capture comprises of such systems as optical character recognition (OCR), magnetic stripe (e.g. credit card), biometric, voice recognition, radio frequency identification (RFID) and of course the most well known, bar codes.

In recent years a lot of "noise" has been made about RFID and it's potentially ground breaking advantages over the bar code system. While it should not be expected that RFID will fully replace bar codes there is however an ever increasing groundswell of interest in RFID and its possible benefits to business. The major drivers behind RFID implementation are retailers such as Wal-Mart and the US Department of Defence (DoD). Owing to the tremendous potential benefits of RFID systems, in June 2003 Wal-Mart announced they would require their top 100 suppliers to tag all pallets and cases they shipped to Wal-Mart distribution centres by January 2005. Despite the mandates by corporations such as Wal-Mart and the DoD many companies are still worried about the return on investment (ROI) of RFID implementation due to unresolved issues such as cost, standards, tag performance, and security of RFID data transmission.

Unfortunately, due to the newness and variety of RFID systems there is minimal analytical scientific research that investigates the different aspects of RFID systems. This has lead to the majority of information about RFID coming from vendors and various media sources.



2.2 *What is RFID?*

RFID was first developed in the 1940s as a way to identify allied and enemy aircraft in World War II, since then RFID has been applied to a myriad of applications from clothing, paper documents, toll collection, access control, baggage handling, animal tagging, people monitoring through to tracing assets/products along a production line. The object of any RFID system is to carry data in transponders, generally known as tags, and to retrieve data, by machine-readable means, at a suitable time and place to satisfy particular application needs.

Data within a tag may provide identification for an item in manufacture, goods in transit, a location, the identity of a vehicle, an animal or individual. RFID tags have the ability to carry additional information such as item specific information (e.g. date of manufacture unlike bar codes) or instructions immediately available on reading the tag. Essentially, it's a technology that connects objects to the Internet/Intranet, so they can be tracked and on a larger scale companies can share data about the movement of products in real time.

There are several methods of identification, but the most common is to store a serial number (e.g. electronic product code) that identifies an object and perhaps other information, on a microchip that is attached to an antenna (the chip and the antenna together are called a RFID transponder or an RFID tag). The antenna enables the chip to receive and transmit identification information to and from a reader (in a radio frequency format). The reader converts the radio waves received from the RFID tag into digital information that can then be passed on to a backend data base.

Active toll tag


Passive animal tag

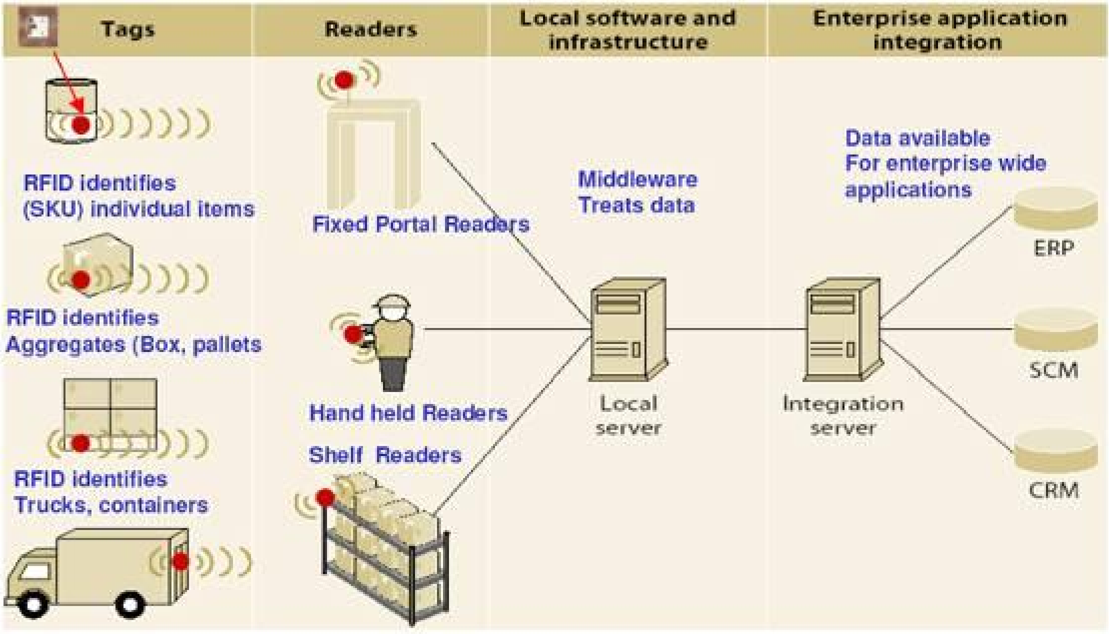
2.3 *RFID System Overview*

A typical RFID system consists of tags (encapsulated chip and antenna), readers (and their antennas), middleware and a backend data base that collects and collates all the appropriate data. Depending on the style of RFID tagging used, sometimes a system will also require a printer/encoder (e.g. in the case of smart labels).

The tags themselves consist of an electronic circuit (microchip) which stores the data, a battery (only in active or semi-passive tags), an antenna which communicates the data via radio waves and a carrier to which the chip and antenna are mounted (sometimes called a substrate e.g. paper label or moulded plastic etc). The data transmitted contains the electronic product code (EPC) or other similar information, which includes various details about the tagged product.

A RFID reader (sometimes called an interrogator) interrogates the tags via antennas to either obtain or transmit information to a tag. A reader may have multiple antennas that are responsible for sending and receiving the radio waves upon which tags and readers communicate. When the reader broadcasts radio waves, all the tags within range will communicate back. Software (called savant or middleware) is required to control the reader and to collect and filter the information so it can then be passed onto the company's computer network (backend database).

RFID System overview



3 *RFID Components*

3.1 *Tags*

RFID tags come in many shapes and sizes. RFID tags can even be combined with paper labels that have either bar codes, 2D text or other human readable text printed on them to create a smart label. RFID tags can be classified in three levels;

1. Passive, semi-passive and active
2. Read-only, write-once read many (WORM), read-write and
3. Low frequency (LF), high frequency (HF), ultra high frequency (UHF) and microwave.

Passive tags receive their energy solely from the radio frequency field supplied by the reader and therefore they don't have a battery. Passive tags either reflect energy from the reader, the technical name for this process is 'modulated back-scatter' or absorb and temporarily store a very small amount of energy from the reader's signal to generate its own quick response. In either case, Passive RFID operation requires a strong signal from the reader and the signal strength returned from the tag is constrained to very low levels by the limited energy available. As a result, the read range is usually small and varies depending on the reader used. Due to passive tags not requiring a battery they have the ability to be much smaller and cheaper to produce. Another advantage is that they can have a longer shelf life.

Semi-passive (or battery assisted) tags use a battery to run the chip's circuitry, however it still utilises the reader's electromagnetic field to "wake up" and reflect the incident RF field to transmitting data back to the reader (i.e. modulated backscatter).. These tags are often dormant (passive) until they are activated by a reader's electromagnetic field. These tags are sometimes used to record sensory information, such as container temperature, at pre-programmed intervals.

Active tags have an on board battery that powers the tag and allows for longer read ranges, better accuracy, more complex data exchange and greater processing capabilities. Due to their active nature, active tags have a limited lifetime but there are new tags that can be recharged or have the battery replaced. Active tags allow very low-level signals to be received by the tag (because the reader does not need to power the tag), and the tag can generate high-level signals, which are driven from its internal power source, back to the reader. This allows active tags to be read and transmit from greater distances than either a passive or semi-passive tag. Due to their onboard battery and increased size active tags are the most expensive.

Active and *semi-active* tags can also employ in-built sensors to record information (such as temperature) even when the tag is not situated in an RF field. These tags are ordinarily more expensive, and are generally designed and deployed for more specialised purposes, such as tracking high value goods or large lots of goods. Passive tags are more suitable for relatively simple, high volume tracking and information retrieval (e.g. totes or cartons).

The memory function of RFID tags serves as writable and non-writable data storage. Microchips in RFID tags can be read-only (R/O), write once read many (WORM) or read-write. *Read-only* tags usually have their data programmed in to them by the tag manufacturer. As the name suggests these tags can only be read and no information updates can be achieved. These types of tags are usually programmed with a very limited amount of data that is intended to be static, such as serial numbers.

Write once read many tags can be programmed by the vendor or on site. Data can only be written onto the tag once; however it can still be read many times (just like a read-only tag). This type of memory could be used on an assembly line to stamp the manufacture date or location onto a tag after the production is complete.

While read-write (R/W) tags usually have a serial number (called a TID, Tag Identifier) that can't be written over. Other parts of the tag's memory make it possible to add information to the tag or write over existing information when the tag is within range of a reader. The additional blocks of data can be used to store item or company specific information (these can usually be locked to prevent overwriting of data). Due to their re-writeable and reusable nature this type of tag can be more expensive.

One of the more important aspects of tag and reader connection (coupling) is the frequency at which they "talk" to each other. This is important because certain frequencies have trouble travelling/working through high water content items (e.g. meat, soft drink cans etc), metal and high electrical noise (e.g. electrical motors) environments (electromagnetic interference, EMI). Just as a radio tunes in to different frequencies to hear different channels, RFID tags and readers have to be tuned to similar frequencies to communicate. RFID systems are classified as a radio system because they generate and radiate electromagnetic waves.

RFID tags operate in four frequency bands; LF, DF (combines LF and HF), HF, UHF (including microwave). Due to a limited amount of spectrum available, the frequency on which RFID can operate on is limited and regulated by governments. Also due to radio waves behaving differently at different frequencies, it is imperative to choose the right frequency for the right application.

LF tags operate from 100-500kHz usually referred to as less than 134 khz. These tags are generally not affected by metallic surroundings and can penetrate through water (e.g. NLIS tags). These tags generally are passive, read slower, affected by electromagnetic interference, have a small read range, and are generally more expensive as they require wire wound coils for the tag antennas, and often larger antennas for the readers. They are used in animal tracking, automobile production tracking.

DF tags generally are first contacted/awoken by readers using low frequency and then the tag will respond using a high frequency signal. This gives DF tags the ability to work in a variety of settings where LF and HF tags struggle. There are no current ISO standards pertaining to DF systems and to date there is only one major manufacturer of DF tags.

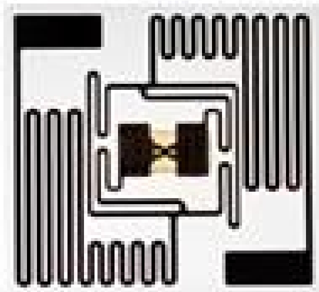
In the *HF* range tags operate at 13.56MHz and therefore can penetrate through most materials including water, however this frequency is affected by metal surroundings. When compared to LF tags HF tags are cheaper (<$1), have a faster data transfer rate and the read range is greater (>1m). Depending on the reader and the placement of the HF tags in relation to the reader up to 50 tags can be read simultaneously. They are typically passive and are used in instances such as libraries, smart cards and baggage handling.

The next range is *UHF* and these active or passive tags operate at 860-956 MHz. While UHF tags are generally cheaper than HF, due to their simpler antenna construction, they offer a greater read range (3-10m) and can be read at 200 tags simultaneously (depending on environment/setup of system). While this allows for speed of reading UHF tags generally do not work well in liquid or metal surroundings.

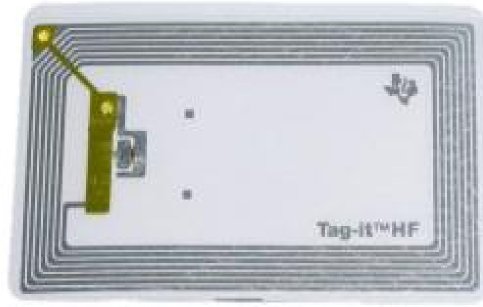
The final frequency of operation for an RFID tag is *microwave* (2.45GHz or 5.8 GHz). The characteristics are similar to UHF tags; however they have the ability to work at greater distances, have faster read rates and are less effective around liquids and metals than lower frequency tags. These tags can be either active or passive and they can be seen in use with electronic toll collection, tracking shipping containers and trains.

A synthesis of the above information illustrates that the read range of RFID tags depends on frequency, orientation of tag, read rate required, size of antenna for both tag and reader, power of reader/tag and the amount of possible interference between the tag and the reader. The surrounding environment, in which the RFID tag is placed, also affects the performance of RFID readability. These factors typically include whether the tag is used near or in open air, high/low humidity, high electromagnetic interference, corrosive materials, high RF noise, magnetic flux or in situations where there is a large amount of vibration or direct hitting of the tag. Also in general, a tag’s size is affected by whether it is LF (LF frequency tags require larger antennas) and by what power system is used (active or passive). In general as the frequency increases, the read rate, and thus the amount of data that can be transferred in a given time, increases.

RFID Tag Examples

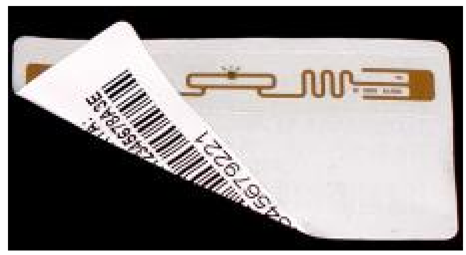


Alien-9529 - "Squiggle®-SQ"



Tag-it HF tag UHF Gen 2

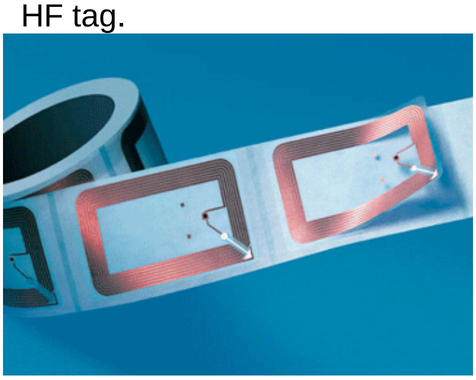
Alien-9540 - "Squiggle™"
UHF Gen 2



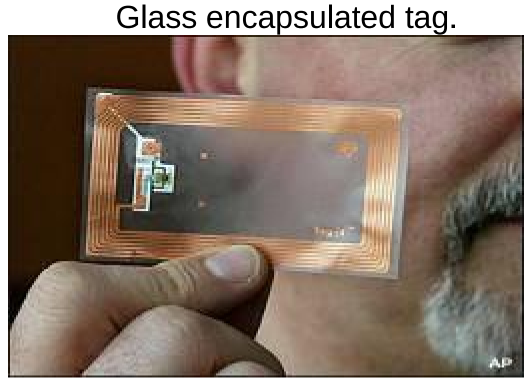
Smart label: Alien-9540 - "Squiggle™"
with human readable code on reverse.

