final report

Project code: B.SCT.005

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Date published: June 2007

ISBN: 9781741917567

PUBLISHED BY
Meat & Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Linking Live Sheep and Carcass Data via RFID

Traditional (Nori-Inverted) Chain

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Abstract

This project was undertaken to develop, test and report a system to monitor and track individual carcasses in an abattoir from slaughter to the weigh station using radio frequency identification (RFID) technology.

Existing abattoir carcass skids were fitted with high frequency RFID transponders. The sheep's electronic identification (EID) ear tag was read and associated to the skid RFID.

Weight and grade information was then associated to the individual sheep.

Suitable RFID technologies were investigated and it was found that high frequency (HF) was the most appropriate frequency to use for tracking the skids in the abattoir as it did not interfere with the low frequency (LF) EID ear tags used in the sheep.

Trace-back and automatic matching of individual animals and their kill data is now possible on a traditional non-inverted chain.

Executive Summary

Radio frequency identification (RFID) technology provides the opportunity to accurately track and monitor individual sheep from farm to abattoir. The ability to monitor individual animal performance provides opportunities to identify groups of animals that have similar traits and then apply better management strategies to deal with those similarities. Historically abattoir feedback has provided information on lines of sheep. The ability to gain carcass feedback on individual animals from the abattoirs would add value to the changing on-farm management regimes. The potential threat from exotic disease outbreaks has also increased the importance of being able to trace individual animals from farm to abattoir. This project was undertaken due to the fact there was no tracking system available for a sheep abattoir.

This project was able to demonstrate that a sheep electronic identification (EID) could be captured within an abattoir environment and associated to a skid and gambrel radio frequency identification (RFID). This in turn links the individual sheep EID with its carcass information. Associated software systems were developed to record the RFID information, track the carcass to the weigh scales and record weight and fat for each carcass.

The system was developed on a non-inverted chain at Hillside Abattoir in Narrogin, Western Australia. It was tested with the assistance of three Q lamb producers supplying lambs fitted with EID ear tags, to Hillside Abattoir. The EIDs of these lambs were successfully assigned to an RFID embedded skid and gambrel and the data was automatically captured at the weight and grade station and recorded in a Microsoft Excel spreadsheet. The key components of the system are described below.

Recommended components:

- Skid RFID: 16mmØ Sokymat 161 13.56MHz Logi-Tag laundry transponders
- Gambrel/skids - transponders injection moulded into existing plastic abattoir skids by SCL
- FEIG MR101A 13.56MHz reader controller
- Electrocom / SCL Harsh environment 120mm wide antenna
- Sheep EID Reader: Allflex 134.2 kHz FDX-B and HDX with 3 amp 12 volt DC power supply
- Sheep EID Antenna: Direct contact modified Allflex flexi-reader encased in food grade HDPE
- Sheep EID Pre-read blocker: Controller & 2 x trippers

The principals of the tracking system can be adapted to most small animal abattoirs and is ready for immediate implementation.

The supply chain from producer to processor stand to benefit from the traceability the system now provides. Improvements in the feedback opportunities should add value to all these sectors also.

Contents

1 Background

1.1 Introduction

1.1.1 Australian Sheep CRC Project 2.3.2

In 2003, Australian Sheep CRC Project 2.3.2 (Opportunities for use of individual animal identification in sheep meat production) began investigations into the use of electronic identification (EID) in prime lamb production systems. In collaboration with six Q Lamb producers, the performance of feedlot lambs were monitored on farm and this data was linked to carcase data at slaughter at Hillside Meats Abattoir, Narrogin W.A. Initially a manual tracking system was used to link the sheep EID with the carcass. This was followed by the development of a portable radio identification (RFID) system using a Symbol Pocket PC and an Allflex blue tooth stick reader.

Whilst this portable system worked well it was recognised that an automatic system could provide further benefits to the producer and processor. Hillside Meats abattoir owner, Peter Trefort was interested in being able to track individual lambs or hoggets through the abattoir and link live animal performance to carcass performance. No commercial system existed to do this. In consultation with Stephen Harvey of Manutech Pty Ltd a draft project description was developed (Harvey 2004).