HF tag.

Glass encapsulated tag.



A roll of tags as used in printer/encoders for smart labels.



Tag-it HF tag.

3.2 *Other considerations for Tags*

Besides choosing a tag that has the most appropriate attributes in relation to programming, operating frequency and how it is powered there are a number of other considerations to be made when choosing the right tags for a particular application. These include:

- What the tag is made of (e.g. plastic or glass housing)
- Data retention time
- Memory size
- Anti-collision properties (the reader also plays a role in this)
- Operating temperature and cost.

The cost of tags tends to decrease as the frequency increases, although active tags cost much more than passive tags, irrespective of frequency. Also, the longer the range required and the more information stored, then the more costly the tag. Most companies that sell RFID tags do not quote prices because pricing is based on volume, the amount of memory on the tag and the packaging of the tag (plastic or embedded in a label etc).

Generally speaking, a 96-bit EPC (EPCglobal compliant) inlay (chip and antenna mounted on a substrate) costs from $0.10 to $0.18 (AUS) for a passive tag. If the tag is embedded in a thermal transfer label on which companies can print a bar code, the price rises to $0.20 (AUS) and up. Active tags range from US$10 to $50 or more.

Within the industry and associated media there is a lot of talk about the mythical $0.05 (US) tag. According to various industry sources the timing of this achievement is anywhere from 3 years to 15 years away. Also when this price is suggested it only refers to the price of manufacturing the chip and does not include an antenna or packaging, both of which impact on cost.

3.3 *Readers*

A reader acts as a bridge between the tags and the middleware and has 4 main tasks:

1. Read the data contents of the tag
2. Write the data to the tag (in the case of Read/Write tags)
3. Relay data to and from the middleware
4. Power or "wake" the tag up (in the case of passive or semi-passive tags respectively)

Readers also implement anti collision measures. Typical reader has one or more antennas that emit radio waves to "wake up" the tag and/or to enquire about the tag's data. The reader then passes this information (in digital form) onto the middleware (see section 3.4).

Readers like tags differ in many different ways and therefore no one reader is a perfect fit for all applications. They come in different shapes and sizes, support different operational protocols and often must conform to regulatory requirements (e.g. ISO). Although some readers can also write data onto a tag, the device is still referred to as a reader or interrogator

Like RFID tags readers can be classified in a couple of ways. First readers are either fixed or portable. For example in a warehouse fixed readers could be set up on walls, conveyer belts and dock doors. Portable readers could be hand held or secured to vehicles such as a forklift. Readers attributes can be broken down even further for example:

- Reader weight and size
- Communication interface (e.g. Serial, Ethernet or wireless)
- Integrated filtering component (filters data when multiple tags respond)
- Antenna (several can be connected to one reader)
- Software
- Time taken to identify tags
- Read/Write rate
- Memory
- Operating temperature and humidity parameters
- Shock resistance (e.g. if hand held or mounted on a fork lift)

Therefore it can be seen that as with tags there are a lot of considerations to be made when investigating what type of reader to acquire.

UHF Alien reader ALR-9900

Alien ALR-9800 (UHF Reader and 2antennas)

Symbol Technologies MC9000 with UHF Reader/Scanner

Tagsys LSA-4 HF antenna

Alien ALX-9010 UHF Portal reader (e.g. used in door ways). The portal is made up of 3 white antennas and 1 black reader.

3.4 *Middleware*

Next is the middleware which manages the readers and extracts the electronic product code data from the readers. It acts as a bridge between the readers and the backend data base (host application). Middleware's main tasks are to perform data collection, monitoring, filtering, management, aggregating, routing of information (to back end system) and also can be used to trigger events/commands based on business objectives. It can also be used to monitor and coordinate reader activity.

The cost of middleware varies from vendor to vendor and is usually based on the number of locations where it will be installed, the complexity of the application and many other factors. Servers to run the middleware and software (to read and transform the data into company useful information) will also need to be purchased.

3.5 *Backend data base*

From the middleware the data is transferred to a backend data base which stores a complete record of RFID tagged items. It maintains detailed item information as well as the tag data which has to be inline with the information read from the RFID. The backend data base will then process the information into the Warehouse Management System (WMS) which integrates mechanical (e.g. robot) and human activities within the system to allow for effective management of warehouse/supply chain activities. The warehouse management system automates receiving, put-away, picking, processing and shipping.

3.6 *Printer/Encoder*

If companies are wishing to implement smart label RFIDs then they are going to have to acquire a RFID printer-encoder. The printer will typically print a bar code or human readable text onto the label and the encoder will electronically write an electronic product code onto the RFID and the two are infused into a label ready to be adhered to a carton, pallet or tote.

Intermec printer/encoder with smart label protruding

Zebra R110Xi UHF printer/encoder

4 *Cost Considerations* *(as tags have been previously mentioned no extra information will be given here)*

In general the cost depends on the application, the size of the installation, the type of system and many other factors, so it is difficult to give an exact figure. However the cost of an RFID system can be broken down into four key areas:

1. Hardware e.g. tags, printers/encoder, readers, antennas, computers and cables etc
2. Software e.g. middleware, upgrade, creation and warehouse management systems etc
3. Service e.g. installation, tuning of system, integration, training, support and maintenance
4. Miscellaneous e.g. hiring technology expertise, reconfiguring current work practices, adaption time, training staff and pilot/performance tests

4.1 *Hardware*

Depending on the style of tag used, plastic mould or label, a printer/encoder is sometimes an extra piece of equipment needed (i.e. for smart labels). The printer/encoders work in the same fashion as a bar code printer but they also encode the RFID at the time of printing out the smart label. Printer/encoder prices can range from $1,500-$5,000 (AUS). Reader range, multi-frequency handling capabilities, operational perimeters (e.g. can be used in cold temps or hand held) and antennae capability all impact on reader cost. Depending on these variables readers can cost anywhere from $500 to $10,000 (AUS). Most readers are accompanied by one or two antennas but sometimes extra antennas are required. Other associated costs might be buying new computers, printers and cables to connect the antennas, middleware and host computers.

4.2 *Software*

Middleware can be one of the more expensive outlays for a company and its price depends on the overall system size. A rough guide is that middleware can cost from $25,000 to $200,000 and includes a site license. Another consideration is whether a company's current software can be upgraded to handle RFID data or whether a complete new system is required.

4.3 *Services*

Installation and integration, of tags, readers, antennas, host computers, can often be a lengthy process (depending on size of system). System integration is a key consideration in RFID business solutions. It is very important that the data generated from an RFID setup is in a format that is compatible—or 'integrated'—with all of the relevant equipment, software and other associated data so as to achieve the full benefits of the system. Part of this process is the tuning of the system. Tuning involves activities such as tag/reader placement or shielding to get optimal performance (read rates/reliability). As mentioned earlier electromagnetic interference (e.g. electric motors, routers, water, metal) poses a major obstacle to RFID systems. Tuning normally involves an industry professional aligning and shielding readers and antennas so the highest possible read rate can be achieved. Companies will also need to invest in training for their employees such as engineering staff who will manage the system on the manufacturing floor and IT staff who will work on the systems that manage RFID data.

4.4 *Miscellaneous*

As with any new technology associated miscellaneous or possible unforseen costs need to be taken into account also. One of the main areas that industry sources don't seem to highlight is the time and cost involved in running pilot and ongoing performance tests of the proposed RFID system. This is even more imperative when for example two different tags (LF and HF etc) are required to be used in the one area.

As with any new technology, people and work practices take time to adapt. While adaptation time is hard to quantify it is still another important consideration to make when reviewing an RFID system and the possible costs that could be incurred by the company.

As the technology improves and is more widely adopted, costs will come down and the technology will be easier to install. However this statement has been made for the past ten years in relation to RFID and while it will continue to be relevant it is also extremely difficult to quantify. For example certain industry sources believe a $0.05 (US) passive, low memory, read only, tag will be achieved within 5 years while others say it will take at least 10 years. As with any developing technology accurately predicting a time for widespread adaptation/usage is extremely difficult and in the meantime it is hard to rule out that a more appropriate technology won't be developed or promoted.

5 *Vendors*

When enquiring into RFID systems vendor selection is a very important procedure due to the ever evolving nature of the technology. Vendors can be broken up into three classes:

- Manufacturers
- Original Equipment Manufacture (OEM)
- Implementers.

Manufacturers are companies that are the base line producers of such items as chips and antenna components.

OEMs are the next stage along and focus on the manufacture of the finished product (e.g. tags and readers).

Generally speaking when a company wants to install an RFID system their primary contact will be with an implementer. Implementers are the companies that install the final RFID system. Within implementers there are also specialised implementers that for example install a complete system such as a boning room which has a RFID component. Therefore their expertise is not explicitly related to RFID systems as it merely makes up part of their overall system instalment.

6 *Standards and Definitions*

Prior to the development of standards for tags and readers, companies primarily developed propriety RFID systems (some still do) so that readers from one vendor often only read tags from the same vendor. For a long time, and even now to a certain degree, the lack of standards within the RFID industry has been a major stumbling block in terms of wide spread adoption. However now, thanks to the International Organisation for Standardisation (ISO) and EPCglobal standards RFID systems are becoming more interoperable (both between companies and internationally).

There are many different ISO standards pertaining to RFID. For example ISO 18000-6 is a proposed international standard governing the way tags and readers communicate in the 860 to 960 MHz spectrum. So when looking into RFID systems it is not as simple as making sure that tags and readers are ISO compliant, a company needs to check that a reader and tag are a specific ISO standard compliant when compared to each other. ISO standards relate to the operating and manufacture of RFID systems. EPCglobal on the other hand have developed the Electronic Product Code and standards that relate to the use of UHF (ISO standard 18000-6) tags and their operating parameters.

The current definitions for ePC from EPCglobal are:

Class-1: Identity Tags
Passive-backscatter tags with the following minimum features:
An electronic product code (EPC) identifier,
A tag identifier (Tag ID),
A function that renders a tag permanently non-responsive
Optional decommissioning or recommissioning of the tag,
Optional password-protected access control, and
Optional user memory.

Class-2: Higher-Functionality Tags
Passive tags with the following anticipated features above and beyond those of Class-1 Tags:
An extended Tag ID,
Extended user memory,
Authenticated access control, and
Additional features (TBD) as will be defined in the Class-2 specification.

Class-3: Battery-Assisted Passive Tags (called Semi-Passive Tags in UHF Gen2)
Semi-Passive tags with the following anticipated features above and beyond those of Class-2 Tags:
A power source that may supply power to the tag and/or to its sensors, and/or
Sensors with optional data logging.
Class-3 Tags still communicate passively, meaning that they (i) require an Interrogator to initiate communications, and (ii) send information to an interrogator using either backscatter or load-modulation techniques.

Class-4: Active Tags
Active tags with the following anticipated features:
An electronic product code (EPC) identifier,
An extended tag ID,
Authenticated access control,
A power source,
Communications via an autonomous transmitter,
Optional User memory,
Optional sensors with or without data logging.

Class-4 tags have access to a transmitter and can typically initiate communications with an interrogator or with another tag. Protocols may limit this ability by requiring an interrogator to initiate or enable tag communications. Because active tags have access to a transmitter, of necessity they have access to a power source. Class-4 tags shall not interfere with the communications protocols used by Class-1/2/3 tags.

Source= http://www.epcglobalinc.org/standards/TagClassDefinitions_1_0-whitepaper-20071101.pdf

Both ISO and EPC continue to work on standards and definitions for the RFID industry with the aim of achieving a higher level of interoperability between systems.

7 *RFID and Bar Codes*

An RFID system can improve on, or complement, a bar code system by capturing larger amounts of data and more specific information about items. RFID tags can, in certain contexts, have a number of advantages over bar codes. Two of the more significant differences are:

- RFID can be read without a direct line of sight
- RFID has the ability to uniquely identify each individual product via item specific electronic product codes

Some other advantages are:

- A RFID tag can potentially carry, or be used to access, far more detailed information about the unique object it's attached to, including specific information about individual items (e.g. date and time of manufacture), rather than just generic information about a whole product line;
- RFID tags can be scanned or read without the need for a 'line of sight',
    - in some cases from considerable distances, or
    - in bulk (when there are multiple objects in the RF field), or
    - in specified classes or subsets, or
    - through opaque cartons and packaging, all seamlessly and automatically;
- RFID tags can in some cases be 'written', or associated with, new or updated information many times, as opposed to barcodes, which are static once they are printed;
- RFID tags can be interfaced with systems that collect and store information (such as temperature) via sensors, and then be commanded to transmit that stored information to a host computer or database.

RFID is often touted as the technology that will overtake a lot of the bar codes current applications. RFID is not necessarily "better" than bar codes rather the two are different technologies and have different applications, which sometimes overlap.

There are a number of differences when comparing RFID and bar codes. Two of the more significant (as highlighted above) are

- Bar codes require direct line of sight to be read,
- Second is the ability of RFID to uniquely identify each individual product via item specific electronic product codes.

Due to the inexpensive nature of bar codes it is hard to see that RFID will ever completely replace them. Rather as has previously been mentioned bar codes and RFID can coexist (e.g. smart labels) and for the foreseeable future this cohabitation will continue. So when deciding which technology, not only bar codes or RFID but also other AIDC technologies, is best suited to specific company requirements it needs to be realised that all technologies have their respective advantages and disadvantages.

8 *Conclusion*

The aim of most AIDC systems is to increase efficiency, reduce data entry/errors and free up staff. RFID is allowing companies to, in the right setting, increase such efficiencies and in the process saving them both time and money through higher quality product/asset tracking in real time. RFID has matured from its use in WWII through to todays uses such as access control, animal tracking and patient care to be one of the more widely used AIDC technologies.

While it seems easy to describe the system as simply involving tags, readers (and their antennas), middleware and a backend data base it has been shown that there are numerous variables involved with each part of the system that need to be taken into account. These range from but are not limited to, operating frequency, power source, memory capacity and associated standards. It is not an easy process to understand and fully comprehend and therefore it is imperative to take time when investigating how a RFID system works and what system would be most appropriate for your company.

RFID is a technology that can provide considerable value in a business world in which operating costs are often dominated by labour. The interest in RFID as a solution to further optimise the supply chain is gathering momentum at an ever increasing pace, with more and more companies announcing trials and mandates to their suppliers. Much of the clamour in the media about RFID has come as a result of these mandates from such organisations as Wal-Mart and DoD.

RFID technology is still not yet widely understood or installed in the supply chain, and cost/return on investment models are far from established. Many companies are therefore now faced with the difficult choice in deciding whether they should be looking at RFID now, or waiting until deployment is more widespread.

For a long time, the lack of standards within the RFID industry has been a major sticking point in terms of wide spread adoption. However now, thanks to the ISO and EPCglobal standards RFID systems are becoming more interoperable (both between companies and internationally).

With the considerable hype about its potential cost savings and reach, a complex variety of technology and solution vendors, and an uncertain/ever evolving base of standards set for its use, the near-term future of RFID adoption is far from clear. Add to this the harsh and ever varying environment where RFID would be required to operate.

The near-term future of RFID adoption is far from clear due to:

- Considerable hype about its potential cost savings and reach,
- A complex variety of technology and solution vendors,
- An uncertain/ever evolving base of standards set for its use,
- The harsh and ever varying environment where RFID would be required to operate,
- The reported inability to consistently achieve 100% read rates and the associated costs,
- The lack of empirical stand non-biased research.

However if there is a process specific issue or position where RFID is shown to be the right technology for the right application and implemented in the correct way it can offer companies a significant return on investment which in turn allows them to continue to evolve and stay one step ahead of their competitors.

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4th June 2008

Section 4.1 of 9: Hook Tracking

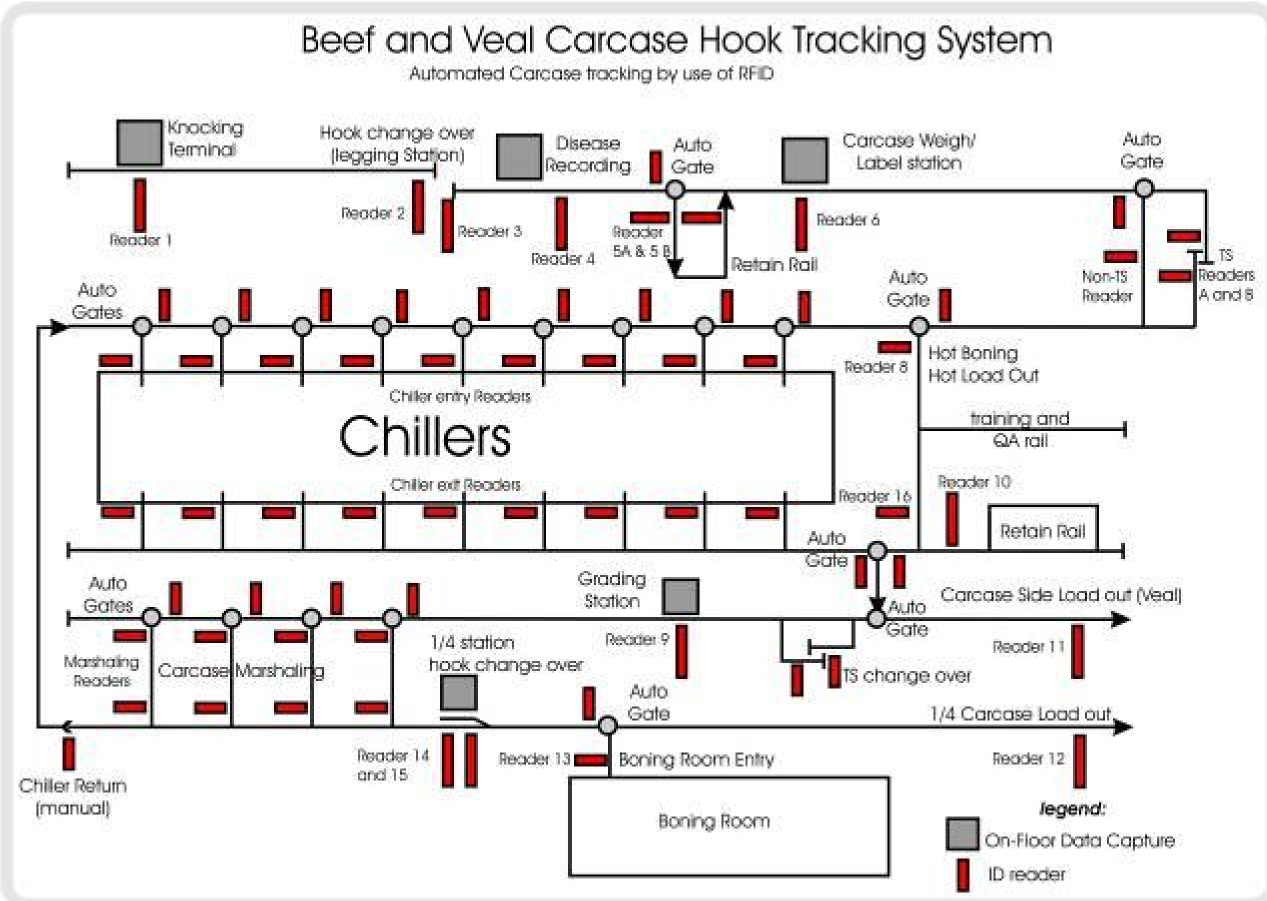
Executive Summary

The following diagram and tables are designed to give the reader an overview of where and how many RFID readers might be used from slaughter to boning room entry for a hook tracking system. Arbitrary costs have been shown to give an idea of possible costs for a RFID hook tracking system from slaughter to boning.

Table of Contents: Hook Tracking

IMPORTANT NOTICE

1 *Hook Tracking*



2 RFID Overview

Band	LF Low Frequency e.g. AM Radio	DF Dual Frequency	HF High Frequency e.g. FM Radio	UHF Ultra High Frequency e.g. mobile phones	Microwave
Typical RFID Frequencies	125–134 kHz	Transmit 125kHz / Receive 6.8MHz	13.56 MHz	433 MHz or 865 – 956MHz	2.45 GHz
Approximate read range (m=metre)	Less than 0.5m	Up to 1.4m	Up to 1.5m	433 MHz = up to 100m 865-956 MHz = 0.5 to 5m	Up to 10m
Typical data transfer rate (kilobit per Second=kbit/s)	less than 1 (kbit/s)	Up to 125 kbit/s	Approx. 25 kbit/s	433–956 = 30 kbit/s 2.45 =100 kbit/s	Up to 100 kbit/s
Advantages	Little signal loss	Little signal loss similar to HF, possible high read rates, can work in electromagnetic noisy environments,	Small signal loss, good read range in noisy environments, reasonable data rate, anti collision, small size easy to embed e.g. 10mmx 10mm x1.2mm 2nd lowest	Excellent read range in good environment, high data transfer rate, concurrent read of <100 items, smallest tags 1st lowest cost	High read range, high data transfer rate,
Disadvantages	Low data transfer rate, larger size, affected by electromagnetic interference, small read distance, slow read rate, 3rd lowest cost	Size, 4th lowest cost		High signal loss, lower memory than HF, doesn't work well around liquids and metal surroundings.	Very high signal loss, 5th lowest cost
Operating parameters (indicative)	-40°C to 85°C	-25° to + 70°C	-40°C to 85°C	-35°C to 70°C	-50°C to+150°C
Comparative Cost (AUD)	$3.00 to $20.00	$6.00 to $30.00	$1.00 to $3.00	<$1.00	$10.00 to $100.00
Multiple tag read rate	Slower ◄——► Faster				
Ability to read near water or metal	Better ◄——► Worse				
Signal loss due to electromagnetic interference	Worse ◄——► Better				

All costs are Australian dollars and are representative costs only.

3 *Readers and Antennas*

Equipment	Advantages	Disadvantages	Operating parameters Indicative (c°)	Comparative Cost (AUD)
Antenna LF HF UHF & Microwave	N/A	N/A	-20° to 70°	10-10,000
Reader LF	Little signal loss	Slow read rate	0° to 55°	$500 -$1000
Reader DF	Able to read/write in LF/HF frequencies,	Cost	0° to 50°	$500 - $3000
Reader HF	Good read distance, can read multiple tags simultaneously		-20° to 60°	$100 - $1000
Reader UHF	Long read distance, can read multiple tags simultaneously, small signal loss		-20° to 60°	$1500 - $3500
Reader Microwave	Large read distance, can read multiple tags simultaneously, focused read areas	Cost, affected by environment	-40º to 80 °	$2000 - $10,000

All costs are Australian dollars and are representative costs only.

4 *Diagram and Table Explanation*

The preceding diagram and tables are designed to give an overview of where and how many RFID readers might be used from slaughter to boning for a hook tracking system. The exact numbers and placement of readers will vary depending on company procedures and size of operation. Also the RFID system frequency will impact on the number and placement of readers.

As highlighted in the table, in relation to current RFID systems available, the use of High Frequency tags and readers would currently be the optimal choice for implementation with a hook tracking system. This type of system would allow for the speed of read needed within a slaughter floor (i.e. chain speed) and these tags can be embedded in either plastic or metal hooks.

As noted in earlier sections the ability to achieve a high percentage of reliable read rates takes careful planning and implementation to get the system up to standard. This can often be a time consuming process which needs to be taken into account when equating the possible return on investment and its associated timeline.

Finally performance of the system will vary over time as a result of environmental changes. For example a company might decide to alter the metal framework near a reader or a person could stand in between a reader and its tag and affect the data transfer process. Due to the varying nature of possible interference to a RFID system 100% read rates (over time) may never be achieved.

5 *Representative Costs*

The return on investment or cost benefit calculation process needs to be calculated on a case by case basis. For example the type of RFID system used for hook tracking will differ to the one used in the boning room.

There may be considerable labour cost savings obtained by unitizing RFID in the correct commercial application, these savings need to be determined on a cases by case basis. For the purpose of this cost example a value of $0 labour cost saving has been applied.

The following example outlines the types of considerations that need to be accounted for when researching the viability of a RFID system:

Note: The following representative cost calculations are worked off a company processing 1000 head a day and the use of a HF RFID system.
Example Capital Cost: $246,600

- Purchase Tags e.g. 5500 x $2.00 (nominal cost) = $11,000
- Retrofit Tags to hooks e.g. 4900 X $4 (nominal fitment cost)= $19,600
- Readers e.g. 67 x $2000 = $134,000
- Antenna e.g. 67 x $1000= $67,000
- Implementation (e.g. tags, software) cost= $80,000
- Pilot/Performance tests cost=$20,000

(Readers and antennas are divided by 4 due to their expected live span of 4 years)

Example Maintenance Cost (30% of capital per year)**:** $54,255

- Reader servicing
- Software changes
- Tag replacement

Example Operational Cost: $55,000

- Consumables
- Additional labour (as with any new system additional roles and responsibilities will be created.)
- Additional process cost (e.g. check hooks after cleaning and before use)

Therefore a cost benefit calculation could look like this:

	Example cost
Capital over 4 years (divided by 4)	$66,150
+ Maintenance per year	$54,255
+ Operational cost	$55,000
Total= Yearly cost	$175,405

	Example cost
Labour cost saving	$0
+Existing error cost saving	$20,000
+Risk / stock reduction value estimate	$100,000
– Yearly cost	$175,405
Total= Yearly return or deficit	-$55,405

(Risk/ stock reduction allows for smaller stock recalls as well as lower stock levels.)

The end sum of this equation shows the possible yearly return or deficit (depending on company specific costs) on the RFID system chosen for implementation for a hook tracking system from slaughter to boning. Once again this equation is only a guide and there may be other costs that need to be added or subtracted.

The above table and figures aim to give an example of the possible layout and costs associated with implementing a RFID hook tracking system from slaughter to boning. This is only a guide and company specific information needs to be taken into account.

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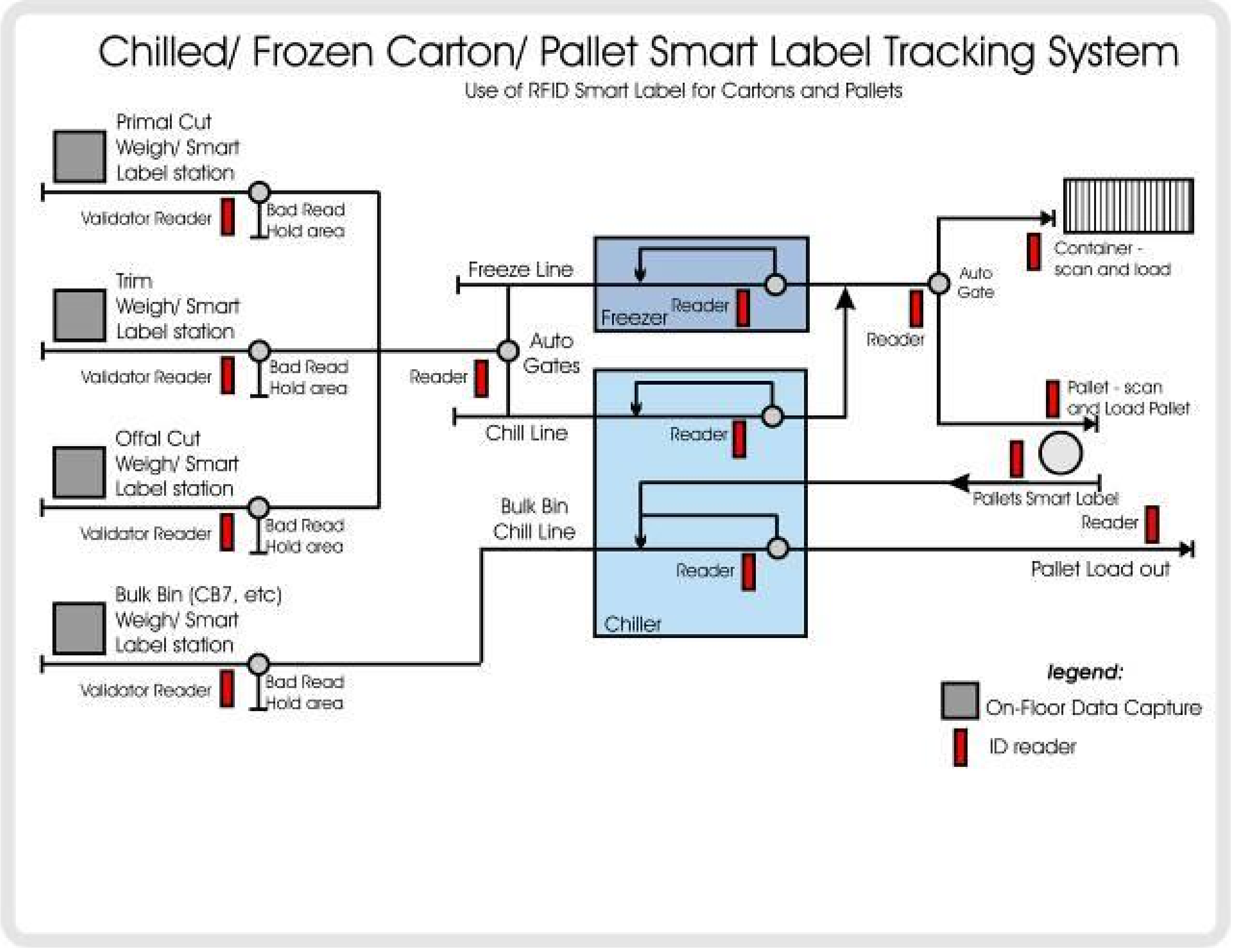
Section 4.2 of 9 Carton Tracking From Boning to Distribution

Executive Summary

The following diagram and tables are designed to give the reader an overview of where and how many RFID readers might be used for carton tracking from boning through to distribution. Arbitrary costs have been shown to give an idea of possible costs for a carton tracking RFID system from boning through to distribution.