1.1.2 Project MLA SCT 005 Linking Live Sheep and Carcass Data via RFID

In 2005, the Sheep CRC and MLA commissioned a project to complete the design of a tracking system and install a demonstration system into Hillside Abattoir. Gerry Wind of Sunshine Technologies was contracted to design and develop the hardware components, whilst Rob Shepherd of Estock Systems developed the software and interface.

Whilst a prototype system was installed there were a number of reliability issues with some of the technology. This report describes the processes and issues encountered in developing the final system to capture the individual EID of live sheep and relate that to a RFID embedded in a skid, capture the weight and grade score of the carcass and provide this via computer software to the processor and producer.

2 Project Objectives

2.1 Project Objectives

The objectives of this project were:

- To install a RFID tracking system within the Hillside Abattoir, in order to transfer ID from a sheep ear tag to the skid/gambrel carrying the carcase and have this information read and available for integration with weight and fat data at the carcass measuring station in the abattoir.
- To document the process of installing the RFID technology at Hillside Abattoir so that a similar installation can be undertaken at other sheep and beef abattoirs.

3 Methodology

3.1 Development Process

The process used to develop the carcass tracking system involved a number of steps. These included:

- System design (hardware and software)
- Prototype installation
- System testing
- Development and implementation of system improvements

3.2 Key Issues

Key hardware and software issues that needed to be addressed included

- Identification of the appropriate RFID frequency
- Identification of the appropriate RFID transponders
- Identification of the most appropriate option for installation of RFIDs into
- Identification and testing of gambrel RFID reader.
- Installation of trippers to detect non-readable RFIDs at initial reader station and weigh scales.
- Positioning of readers at crucial points on the chain.
- Development and installation of AVR micro-controller to interface with the trippers.
- Development, siting and testing of EID ear tag reader.
- Development of software to allow recording of RFIDs and checking of sequence issues.
- Development of a programme to use the tripper event, RFID read and SASTEK printer capture to associate the animal EID with the SASTEK body number.
- Fine-tuning of weigh station data recording with positioning device for accurate read.
- Installation of cabling to allow connection between readers and office data logging computer.

4 Results and Discussion

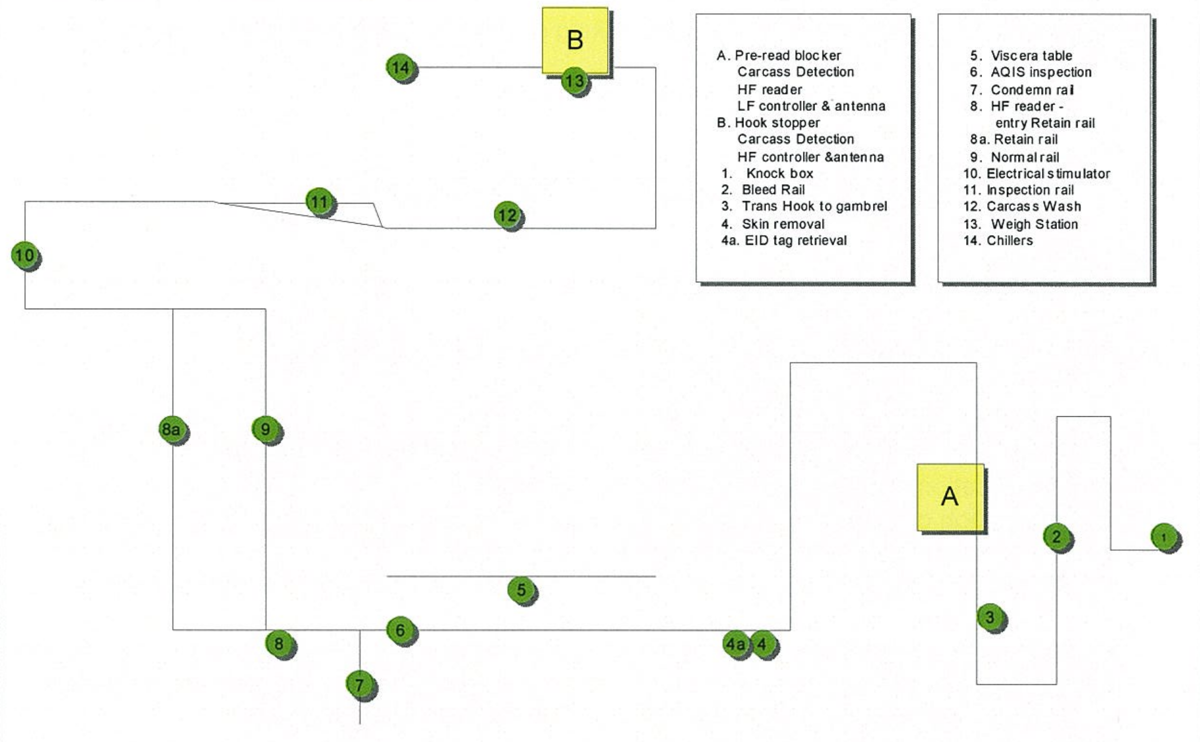
The project was able to demonstrate the concept of reliably capturing a live sheep RFID eartag and correlating this to its carcass body number and associated carcass data recorded at the weigh scales.