Table of Contents: Carton Tracking From Boning to Chiller

1 *Carton Tracking from Boning to Distribution*



2 RFID Overview

Smart Label band	HF High Frequency e.g. FM Radio	UHF Ultra High Frequency e.g. mobile phones
Typical RFID Frequencies	13.56 MHz	433 MHz or 865 – 956MHz
Approximate read range (m=metre)	Up to 1.5m	433 MHz = up to 100m 865-956 MHz = 0.5 to 5m
Typical data transfer rate (kilobit per Second= kbit/s)	Approx. 25 kbit/s	433–956 = 30 kbit/s 2.45 =100 kbit/s
Advantages	Combines both human readable and RFID data, size, scope of use	Combines both human readable and RFID data, size, scope of use
Disadvantages	Cost when compared to bar code, small signal loss, good read range in noisy environments, reasonable data rate, anti collision, small size easy to embed e.g. 10mmx 10mm x1.2mm	Cost when compared to bar code, Excellent read range in good environment, high data transfer rate, concurrent read of <100 items, smallest tags High signal loss
Operating parameters (indicative)	-40°C to 85°C	-35°C to 70°C
Comparative Cost (AUD)	20c to $2	20c to $2

3 Readers and Antennas

Equipment	Advantages	Disadvantages	Operating parameters Indicative (c°)	Comparative Cost (AUD)
Antenna LF HF UHF & Microwave	N/A	N/A	-20° to 70°	$10-$10,000
Reader HF	Good read distance, can read multiple tags simultaneously		-20° to 60°	$100 -$1000
Reader UHF	Long read distance, can read multiple tags simultaneously, small signal loss		-20° to 60°	$1500 - $3500
Printer/Encoder HF and UHF	Utilises both human readable and RFID technology, high data transfer rate,	Needs to be protected from harsh temperatures	0° C to 40°	$1,500 - $5,000

All costs are Australian dollars and are representative costs only.

4 Diagram and Table Explanation

The preceding diagram and tables are designed to give the reader an overview of where and how many RFID readers might be used for carton tracking from the boning room to distribution. The exact numbers and placement of readers will vary depending on company procedures and size of operation. Also the RFID system frequency will impact on the number and placement of readers.

As highlighted in the table, in relation to current RFID systems available, the use of High Frequency smart labels and readers would currently be the optimal choice for implementation with carton tracking from boning through to distribution. Smart labels are the best suited to this application as they have the ability to combine both the current bar code system as well as a RFID tag.

As noted in earlier sections the ability to achieve a high percentage of reliable read rates takes careful planning and implementation to get the system up to standard. This can often be a time consuming process which needs to be taken into account when equating the possible return on investment and its associated timeline.

Finally performance of the system will vary over time as a result of environmental changes. For example a company might decide to alter the metal framework near a reader or a person could stand in between a reader and its tag and affect the data transfer process. Due to the varying nature of possible interference to a RFID system 100% read rates (over time) may never be achieved.

Note: To date very limited research has been conducted into the possible affects of X-Rays on RFID. This needs to be taken into account when exploring the possibility of implementing smart label RFIDs.

5 *Representative Costs*

The return on investment or cost benefit calculation process needs to be calculated on a case by case basis. For example the type of RFID system used for carton tracking will be different to the one used in the slaughter floor.

There may be considerable labour cost savings obtained by unitizing RFID in the correct commercial application, these savings need to be determined on a cases by case basis.

The following example outlines the types of considerations that need to be accounted for when researching the viability of a RFID system:

Example Capital Cost: $1,805,825

- Smart labels e.g. 1,771,200 (per year) x $1.00= $1,771,200
- Readers e.g. 13 x $1500= $19,500
- Antenna e.g. 13 x $1000= $13,000
- Printer/Encoders e.g. 3 x $3,000= $6,000
- Implementation (e.g. tags, software) cost= $80,000
- Pilot/Performance tests cost=$20,000

Example Maintenance Cost (30% of capital per year)**:** $41,550

- Reader servicing
- Software changes
- Tag replacement

Example Operational Cost**:** $55,000

- Consumables
- Additional labour (e.g. as with any new system additional roles and responsibilities will be created.)
- Additional process cost

Therefore a Cost benefit calculation could look like this:

Note: The following arbitrary calculations are worked off a company processing 1000 head a day and the use of a HF RFID system.

	Example cost
Capital over 4 years (divided by 4)	$34,625
+ Smart label yearly capital	$1,771,200
+ Maintenance per year	$41,550
+ Operational cost	$55,000
Total= Yearly cost	$1,902,375

	Example cost
Labour cost saving	$300,000
+Existing error cost saving	$20,000
+Risk/ stock reduction value estimate	$500,000
– Yearly cost	$1,902,375
Total= Yearly return or deficit	-$1,082,375

(Risk insurance example: old system involves recalling whole day of production, new RFID system involves recalling 1 hour of production which saves money. Stock reduction allows for a cost saving in stock on hand.)

The end sum of this equation shows the possible yearly return or deficit (depending on company specific costs) on the RFID system chosen for implementation for carton tracking from boning to distribution. Once again this equation is only a guide and there maybe other costs that need to be added or subtracted.

The above table and figures aim to give an example of the possible costs associated with implementing a RFID system for carton tracking from boning through to distribution. This is only a guide and company specific information needs to be taken into account.

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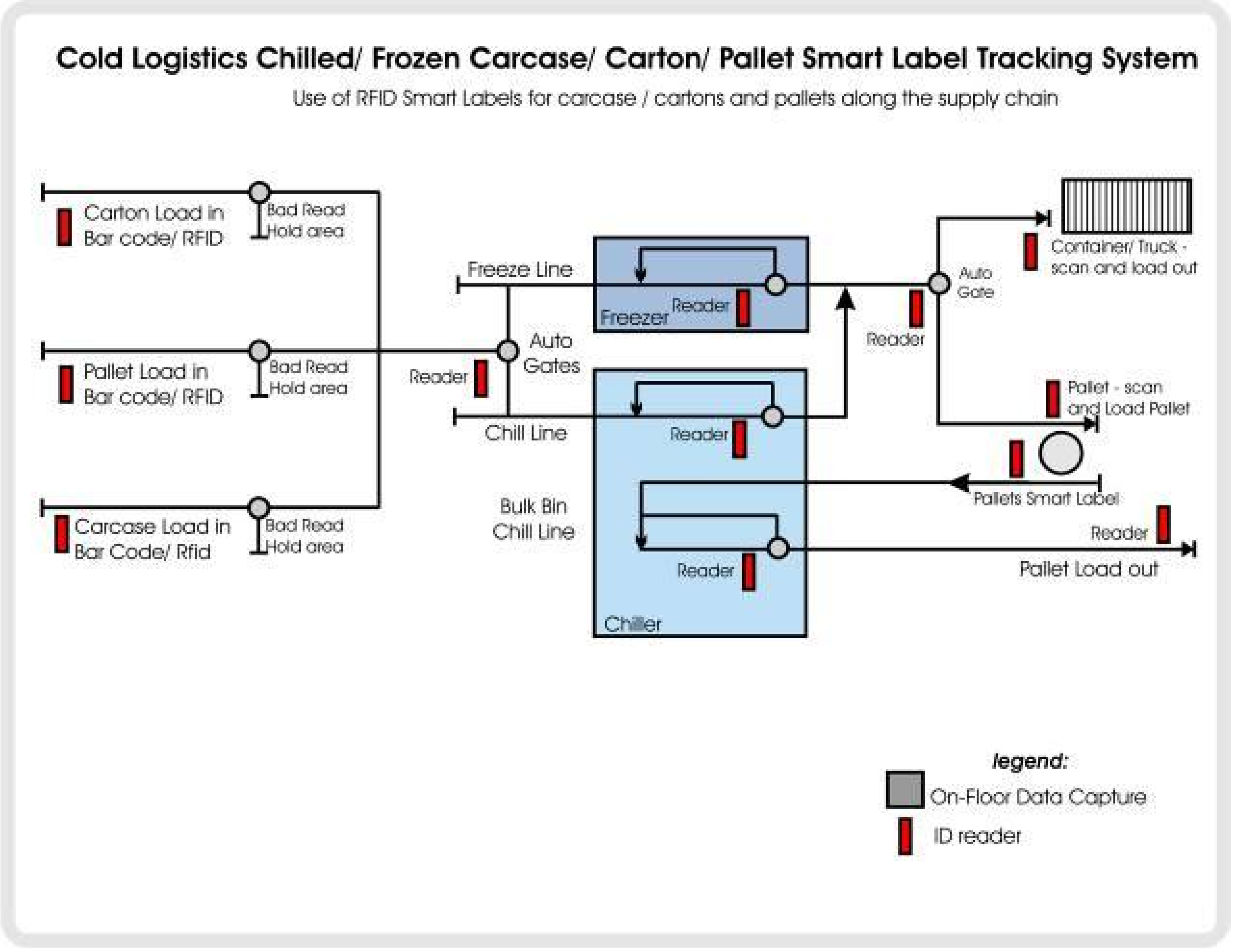
Section 4.3 of 9: Carton and Pallet Tracking From Load in to Distribution

Executive Summary

The following diagram and tables are designed to give the reader an overview of where and how many RFID readers might be used for carton and pallet tracking from load in to distribution. Arbitrary costs have been shown to give an idea of possible costs for a carton and pallet tracking RFID system from load in to distribution.

Table of Contents: Carton and Pallet Tracking From Load in to Distribution

1 *Carton and Pallet Tracking From Load in to Distribution*



2 *RFID Overview*

Smart Label band	HF High Frequency e.g. FM Radio	UHF Ultra High Frequency e.g. mobile phones
Typical RFID Frequencies	13.56 MHz	433 MHz or 865 – 956MHz
Approximate read range (m=metre)	Up to 1.5m	433 MHz = up to 100m 865-956 MHz = 0.5 to 5m
Typical data transfer rate (kilobit per Second=kbit/s)	Approx. 25 kbit/s	433–956 = 30 kbit/s 2.45 =100 kbit/s
Advantages	Combines both human readable and RFID data, size, scope of use	Combines both human readable and RFID data, size, scope of use
Disadvantages	Cost when compared to bar code, small signal loss, good read range in noisy environments, reasonable data rate, anti collision, small size easy to embed e.g. 10mmx 10mm x1.2mm	Cost when compared to bar code, Excellent read range in good environment, high data transfer rate, concurrent read of <100 items, smallest tags High signal loss
Operating parameters (indicative)	-40°C to 85°C	-35°C to 70°C
Comparative Cost (AUD)	20c to $2	20c to $2

3 *Readers and Antennas*

Equipment	Advantages	Disadvantages	Operating parameters Indicative (c°)	Comparative Cost (AUD)
Antenna LF HF UHF & Microwave	N/A	N/A	-20° to 70°	10-10,000
Reader HF	Good read distance, can read multiple tags simultaneously		-20° to 60°	$100 - $1000
Reader UHF	Long read distance, can read multiple tags simultaneously, small signal loss		-20° to 60°	$1500 - $3500
Printer/Encoder HF and UHF	Utilises both human readable and RFID technology, high data transfer rate,	Needs to be protected from harsh temperatures	0º C to 40º	$1,500 - $5,000

All costs are Australian dollars and are representative costs only.

4 *Diagram and Table Explanation*

The preceding diagram and tables are designed to give the reader an overview of where and how many RFID readers might be used for carton and pallet tracking from load in to distribution. The exact numbers and placement of readers will vary depending on company procedures and size of operation. Also the RFID system frequency will impact on the number and placement of readers.

As highlighted in the table, in relation to current RFID systems available, the use of High Frequency smart labels and readers would currently be the optimal choice for implementation with carton and pallet tracking from load in to distribution. Smart labels are the best suited to this application as they have the ability to combine both the current bar code system as well as a RFID tag.

As noted in earlier sections the ability to achieve a high percentage of reliable read rates takes careful planning and implementation to get the system up to standard. This can often be a time consuming process which needs to be taken into account when equating the possible return on investment and its associated timeline.

Finally performance of the system will vary over time as a result of environmental changes. For example a company might decide to alter the metal framework near a reader or a person could stand in between a reader and its tag and affect the data transfer process. Due to the varying nature of possible interference to a RFID system 100% read rates (over time) are never achieved.

5 *Representative Costs*

The return on investment or cost benefit calculation process needs to be calculated on a case by case basis. For example the type of RFID system used for carton tracking will be different to the one used in the slaughter floor.

There may be considerable labour cost savings obtained by unitizing RFID in the correct commercial application, these savings need to be determined on a cases by case basis.

The following example outlines the types of considerations that need to be accounted for when researching the viability of a RFID system:

Example Capital Cost: $1,805,200

- Smart labels e.g. 1771,200 (per year) x $1.00= $1,771,200
- Readers e.g. 12 x $1500= $18,000
- Antenna e.g. 12 x $1000= $12,000
- Printer/Encoders e.g. 3 x $3,000= $6,000
- Implementation (e.g. tags, software) cost= $80,000
- Pilot/Performance tests cost=$20,000

Example Maintenance Cost (30% of capital per year)**:** $34,000

- Reader servicing
- Software changes
- Tag replacement

***Example Operational Cost*:** $55,000

- Consumables
- Additional labour (as with any new system additional roles and responsibilities will be created.)
- Addition process cost (e.g. check hooks after cleaning and before use)

Therefore a Cost benefit calculation could look like this:

Note: The following arbitrary calculations are worked off a company processing 1000 head a day and the use of a HF smart label RFID system

	Example cost
Capital over 4 years (divided by 4)	$34,000
+ Smart label yearly capital	$1,771,200

+ Maintenance per year	$41,550
+ Operational cost	$55,000
Total= Yearly cost	$1,901,750

	Example cost
Labour cost saving	$300,000
+Existing error cost saving	$20,000
+Risk /stock reduction value estimate	$500,000
– Yearly cost	$1,901,750
Total= Yearly return or deficit	-$1,081,750

(Risk insurance example: old system involves recalling whole day of production, new RFID system involves recalling 1 hour of production which saves money. Stock reduction allows for a cost saving in stock on hand.)

The end sum of this equation shows the possible yearly return or deficit (depending on company specific costs) on the RFID system chosen for implementation for carton and pallet tracking from load in to distribution. Once again this equation is only a guide and there maybe other costs that need to be added or subtracted.

The above table and figures aim to give an example of the possible costs associated with implementing a RFID system for carton and pallet tracking from load in to distribution. This is only a guide and company specific information needs to be taken into account.

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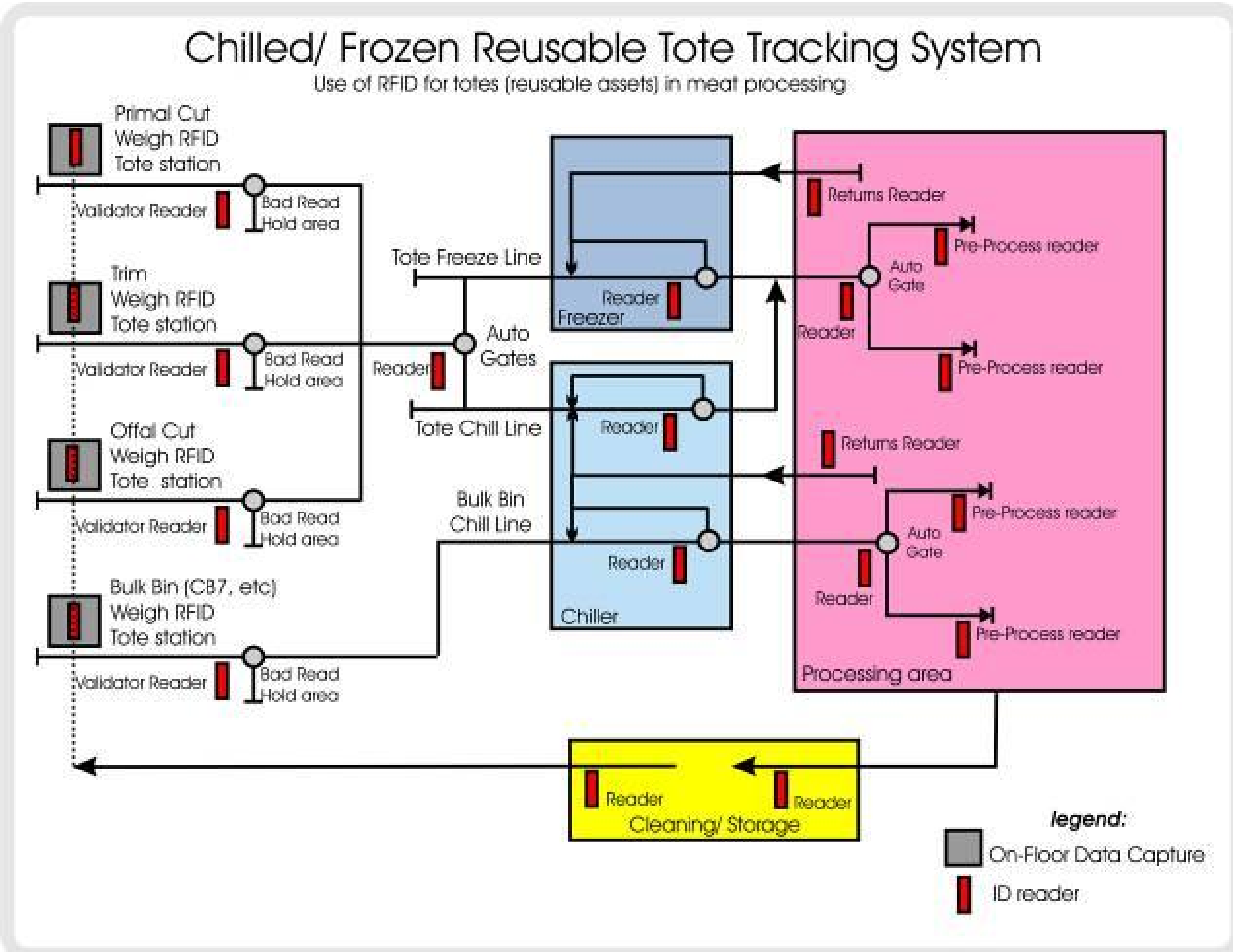
Section 4.4 of 9: Reusable Tote Tracking

Executive Summary

The following diagram and tables are designed to give the reader an overview of where and how many RFID readers might be used for a reusable tote tracking system. Arbitrary costs have been shown to give an idea of possible costs for a RFID system for reusable tote tracking.

Table of Contents: Tote Tracking

1 *Reusable Tote Tracking*



2 *RFID Overview*

Band	LF Low Frequency e.g. AM Radio	DF Dual Frequency	HF High Frequency e.g. FM Radio	UHF Ultra High Frequency e.g. mobile phones	Microwave
Typical RFID Frequencies	125–134 kHz	Transmit 125kHz / Receive 6.8MHz	13.56 MHz	433 MHz or 865 – 956MHz	2.45 GHz
Approximate read range (m=metre)	Less than 0.5m	Up to 1.4m	Up to 1.5m	433 MHz = up to 100m 865-956 MHz = 0.5 to 5m	Up to 10m
Typical data transfer rate (kilobit per Second=kbit/s)	less than 1 (kbit/s)	Up to 125 kbit/s	Approx. 25 kbit/s	433–956 = 30 kbit/s 2.45 =100 kbit/s	Up to 100 kbit/s
Advantages	Little signal loss	Little signal loss similar to HF, possible high read rates, can work in electromagnetic noisy environments,	Small signal loss, good read range in noisy environments, reasonable data rate, anti collision, small size easy to embed e.g. 10mmx 10mm x1.2mm 2nd lowest	Excellent read range in good environment, high data transfer rate, concurrent read of <100 items, smallest tags 1st lowest cost	High read range, high data transfer rate,
Disadvantages	Low data transfer rate, larger size, affected by electromagnetic interference, small read distance, slow read rate, 3rd lowest cost	Size, 4th lowest cost		High signal loss, lower memory than HF, doesn't work well around liquids and metal surroundings.	Very high signal loss, 5th lowest cost
Operating parameters (indicative)	-40°C to 85°C	-25° to + 70°C	-40°C to 85°C	-35°C to 70°C	-50°C to+150°C
Comparative Cost (AUD)	$3.00 to $20.00	$6.00 to $30.00	$1.00 to $3.00	<$1.00	$10.00 to $100.00
Multiple tag read rate	Slower ◄——► Faster				
Ability to read near water or metal	Better ◄——► Worse				
Signal loss due to electromagnetic interference	Worse ◄——► Better				

3 *Readers and Antennas*

Equipment	Advantages	Disadvantages	Operating parameters Indicative (c°)	Comparative Cost (AUD)
Antenna LF HF UHF & Microwave	N/A	N/A	-20° to 70°	10-10,000
Reader LF	Little signal loss	Slow read rate	0° to 55°	$500 -$1000
Reader DF	Able to read/write in LF/HF frequencies,	Cost	0° to 50°	$500 - $3000
Reader HF	Good read distance, can read multiple tags simultaneously		-20° to 60°	$100 - $1000
Reader UHF	Long read distance, can read multiple tags simultaneously, small signal loss		-20° to 60°	$1500 - $3500
Reader Microwave	Large read distance, can read multiple tags simultaneously, focused read areas	Cost, affected by environment	-40º to 80 °	$2000 - $10,000

All costs are Australian dollars and are representative costs only.

4 *Diagram and Table Explanation*

The preceding diagram and tables are designed to give the reader an overview of where and how many RFID readers might be used for a tote tracking system. The exact numbers and placement of readers will vary depending on company procedures and size of operation. Also the RFID system frequency will impact on the number and placement of readers.

As highlighted in the table, in relation to current RFID systems available, the use of either Dual Frequency or High Frequency tags and readers would currently be the optimal choices for implementation with tote tracking. This type of system would allow for the speed of read needed for tote tracking as well as the tags can be embedded in plastic.

Also noted in earlier sect the ability to achieve a high percentage of reliable read rates takes careful planning and implementation to get the system up to standard. This can often be a time consuming process which needs to be taken into account when equating the possible return on investment and its associated timeline.

Finally performance of the system will vary over time as a result of environmental changes. For example a company might decide to alter the metal framework near a reader or a person could stand in between a reader and its tag and affect the data transfer process. Due to the varying nature of possible interference to a RFID system 100% read rates (over time) may never be achieved.

5 *Representative Costs*

The return on investment or cost benefit calculation process needs to be calculated on a case by case basis. For example the type of RFID system used for tote tracking will be different to the one used in the slaughter floor.

There may be considerable labour cost savings obtained by unitizing RFID in the correct commercial application, these savings need to be determined on a cases by case basis.

The following example outlines the types of considerations that need to be accounted for when researching the viability of a RFID system:

Note: The following arbitrary calculations are worked off a company processing 1000 head a day and the use of a HF RFID system.

Example Capital Cost: $139,000

- Tags e.g. 3000 x $2.00= $6,000
- Readers e.g. 22 x $500= $11,000
- Antenna e.g. 22 x $1000= $22,000
- Implementation (e.g. tags, software) cost= $80,000
- Pilot/Performance tests cost=$20,000

Example Maintenance Cost: (30% of capital per year)**:** $41,700

- Reader servicing
- Software changes
- Tag replacement

Example Operational cost: $55,000

- Consumables
- Additional labour (as with any new system additional roles and responsibilities will be created.)
- Addition process cost (e.g. check hooks after cleaning and before use)

Therefore a Cost benefit calculation could look like this:

	Example cost
Capital over 4 years (divided by 4)	$34,750
+ Maintenance per year	$54,255
+ Operational cost	$55,000
Total= Yearly cost	$144,005

	Example (arbitrary) cost
Labour cost saving	$55,000
+Existing error cost saving	$20,000
+Risk/ stock reduction value estimate	$100,000
– Yearly cost	$144,005
Total= Yearly return or deficit	$30,995

(Risk insurance example: old system involves recalling whole day of production, new RFID system involves recalling 1 hour of production. Stock reduction allows for a cost saving in stock on hand.)

The end sum of this equation shows the possible yearly return or deficit (depending on company specific costs) on the RFID system chosen for implementation in tote tracking. Once again this equation is only a guide and there maybe other costs that need to be added or subtracted.

The above table and figures aim to give an example of the possible costs associated with implementing a RFID system for a tote tracking system. This is only a guide and company specific information needs to be taken into account.

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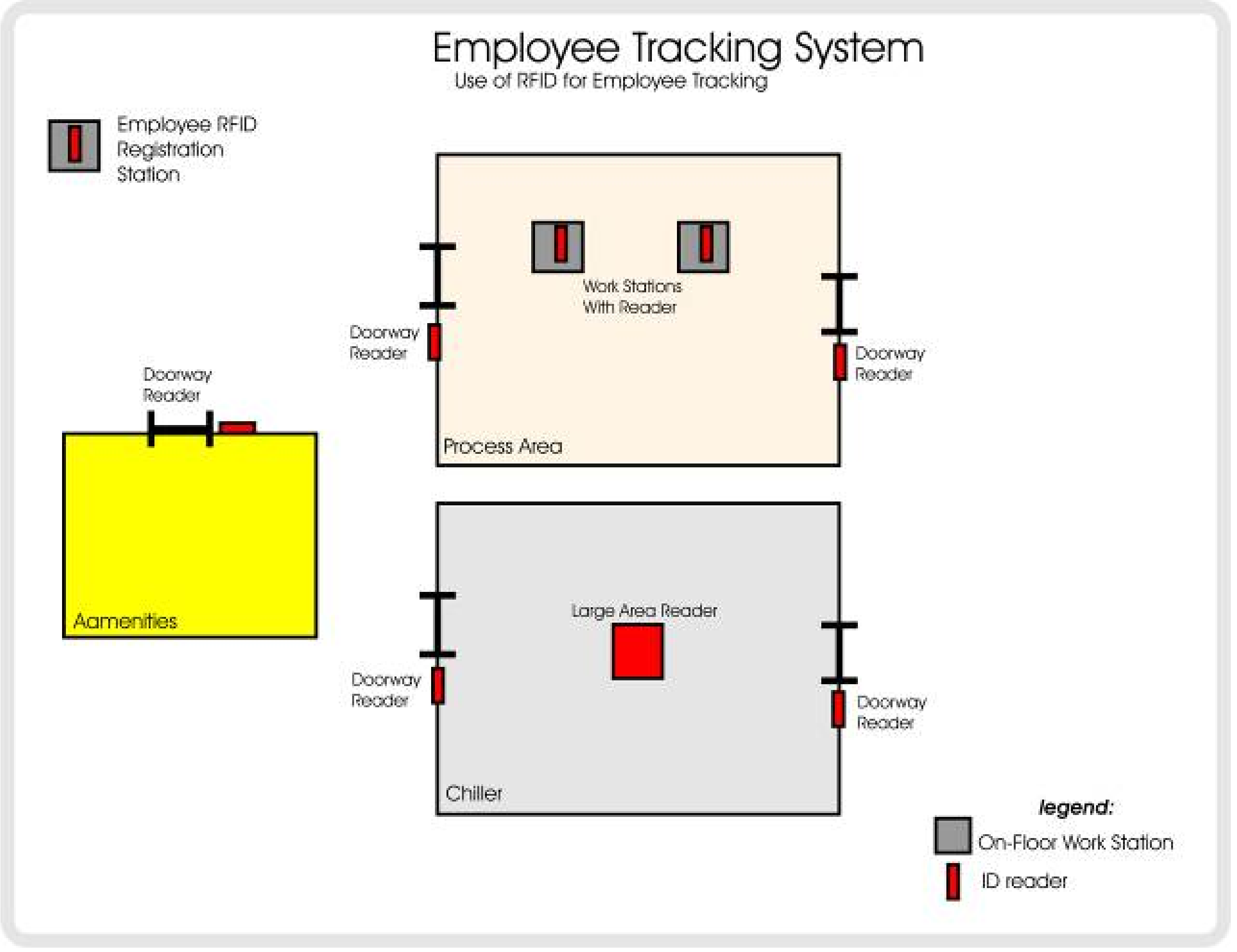
Section 4.5 of 9: Employee Tracking

Executive Summary

The following diagram and tables are designed to give the reader an overview of where and how many RFID readers might be used for an employee tracking system for employee safety and bio-security in food processing. Arbitrary costs have been shown to give an idea of possible costs for a RFID system for employee tracking.