The project identified the appropriate equipment to install in an operating abattoir environment. The criteria considered was such that the equipment had to:

- be installed with as little disruption to the operation of the plant as possible,
- be available commercially at the end of the trial, and
- be able to withstand the operating conditions within the abattoir over an acceptable period of time - i.e. withstand the wet and humid environment and washing regimes including the caustic wash and possible mechanical damage.

Diagram 1 shows a schematic floor plan of Hillside Abattoir and the location of various key components.

Diagram 1. Hillside Abattoir Floor Plan



The final recommended components are shown below.

Recommended hardware components:

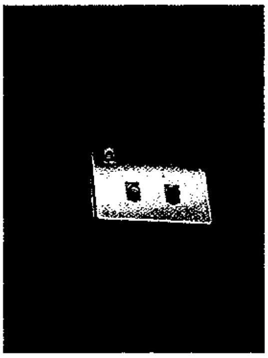
- Skid RFID: 16mmØ Sokymat 161 13.56MHz LogiTag laundry transponders
- Gambrel/skids – transponders injection moulded into existing plastic (acetyl) abattoir skids by SCL
- Sheep EID reader: Allflex 134.2 kHz FDX-B and HDX with 3 amp 12volt DC power supply
- Sheep EID Antenna: Direct contact modified Allflex flexi-reader encased in food grade HDPE
- Sheep EID pre-read blocker: AVR (PLC) controller and proximity trippers

The demonstration system at Hillside uses software that accesses the carcass data from the SASTEK data logging printer. It is recommended that the system be linked directly to the existing software framework. This will be possible after the upcoming SASTEK system upgrade at Hillside.

Details on the development of each of the hardware and software components are described in the discussion below:

4.1 Ear tag EID Reader and Antenna

4.1.1 EID Animal Reader - Controller



An Allflex 134.2kHz FDX-B / HDX panel reader controller, coupled with various antenna derivatives was tested to read the animal's EID ear tag before head removal.

The reader controller is a standard Allflex unit and was wall mounted in a harsh environment stainless steel cabinet complete with its own 3 amp 12volt DC power supply. The original power supply was rated at 2amps but this was not sufficient for continuous operation with the antennas under development. The reader was originally connected to the host computer by RS422. This was changed to RS323 when the re-read blocker was installed.

4.1.2 EID ear tag Reader - Antenna

Hillside abattoir has very little background RF interference. The main chain is hydraulically driven so there are no vari-speed motors to create interference. The High Voltage (800 volt) carcass electro-stimulation unit appears not to cause any issues with the RF readers.

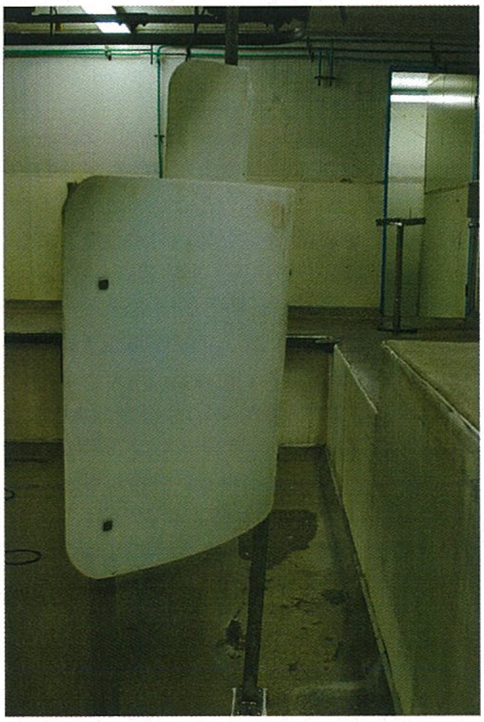
An underlying problem with reading eartag EIDs is the distance between the animals versus the read range of the antenna. Earlier antennas had a read range of over 1000mm in all directions, while the animals are only 900mm apart. This would not be a problem if all the animals were fitted with an EID and all were *either* FDX *or* HDX. As neither system is anti-collision*(1) the best oriented EID blocks the read of any other tags in the read-field. The problem arises when the animal in front of the reader does not have an EID or it is a different duplex to the next animal. There is therefore no blocking effect from the tag in front of the reader and the next animal can be read instead or as well. A similar situation arose with poor orientation of the tag in front of the reader coupled with a perfect orientation of the next EID.

**(1) Anti-collision is a system more commonly used with HF where the RFID reader can read all the RFID transponders in the read range of the antenna. As each RFID is read it goes quiet so it does not collide with the next and allows it to be read.*

The Original Allflex abattoir antenna was designed to read rumen bolus as well as ear EIDs. A curved leading edge was added to stop horned animals catching the antenna. This original antenna worked too well, with a read range of up to 1000mm.

However it was still possible to miss the occasional animal due to a perfect orientation of the previous or next animal blocking the read of a poorly orientated animal in front of the reader.

Swinging carcasses also posed a problem, as the oscillating carcasses would come in and out of orientation with the reader. A temporary stainless steel guard was added to stop the carcasses swinging.

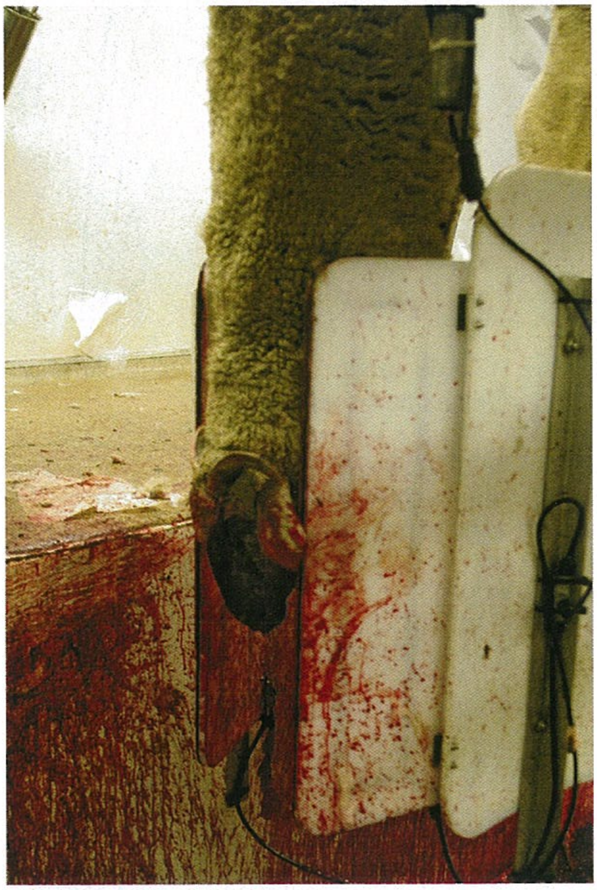


It successfully stopped the carcasses swinging however AQIS was concerned about shorter animals dragging their feet along the top of it, leading to possible contamination issues.