Table of Contents: RFID Explained

1 *Employee Tracking*



2 *RFID Overview*

Band	LF Low Frequency e.g. AM Radio	DF Dual Frequency	HF High Frequency e.g. FM Radio	UHF Ultra High Frequency e.g. mobile phones	Microwave
Typical RFID Frequencies	125–134 kHz	Transmit 125kHz / Receive 6.8MHz	13.56 MHz	433 MHz or 865 – 956MHz	2.45 GHz
Approximate read range (m=metre)	Less than 0.5m	Up to 1.4m	Up to 1.5m	433 MHz = up to 100m 865-956 MHz = 0.5 to 5m	Up to 10m
Typical data transfer rate (kilobit per Second=kbit/s)	less than 1 (kbit/s)	Up to 125 kbit/s	Approx. 25 kbit/s	433–956 = 30 kbit/s 2.45 =100 kbit/s	Up to 100 kbit/s
Advantages	Little signal loss	Little signal loss similar to HF, possible high read rates, can work in electromagnetic noisy environments,	Small signal loss, good read range in noisy environments, reasonable data rate, anti collision, small size easy to embed e.g. 10mmx 10mm x1.2mm 2nd lowest	Excellent read range in good environment, high data transfer rate, concurrent read of <100 items, smallest tags 1st lowest cost	High read range, high data transfer rate,
Disadvantages	Low data transfer rate, larger size, affected by electromagnetic interference, small read distance, slow read rate, 3rd lowest cost	Size, 4th lowest cost		High signal loss, lower memory than HF, doesn't work well around liquids and metal surroundings.	Very high signal loss, 5th lowest cost
Operating parameters (indicative)	-40°C to 85°C	-25° to + 70°C	-40°C to 85°C	-35°C to 70°C	-50°C to+150°C
Comparative Cost (AUD)	$3.00 to $20.00	$6.00 to $30.00	$1.00 to $3.00	<$1.00	$10.00 to $100.00
Multiple tag read rate	Slower ◄——————————► Faster				
Ability to read near water or metal	Better ◄——————————► Worse				
Signal loss due to electromagnetic interference	Worse ◄——————————► Better				

3 *Readers and Antennas*

Equipment	Advantages	Disadvantages	Operating parameters Indicative (c°)	Comparative Cost (AUD)
Antenna LF HF UHF & Microwave	N/A	N/A	-20° to 70°	10-10,000
Reader LF	Little signal loss	Slow read rate	0° to 55°	$500 -$1000
Reader DF	Able to read/write in LF/HF frequencies,	Cost	0° to 50°	$500 - $3000
Reader HF	Good read distance, can read multiple tags simultaneously		-20° to 60°	$100 - $1000
Reader UHF	Long read distance, can read multiple tags simultaneously, small signal loss		-20° to 60°	$1500 - $3500
Reader Microwave	Large read distance, can read multiple tags simultaneously, focused read areas	Cost, affected by environment	-40º to 80 °	$2000 - $10,000

All costs are Australian dollars and are representative costs only.

4 *Diagram and Table Explanation*

The preceding diagram and tables are designed to give the reader an overview of where and how many RFID readers might be used for an employee tracking system. The exact numbers and placement of readers will vary depending on company procedures and size of operation. Also the RFID system frequency will impact on the number and placement of readers.

As highlighted in the tables, in relation to current RFID systems available, the use of either proprietary Dual Frequency or Ultra High Frequency tags and readers would currently be the optimal choice for implementation with employee tracking. If the tags were to be implanted with staff uniforms both Dual Frequency and High Frequency RFIDS would suit the harsh environment (i.e. washing and drying of clothes). While High frequency would allow for door portal readers to be used Ultra High Frequency would allow readers to be placed at a farther distance thus allowing for earlier reads and fewer readers.

As noted in earlier sections the ability to achieve a high percentage of reliable read rates takes careful planning and implementation to get the system up to standard. This can often be a time consuming process which needs to be taken into account when equating the possible return on investment and its associated timeline.

Finally performance of the system will vary over time as a result of environmental changes. For example a company might decide to alter the metal framework near a reader and this has the ability to affect the data transfer process. Due to the varying nature of possible interference to a RFID system 100% read rates (over time) may never be achieved.

5 *Representative Costs*

The return on investment or cost benefit calculation process needs to be calculated on a case by case basis. For example the type of RFID system used for employee tracking will be different to the one used in the other applications.

There may be considerable labour cost savings obtained by unitizing RFID in the correct commercial application, these savings need to be determined on a cases by case basis. For the purpose of this cost example a value of $0 labour cost saving has been applied.

The following example outlines the types of considerations that need to be accounted for when researching the viability of a RFID system:

Note: The following arbitrary calculations are worked off the use of a UHF RFID system for a company processing 1000 head a day and the associated staff needed to run the plant.

Example Capital Cost: $131,680

- Tags e.g. 300 x $0.60= $180
- Readers e.g. 9 x $2500= $22,500
- Antenna e.g. 9 x $1000= $9,000
- Implementation (e.g. tags, software) cost= $80,000
- Pilot/Performance tests cost=$20,000

(Readers and antennas are dived by 4 due to their expected live span of 4 years)

Example Maintenance Cost: (30% of capital per year)**:** $39,504

- Reader servicing
- Software changes
- Tag replacement

Example Operational cost: $55,000

- Consumables
- Additional labour (as with any new system additional roles and responsibilities will be created.)
- Addition process cost

Therefore a Cost benefit calculation could look like this:

	Example (arbitrary) cost
Capital over 4 years (divided by 4)	$32,920
+ Maintenance per year	$39,504
+ Operational cost	$55,000
Total= Yearly cost	$127,424

	Example (arbitrary) cost
Labour cost saving	$0
+Existing error cost saving	$20,000
+Risk value estimate	$100,000
– Yearly cost	$127,424
Total= Yearly return or deficit	-$7,424

(Risk value relates to lower incident costs due to better personnel management).

The end sum of this equation shows the possible yearly return or deficit (depending on company specific costs) on the RFID system chosen for implementation of employee tracking. Once again this equation is only a guide and there maybe other costs that need to be added or subtracted.

The above table and figures aim to give an example of the possible costs associated with implementing a RFID system for employee tracking. This is only a guide and company specific information needs to be taken into account.

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Section 5.4 Performance and Test Protocols for Reusable Tote Tracking

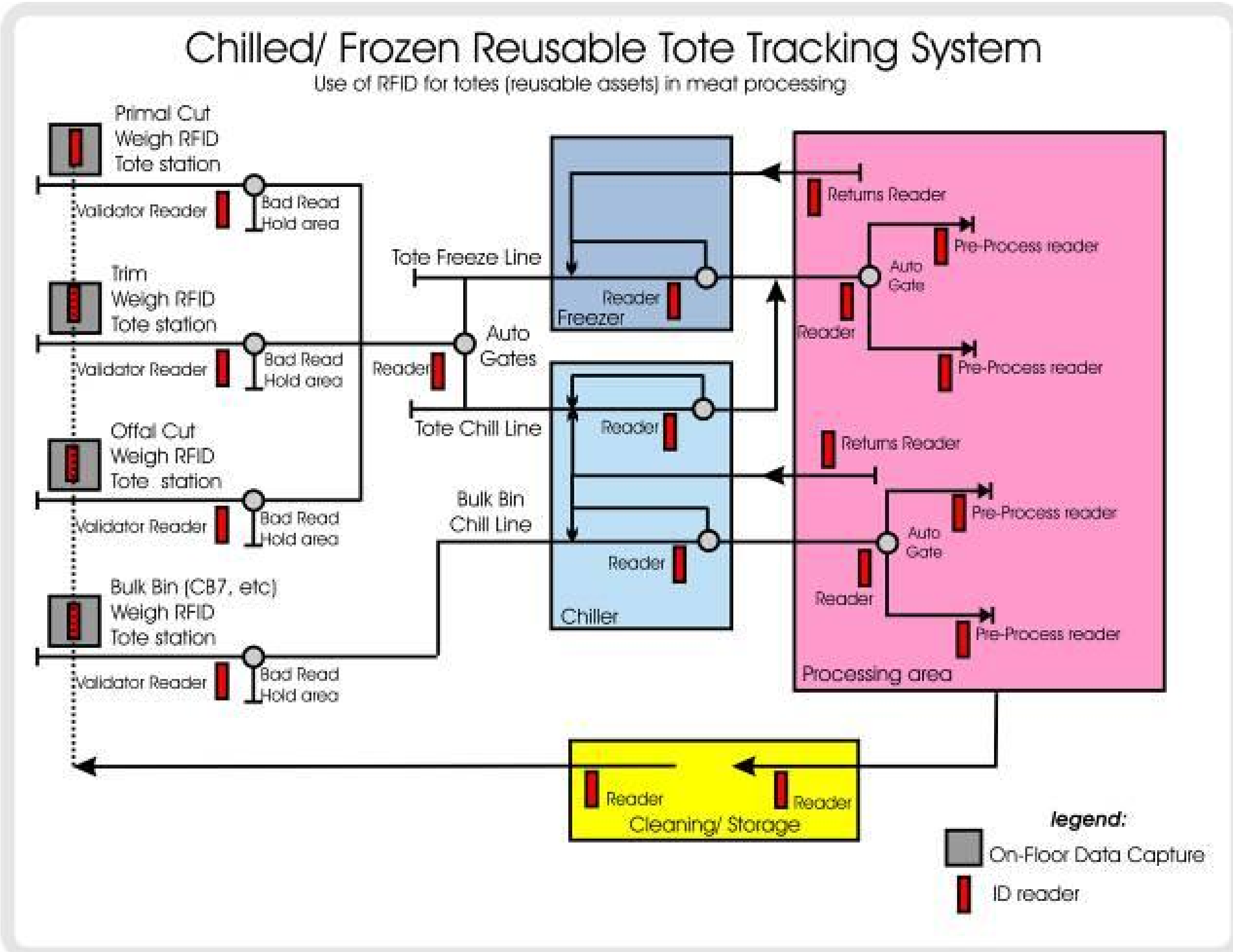
Executive Summary

This document defines the basic performance requirements for specific RFID tags, readers and integration software for the environments and use factors for specific operational functions. The document also outlines a general testing protocol useful for comparing the operational performance of different RFID tags, readers and integration software in a representative environment to approximate specific operational functions.

This set of RFID performance and test protocols has been prepared for the operational function or functions of reusable tote tracking.

Table of Contents: Tote Tracking

1 *Reusable Tote Tracking*



2 *Use and Environment*

Reusable totes are often used for holding offal, primal cuts, trim and related products after collection and before additional processing and/ or packaging. The totes are a reusable asset and require tracking through the various operational processes.

2.1 *Operating Environment*

The operational environments for the tags and reader/ antenna assemblies are very harsh. Tags and reader/ antenna assemblies will be subject to extremes of environments.

These include:

- Temperature Range: Minus 30°C to plus 40°C
- Humidity Range: 0% to 100% condensing wash down
- Mechanical (Drop, knock, Force , etc) 5G force
- Electrical high levels of static discharge from conveyors, etc.
- Electro Magnetic Interference(RF noise) high levels of static discharge from conveyors, etc.
- Ionising radiation (eg X-ray and similar systems.) for Metal Detectors

2.2 *Cleaning/ Transport/ Storage Environment:*

- Temperature Range:
  - o tags (on totes) Minus 30°C to plus 90°C
  - o Reader Minus 30°C to plus 50°C
- Humidity Range: 0% to 100% condensing wash down
- Mechanical (Drop, knock, Force , etc) 5G force
- Electrical high levels of static discharge from conveyors, etc.
- Electro Magnetic Interference (RF noise) high

2.3 *Representative Tag/labels Volumes, Tag Application, Writer/ Reader Infrastructure:*

2.3.1 Tag/ label Volumes

For a 1000 head a day beef slaughter facility there would in the order 1000 and 5000 totes in use on site. This is dependent on the use of the totes. This use may range from just offal collection before packing through to all primal cuts and trim before further processing and packing.

On an annual basis there is approximately 2 to 5 percent replacement due to wear and/ or damage.

2.3.2 Tag Readers

The number of readers in use range widely (such as from 5 to 20 readers) depending on a number of factors, including:

- Complexity for site,
- Tote use eg offal, primal cuts, trim and value added product,
- Conveyor/ chiller layout,
- Number of auto gating systems used.

The RFID tags would need to be affixed either permanently (as part of the tote moulding or added after moulding) to the tote or as a temporary attachment. An example of temporary attachment is when a disposable smart label is applied at time of use.

Readers would need to be placed a key locations such as:

- Pre-use tote check.
- Tote filling station where the RFID is read and recorded against the product
- Post filling checking reader,
- Conveyor sorting gates,
- Chiller auto gate areas.
- Processing area and return conveyors
- Cleaning facilities both before cleaning and post cleaning to detect tag failures.
- Other areas as identified on a site by site basis.

The reader location would be in or adjacent to conveyors and work areas. This is normally an area of high electrical noise, electro magnetic noise and mechanical forces that affect the readers. There is also the likelihood of cleaning of the reader by high pressure hot water/ detergent mix. Water ingress is highly likely and often occurs to apparently sealed electronic enclosures located in processing, cleaning and associated areas.

The integration software requirements will vary greatly depending of the level of integration required with existing slaughter floor (for offal)/ carcase boning (for primal cuts and trim)/ chiller management/ further processing and carton packing systems.

Integration time frames vary greatly. Typical times can vary from a few months to over a year.

System hardware (tags and readers) and software annual maintenance costs for these types of systems in these environments are often in the order of 20% to 30% of the capital purchase costs.

3 *Performance Requirements*

The minimum performance requirements will vary from organisation to organisation and will depend on the operational and financial costs of errors or failures. This section of the document outlines typical areas of performance and typical performance requirements. Specific system requirements will vary from organisation to organisation. Use the operational performance requirements in the document as a guide only.