The steel guard was then replaced with a curved guard made out of 2 sheets of food grade HDPE sandwiched around a layer of aluminium foil. The foil was designed to block the next carcass EID. Initial trials with foil wrapped around cardboard appeared to reduce the pre-reads of EIDs. The guard was very successful but the foil interlay proved ineffective.

A further development of trying to block pre- reads was to place a swinging shield between the tag reader and the next sheep. Again this was a sheet of aluminium foil sandwiched between two sheets of HDPE. The swing shield appeared to have little effect on the pre reads.

Post reads of the EID posed no problems as once an EID was read, it was added to a lookup stack of recently read EIDs on the host computer. Each new read is compared to the stack and if it has already been read it is ignored.
The end result a combination of directional short range antennas coupled with a reader output blocking device that is controlled by two trippers and give a read opportunity of about 150mm.



The wire coils were removed from a set of Allflex Flexi-antennas. These were then placed between two sheets of 10mm neutral (white) food grade HDPE (High Density Polly Ethylene). A channel was routed in both front sections of the panels and the coils were laid in them. The two sheets of each side were then coated in acid-cure RTV silicon sealer and pressed together and allowed to cure overnight. Both antennas were then seam welded to completely seal them.

The two flexi-antennas were set at 45° to oppose each other at rest. This causes the antennae to go out of tune drawing about 0.75amps while there is no animal to separate them.

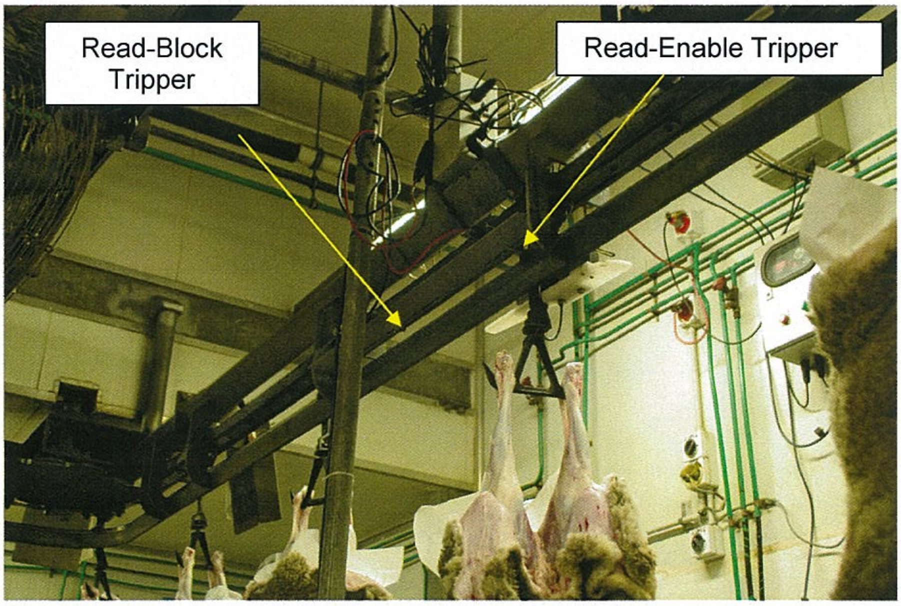
When the animal pushes between them they become parallel and re-tune to about 0.95amps and read the EID while in contact with the animal. The antennas then return to the closed state and once again de-tune.

4.1.3 EID Pre-read Blocker

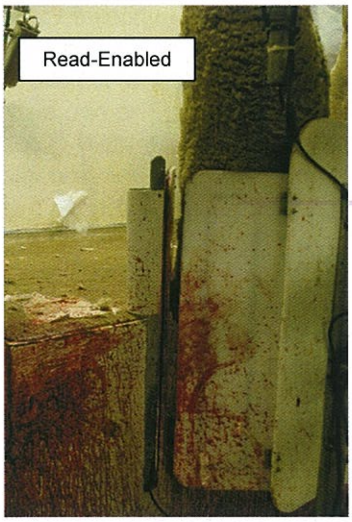
The de-tuning of the antenna is only part of the solution to solving the pre-read of EID issue. A pre-read blocking unit has been developed that intercepts the serial output data from the Allflex reader before it is sent to the host recording system.

The pre-read blocker has two sensors (trippers) mounted in contact with the chain.

They are triggered by the metal blocks that push the skids along the rail. Both the read-enable and read-block trippers are slide mounted so they can be adjusted to adapt to any read-block combination.



The first or 'read-enabling' tripper is placed after the HF skid reader where the animals head first comes in contact with the closed and therefore detuned Allflex flexi-readers.



The second 'read-blocking' tripper is set to trip before the flexi-antennas reach full power as the animal pushes between the flaps. This has allowed us to achieve a 150mm read window and a 750mm read buffer from the next animal as the skids are spaced 900mm apart on the chain.

The serial output port of the Allflex reader is connected to the input port of the pre-read blocker. An optical isolator circuit and separate power supply had to be used as the Allflex reader would not read when connected directly to the pre-read blocker.

The Allflex reader reads every EID eartag that comes into range. It must be set to send every read mode otherwise it will miss most of the animal EID's during the read-block cycle. Other people have tried de-powering the Allflex reader or stopping the exciter circuit, but this may result in the animal's EID being missed due to the delay as the reader powers back up.
The pre-read blocker continually monitors the serial output of the Allflex reader and ignores all data until the animal is between the two trippers and directly in contact with the flexi-antennas. The EID is then analysed to make sure it is a valid number and not a re-read of a previous animal. The pre-read blocker then sends the new EID only once to the Host computer.

4.1.4 Abattoir procedural changes at the eartag reader site

Although the tracking system has been installed at Hillside with the objective of being as least intrusive as possible, some procedural changes are inevitable.
Initially with the large Allflex antenna carcass orientation was not an issue. Now the new antenna is subject to a limited read opportunity, orientation has become important. Most observations on the kill floor showed the carcass's entered the reader head first. Adjustments to the pre-read trippers were made to cater for this. There is one operator that appears to have no control over which way the carcass leaves the leg lifter, and therefore the carcass can enter the reader in any orientation. If it enters feet first, the signal is blocked before the ears come in contact with the reader, and the animal EID can be missed.
A procedure needs to be put in place to instruct the leg lifter to place the carcass head first towards the reader. The system can be adjusted to go feet first if all operators wish this to be the case.

4.1.5 Alternative Antenna – Allflex Multi-coil Antenna

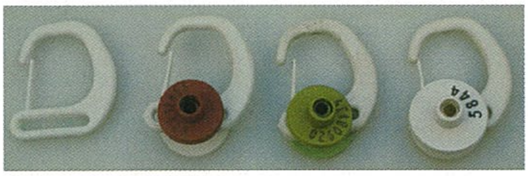
Prior to achieving a good EID eartag read result with the current contact antenna Allflex had begun the development of a potential alternate directional antenna. It is designed around a multi-core sequential-read directional cylindrical antenna. This antenna has a short read range and may have been an alternative EID eartag reader in a low RF noise plant.

Another tracking system is being planned for the inverted chain abattoir of Peel Valley Exporters Pty. Ltd. at Tamworth. A site survey has however found that this antenna would not be appropriate due to the high amount of RF (radio frequency) noise in the plant.

4.1.6 Testing the EID eartag reader

A system for testing the Allflex EID reader and antennas was developed using a protocol of 3EID - Miss one - 3EID sequence. The EID eartags are a mixture of HDX and FDX from various manufacturers. This sequence immediately shows up any mis-reads or pre-reads.