3.1 *Typical RFID System Operational Performance Requirement*

Operational performance requirements can be divided into the following sections:

- Tag/ label:
    - Reading range under operational conditions.
    - Reading rate/ speed under operational conditions.
    - Reading error rates under operational conditions (misreads).
    - Failure rate of RFID function under operational conditions.
    - Failure rate of tag attachment/ mechanical damage under operational conditions.
- Reader/ antenna
    - Reading range under operational conditions.
    - Reading rate/ speed under operational conditions.
    - Reading error rates under operational conditions (misreads).
    - Reading error rates multi-tag conditions – 10 tags in read field
    - Failure rate of RFID function under operational conditions.
    - Failure rate of mechanical damage/ water ingress under operational conditions.
- Middleware – based on 22 readers with 1000 tags per minute across the 22 readers
    - Reader/ middleware data processing/pass through rate under operational conditions.
    - Reader/ middleware data processing/pass through error rate under operational conditions.
    - Reader/ middleware uptime percentage.
- Production/ Operational System integration – based on 22 readers with 1000 tags per minute across the 22 readers
    - Middleware data pass through to production/ operational system rate under operational conditions.
    - Middleware data pass through to production/ operational system error rate under operational conditions.
    - Production/ operational system interface with middleware uptime percentage.

3.2 *Typical Performance Requirements Table*

		Minimum Acceptable	Average	Optimal
Tag/label				
	Reading range direction	100mm	250mm	400mm
	Reading rate	2 per second	5 per second	10 per second
	Reading speed	200mm per second	400mm per second	1000mm per second
	Reading error rates (misreads)	10 per 10,000	5 per 10,000	<1 per 10,000
	Failure rate of RFID function	<100 per 10,000 per year	<20 per 10,000 per year	<10 per 10,000 per year
	Failure rate mechanical attachment	<200 per 10,000 per year	<10 per 10,000 per year	<50 per 10,000 per year
Reader/ Antenna				
	Reading Range	100mm	250mm	400mm
	Reading rate	2 per second	5 per second	10 per second
	Reading speed	200mm per second	400mm per second	1000mm per second
	Reading error (misreads).	2 per 10,000	1 per 10,000	<1 per 10,000
	Reading error multi-tag 10 tags in field	100 per 10,000	25 per 10,000	<10 per 10,000
	Failure rate of RFID read function per unit	24 hours per year	1 hour per year	< 1 hour per year
	Failure rate of mechanical damage/ water ingress	24 hours per year	1 hour per year	< 1 hour per year
Middleware	based on 22 readers with 1000 tags per minute across the 22 readers			
	Data processing/pass through rate	1000 tags per minute	2200 tags per minute	>2200 tags per minute
	Data processing/pass through error rate	1 per 10,000	0.5 per 10,000	<0.1 per 10,000
	Uptime percentage	99.5%	99.9%	>99.9%
Production/ Operational System integration				
	Data pass through rate	1000 tags per minute	2200 tags per minute	>2200 tags per minute
	Data pass through error rate	1 per 10,000	0.5 per 10,000	<0.1 per 10,000
	Uptime percentage	99.8%	99.99%	>99.99%

4 *RFID System Test Protocol*

The decision making process for selection of the appropriate RFID technology and specific vendor should be based on repeatable and measurable system performance. A Reliable method to determine the system performance is to prepare and follow a system test protocol. The protocol must reflex the operational and performance requirements of the organisation as well as be statistically valid for the organisations operational volumes. Use this system test protocol document as the guide only in the preparation of an organisationally specific system test protocol.

Often what appear to be a suitable technology and/ or system vendor, fail when fully implemented due to lack of operational testing and proving of the required performance levels.

4.1 *Typical RFID System Test Protocol Areas*

A RFID system test protocol should include the follow areas:

- Tag/ label:
    - Typical operational volume.
    - Number of tags/ label to test to statistically represent the operational volumes
    - Length of time for the testing to statistically represent the operational environment
    - Reading range under operational conditions.
    - Reading rate/ speed under operational conditions.
    - Reading errors rates under operational conditions (misreads).
    - Failure rate of RFID function under operational conditions.
    - Failure rate of tag attachment/ mechanical damage under operational conditions.
- Reader/ antenna
    - Typical operational number of readers required.
    - Number of reader/antenna assembles to test to statistically represent the operational volumes and environments.
    - Location of reader/antenna assembles to test to statistically represent the operational location environments.
    - Length of time for the testing to statistically represent the operational environment
    - Reading range under operational conditions.
    - Reading rate/ speed under operational conditions.
    - Reading error rates under operational conditions (misreads).
    - Reading error rates multi-tag conditions – 10 tags in read field
    - Failure rate of RFID function under operational conditions.
    - Failure rate of mechanical damage/ water ingress under operational conditions.
- Middleware volume and speed performance models to statistically represent the operational volumes, work environment and existing system infrastructure.
    - Reader/ middleware data processing/pass through rate under operational conditions.
    - Reader/ middleware data processing/pass through error rate under operational conditions.
    - Reader/ middleware uptime percentage.

- Production/ Operational System integration volume and speed performance models to statistically represent the operational volumes, work environment and existing system infrastructure.
    - Middleware data pass through to production/ operational system rate under operational conditions.
    - Middleware data pass through to production/ operational system error rate under operational conditions.
    - Production/ operational system interface with middleware uptime percentage.

4.2 *Typical RFID System Test Protocol Table*

		Minimum Acceptable	Average	Optimal
Tag/label				
	Typical operational volume		4000	
	Number of tags/ label to test		400 (10% of operational)	
	Length of time for the testing		3 months	
	Reading range direction	100mm	250mm	400mm
	Reading rate	2 per second	5 per second	10 per second
	Reading speed	200mm per second	400mm per second	1000mm per second
	Reading Error rates (misreads)	10 per 10,000	5 per 10,000	<1 per 10,000
	Failure rate of RFID function	<100 per 10,000 per year	<20 per 10,000 per year	<10 per 10,000 per year
	Failure rate mechanical attachment	<200 per 10,000 per year	<10 per 10,000 per year	<50 per 10,000 per year
Reader/ Antenna				
	Typical operational number of readers		20	
	Number of reader/antenna assembles to test		4 or more (must be placed in each operational environment)	
	Length of time for the testing		3 months	
	Reading Range	100mm	250mm	400mm
	Reading rate	2 per second	5 per second	10 per second
	Reading speed	200mm per second	400mm per second	1000mm per second
	Reading errors (misreads).	2 per 10,000	1 per 10,000	<1 per 10,000
	Reading error multi-tag 10 tags in field	100 per 10,000	25 per 10,000	<10 per 10,000
	Failure rate of RFID read function per unit	24 hours per year	1 hour per year	< 1 hour per year

	Failure rate of mechanical damage/ water ingress	24 hours per year	1 hour per year	< 1 hour per year
Middleware	based on number of operational readers with 1000 tags per minutes			
	Data processing/pass through rate	1000 tags per minute	2200 tags per minute	>2200 tags per minute
	Data processing/pass through error rate	1 per 10,000	0.5 per 10,000	<0.1 per 10,000
	Uptime percentage	99.5%	99.9%	>99.9%
Production/ Operational System integration				
	Data pass through rate	1000 tags per minute	2200 tags per minute	>2200 tags per minute
	Data pass through error rate	1 per 10,000	0.5 per 10,000	<0.1 per 10,000
	Uptime percentage	99.8%	99.99%	>99.99%

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Section 6 of 9: Future Directions

Executive Summary

RFID technology in the right area and for the right reasons can result in a company gaining a significant return on investment. It has been highlighted that as with any emerging technology RFID is not a fix all or a “plug and play” technology. In this section future direction for the investigation of RFID and its possible implementation throughout the processing supply chain is explained.

Table of Contents: RFID Explained

IMPORTANT NOTICE

1 *Research to date*

RFID technology in the right area and for the right reasons can result in a company gaining a significant return on investment. It was highlighted that as with any emerging technology RFID is not a fix all or a "plug and play" technology.

Business processes must be sound and logical for the adoption of RFID technology to provide any operational improvement. Implementation of a RFID technology by it self won't correct bad operational activities or practices. The right technology must be implemented for the right reasons in the correct manner for a defined stated outcome. The implementation of the wrong technology or for the wrong reasons can actually have a negative impact on the organisation. Therefore future independent research needs to be based on analytical quantifiable empirical methods. To date there is minimal empirical research that can stand alone as being non biased and fair in independent evaluation of RFID and its capabilities. Most of the case studies and news articles are vendor or non-independent based. True independent research or case study analysis will be difficult to conduct as gaining access to processing plants or recreating a processing environment for research purposes is extremely difficult. This complexity can be seen by the fact that each processing plant has its own unique environment and associated standard operating procedures.

To overcome this, consultations need to be held between processors, RFID vendors/ implementers and researchers to try and work out where and when applicable independent research can be carried out. This needs to take place so that the Australian Red Meat Industry can continue to maintain its position as an international leader of quality products. Without published independent research and independent pilot project analysis companies will continue to invest in RFID systems based on information from vendors. Often when this occurs the vendor blames any issues or problems on lack of information being provided or changing circumstances related to the purchaser. This being said, individual companies still need to conduct their own in house investigation to look at:

- whether they can solve a problem by altering current procedures
- other possible technologies
- or whether RFID will actually improve or exasperate a problem.

2 *Conclusions and Recommendations*

1. Highlighted current possible RFID application points include hooks, cartons, pallet labels, employees, cutting boards, primal bags, totes and assets e.g. plant equipment.

2. To date 100% read rates with RFID have been difficult to achieve or if achieved difficult to maintain. Some application may require less than 100% read rates. Some applications may only be successful if 100% read rates are achieved 100% of the time.

3. Environmental variables found in the meat industry, in which RFID systems will be required to work have a major impact on whether a system will deliver the required results.

4. Empirical research into what type of specific technology is best suited for each stage of processing needs to be conducted e.g. slaughter, chilling, boning, packaging, people, distribution and stock control of consumables such as cartons.

5. Industry wide investigation into implementation of smart labels is required to determine the possible return on investment for both a company level and whole supply chain level.

6. If RFID smart labels are shown to be of value, the industry needs to publish the related results. Then through industry consultation an action plan needs to be developed that would clear the way for the use of Electronic Product Code compliant smart labels across the industry. This would allow for track forward and track back on an industry wide scale.

7. RFID technology should be empirically compared so that companies can decide which vendor's technologies best suit their applications.

8. Continue to review and develop test/performance protocols suitable for the meat industry and publish the related findings.

9. MLA needs to publish all relevant empirical studies and allow them to be accessible to all interested parties. This will allow for feedback from a variety of interested parties and therefore help shape future research.

10. Publish MLA recommendations associated with RFID, to all companies along the processing supply chain.

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Section 7 of 9: Glossary

FURTHER INFORMATION

The internet has a wide range of both subscription and free articles relating to RFID technology. A number of Vendors also have a large amount of information pertaining to their RFID products on the internet. As with any public or private forum care needs to be taken when reviewing such information. Throughout this project it has become obvious that the level of information published onto the internet in relation to RFID is to date highly biased and flawed. It tends to focus on highlighting the positives associated with RFID and is limited in elaborating on the possible negatives. There are however a number of specialised journals and institutions that can provide valuable and realistic information:

- RFIDAA
- Auto-ID Laboratory (Adelaide)
- GS1 Australia
- EPCglobal
- CSIRO
- RFID Journal (www.rfidjournal.com)

(Note: This Glossary has been prepared from common use terms. Some terms and definitions will vary between sources.)

Glossary

Active Tag – An RFID tag that uses a battery to power its microchip and communicate with a reader. Active tags can transmit over the greatest distances (100+ feet). Typically they can cost $20.00 or more and are used to track high value goods like vehicles and large containers of merchandise.

Agile Reader – A reader that can read different types of RFID tags – either made by different manufacturers or operating on different frequencies.

Antenna – A device for sending or receiving electromagnetic waves.

Anti-Collision – A feature of RFID systems that enables a batch of tags to be read in one reader field by preventing the radio waves from interfering with one another. It also prevents individual tags from being read more than once.

Automatic Identification Data Capture (AIDC) – Methods of collecting data and entering it directly into a computer system without human intervention. Automatic Identification (Auto-ID) Refers to any technologies for capturing and processing data into a computer system without using a keyboard. Includes bar coding, RFID and voice recognition.

Auto-ID Centre – A group of potential RFID end users, technology companies and academia. The Auto-ID Center began at the Massachusetts Institute of Technology (MIT) and is now a global entity. It is focused on driving the commercialisation of ultra-low cost RFID solutions that use Internet like infrastructure for tracking goods throughout the global supply chain. The Auto-ID Center organisation ceased to exist in Nov 2003, and its IP was licensed to EPCglobal Inc, a joint venture of GS1 Inc, and GS1 US. The research at the Auto-ID Center now takes place at the Auto-ID Labs

Back-scatter - A method of communication between passive tags and readers. A radio frequency field sent out by the RFID reader 'excites' the antenna of the RFID tag, causing radio waves to scatter back to the reader. The reflected signal is 'modulated' to transmit data.

Barcode - A printed pattern of parallel lines or bars containing encoded information.

Bit – The smallest unit of digital information - A binary code – a single ‘0’ or ‘1’, where many different codes can be developed to represent pertinent information. A 96-bit EPC is a string of 96 bits containing zeros and ones.

Byte – 1 byte = 8 bits. One byte of memory is needed to generate an alpha character or digit.

Chip Based RFID – Refers to RFID tags that contain a silicon computer chip and therefore can store information and transmit it to a reader.

Collision – Radio Signals interfering with one another. Signals from tags and readers can collide.

Die – A tiny square of silicon with an integrated circuit etched on it – more commonly known as a silicon chip.

Electronic Article Surveillance Tags (EAS) – Single bit (either ‘on’ or ‘off’) electronic tags used to detect items for anti-theft purposes.

Electromagnetic Compatibility (EMC) – The ability of a technology or product to coexist in an environment with other electro-magnetic devices.

Electromagnetic Interference (EMI) – Any electromagnetic disturbance that interrupts, obstructs, or otherwise degrades or limits the effective transmission or reception of communication signals.

Electronic Product Code (EPC) – A standard format for a 96-bit code that was developed by the Auto-ID Center, and refined by EPCglobal. It is designed to enable identification of products down to the unique item level. EPC’s have memory allocated for the product manufacturer, product category and the individual item. The benefit of EPC’s over traditional bar codes is their ability to be read without line of sight and their ability to track down to the individual item versus at the SKU level.

EPCglobal –EPCglobal is a joint venture of GS1 Inc and GS1 US, formed to develop standards based on RFID technology, initially for the retail supply chain, but is being extended to other industries.

Frequency – Refers to a band of operation for radio-based technologies. Frequencies allocated for RFID use exist in the low, high, ultra-high and microwave frequency bands. Each frequency has its own advantages and disadvantages such as read distance, tag size and resistance to electronmagnetic noise.

GTAG (Global Tag) – A standardization initiative of the Uniform Code Council (UCC) and the European Article Numbering Association (EAN) for supply chain tracking applications using UHF RFID frequencies.

Global Trade Item Number (GTIN) – A superset of bar code standards that is used internationally. In addition to manufacturer and product category, GTIN can also include weight and other information.

Gen 2 – The second generation global protocol operating in the UHF (ultra high frequency) range. The current choice for many retail supply chain carton and pallet compliance applications.

***GS1* Australia –** GS1 is a leading global organisation dedicated to the design and implementation of global standards and solutions to improve the efficiency and visibility of supply and demand chains globally and across sectors. The GS1 System has four key product areas: Barcodes (used to automatically identify things), eCom (electronic business messaging allowing automatic electronic transmission of data), GDSN (Global Data Synchronisation Network which allows partners to have consistent item data in their systems at the same time) and EPCglobal (which uses RFID technology to immediately track an item). The GS1 system of standards is the most widely used supply chain standards system in the world..

High-Frequency RFID (13.56 MHz) – RFID that uses the high-end 13.56 MHz radio frequency band. Features medium sized tags with relatively good reading distances. In the U.S. 13.56 MHz tags can be typically read at approximately 3-4 inches with a handheld reader and 4 to 6 feet with a portal reader.

Integrated Circuit (IC) – Another name for a chip or microchip.

Interrogator – An RFID reader.

ISO - The International Organization for Standardization, based in Switzerland. ISO is involved in standards development for RFID.

Line-of-Sight – Is a technology that requires an item to be "seen" to be automatically identified by a machine. Unlike bar codes and OCR technologies, RFID tags can be read "through" merchandise and most packaging with no line of sight required.

Low Frequency RFID (125 & 134 KHz) – Low frequency radio band allocated for RFID use. The main disadvantage of low frequency RFID is its cost and relatively slow data transfer as well as its inability to read many tags at the same time.

Multiple Tag Read/Write – Refers to the ability of RFID systems to read multiple tags at the same time. Reading and writing of multiple tags is achieved through the anti-collision feature of RFID.

Microwave RFID Frequency (2,450 MHz or 2.45 GHz) – A microwave frequency band allocated for RFID use. Used for Item level tracking including retail merchandise. This frequency also offers fast data transmission, but is somewhat more bothered by shielding of liquid products and reflections from metal structures, etc.

Misread - A condition that exists when the data presented by the reader is different from the corresponding data in the tag.

NLIS - The National Livestock Identification System, an Australian RFID system used to track the movements of cattle.

Orientation - Alignment of the tag with respect to the scanner, measured in pitch, roll, and yaw.

Orientation Sensitivity - The degree range is decreased by non-optimal orientation.

Passive RFID Tag – An RFID tag that does not use a battery. Passive tags draw their power from the reader. The reader transmits a low power radio signal through its antenna. The tag in turn receives it through its own antenna to power the integrated circuit (chip). Using the energy it gets from the signal, the tag will briefly converse with the reader for verification and the exchange of data. As a result, passive tags can transmit information over shorter distances (typically 10 feet or less) than active tags. They are considerably lower in cost ($.50 or less) making them ideal for tracking lower cost items.

Projected Life -This is defined in terms of number of read and/or write cycles, or in active tags this may include shelf life.

Radio Frequency Identification (RFID) – A method of identifying items uniquely using radio waves. Radio waves do not require line of site and can pass through materials like cardboard and plastic but not metals and some liquids.

Radio Frequency (RF) Field - An RF field is a physical area in which radio waves are emitted, and can be usefully used. An RFID tag outside an RF field created by a reader is out of range and cannot be read.

Range - The distance at which successful reading and/or writing can be accomplished.

RFIDAA - The RFID Association of Australia, a body representing interests relating to RFID technologies, standards and best practices in Australia.

Read Range – The distance from which a reader can communicate with a tag. Several factors including frequency used, orientation of the tag, power of the reader and design of the antenna affect range.

Read Rate

The maximum rate at which data can be read from a tag expressed in bits or bytes per second.

Reader – Also called an interrogator. The RFID reader communicates via radio waves with the RFID tag and passes information in digital form to the middleware. Readers can be configured with antennas in many formats including handheld devices, portals or conveyor mounted.

Read Only Tags – Tags that contain data that cannot be changed. Read only chips are less expensive than read-write chips.

Read-Write Tags – RFID chips that can be read and written multiple times. Read/Write tags can accept data at various points along the distribution cycle. This may include transaction data at the retail point of sale. They are typically more expensive than read only tags but offer more flexibility.

RFID Transponder – Another name for a RFID tag. Typically refers to a microchip that is attached to an antenna, which communicates with a reader via radio waves. RFID tags contain serial numbers that are permanently encoded, and which allow them to be uniquely identified.
RFID tags vary widely in design. They may operate at one of several frequency bands, may be active or passive and may be read-only or read-write.

Savant – Distributed network software that manages and moves data related to Electronic Product Codes (EPC).

Semi-active Tag - A semi-active RFID tag employs ‘back-scatter’ to communicate with a reader, much like a passive tag, but also incorporates an independent power source to run its integrated circuit. This means its integrated circuit can be ‘live’ even when the tag is not in an RF field. Such uses may be to support and extended read range, or to support an on-board temperature sensor, so that when in the field of a reader, the temperature log can be downloaded

Smart Label – A label that contains an RFID chip and antenna and human readable text. These labels can store information such as a unique serial number and communicate with a reader.

Tag – The generic term for a radio frequency identification device. Also sometimes referred to as smart labels.

Tag Collision – Interference caused when more than one RFID tag sends back signals to the reader at the same time.

Transponder – A combination transmitter-receiver that is activated when it receives a predetermined signal. RFID tags are sometimes referred to as transponders.

Ultra-High Frequency (UHF; 850 to 950 MHz) – Ultra-high frequency radio band allocated for RFID use. UHF RFID can send information faster and farther than high and low frequency tags. UHF RFID is gaining industry support as the choice bandwidth for inventory tracking applications including pallets and cases.

"WORM" Chip (Write Once Read Many) – It can be written once and then becomes "Read Only" afterwards.

Write

The transfer of data to a tag, the tags internal operation of storing the data and it may include reading the data in order to verify the operation.

Write Rate

The rate at which information is transferred to a tag, written into the tag's memory and verified as being correct. It is quantified as the average number of bits or bytes per second in which the complete transaction can be performed.

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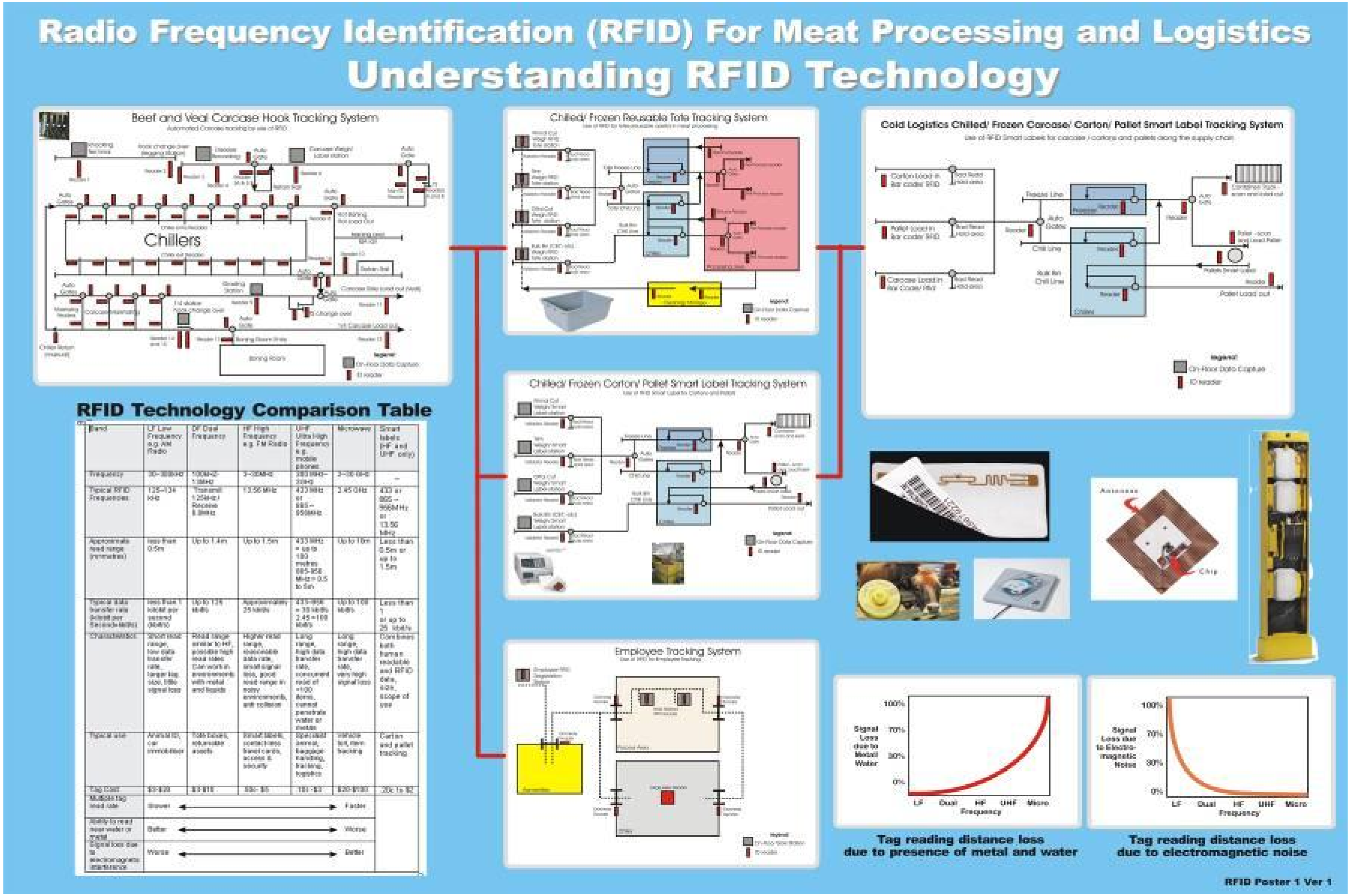
Appendix A



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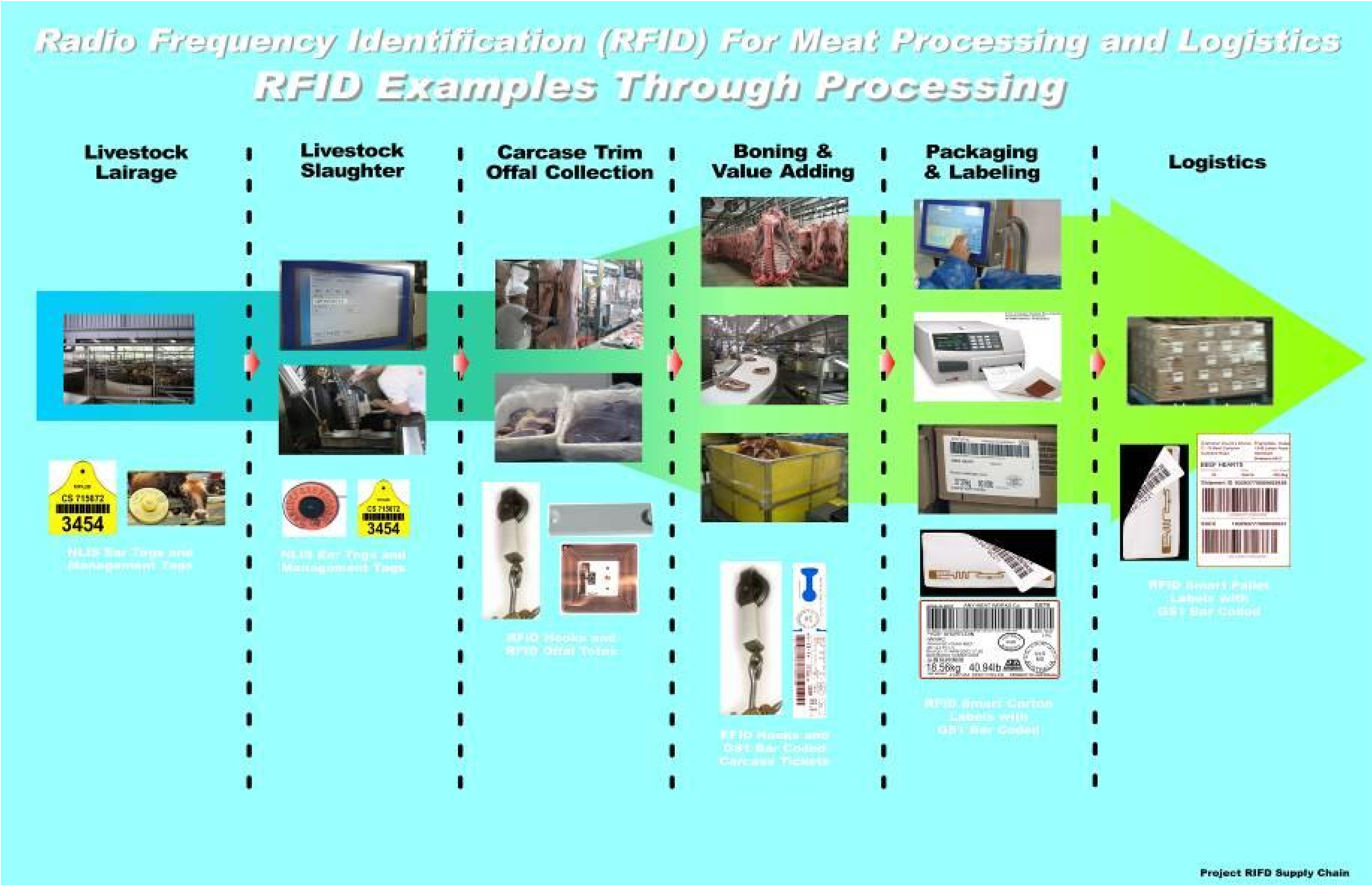
Appendix B


Radio Frequency Identification (RFID) For Meat Processing and Logistics
RFID Examples Through Processing
Livestock Lairage
Livestock Slaughter
Carcase Trim Offal Collection
Boning & Value Adding
Packaging & Labeling
Logistics
NLIS Ear Tags and Management Tags
NLIS Ear Tags and Management Tags
RFID Hooks and RFID Offal Totes
RFID Hooks and GS1 Bar Coded Carcass Tickets
RFID Smart Carton Labels with GS1 Bar Coded
RFID Smart Pallet Labels with GS1 Bar Coded
Project RIFD Supply Chain