Yachting clips are used to temporarily attach EID tags to animals. The clips are either clipped to an existing ear tag or slipped over the ear.



Above is an example of the yachting clip along with an Allflex HDX, Allflex FDX-B and a Leader FDX-B. This system allows easy testing of equipment during development. Once the system is working correctly, animals that have been tagged prior to entry to the abattoir can be tested.

4.1.7 Constraints

The issue of the 'pre-read' of EID tags, especially when the animal in front of the reader has no EID or a FDX EID tag and the following tag is a HDX EID tag has finally been resolved. The modified Allflex 'Flexi-antenna' combined with the pre-read blocking circuit now completely eliminates all pre-reads.

4.2 Gambrel Skid Transponders

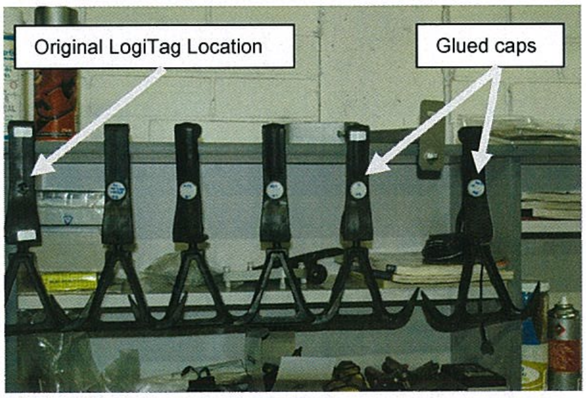
4.2.1 Transponders

a) The original proposal from Sunshine Technologies was to use passive dual frequency transponders attached to the gambrel skids. However testing the Allflex reader in the vicinity of the duel frequency reader completely blocked the LF part of the dual frequency reader.
b) To avoid any further conflict with the LF EID tags and readers used with the sheep high frequency (13.56MHz) was chosen for the skid transponders.
c) A transponder developed for tracking clothing in laundries made by Sokymat was chosen to track carcasses. It is a Sokymat 161 13.56MHz LogiTag that is 16mm in diameter and 3mm thick at its deepest point.
d) LogiTags have a high tolerance to heat and are encased in a plastic that is meant to be impervious to acids and bases and petroleum.

Unprotected, the caustic solution from the wash eventually penetrated the outer casing of the LogiTags causing the transponders to slowly fail over a period of six months.

This problem was overcome by encapsulating the transponders by injection moulding them into the skids. (see 4.2.2)

4.2.2 Attachment of HF transponders to Gambrel Skids



Hillside abattoir use ITW-Fastek black acetyl skids and gambrels throughout the abattoir. The animal still has its head attached when the carcass is placed on the gambrel after the first legger.

4.2.2.1 Initially Sunshine Technologies attached the LogiTags to the centre of the skids by gluing them in a countersunk hole. Approximately 250 skids were initially fitted with transponders. These failed immediately with some of the LogiTags being ejected at each location where a load was put on the skid. A number of skids also snapped through the countersunk hole.

Heat Welded Cap & LogiTag

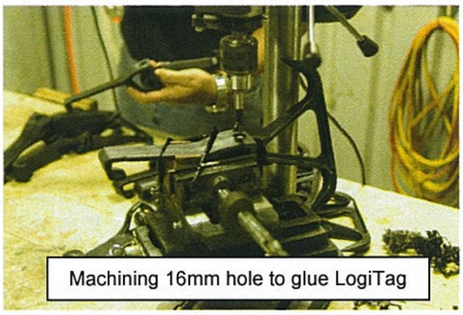
4.2.2.2 To overcome the weakness caused by the countersunk hole a number of options were trialled. An acetyl cap was machined to hold the chip to attach the LogiTag to the skid. Glue was used to attach the cap to the acetyl skid at the original position, but it failed to hold under the flexing of the skid. The cap was then heat welded to the skid in the original position. This held the caps under flexing but some skids broke upon leaving the chillers.

Cap & LogiTag

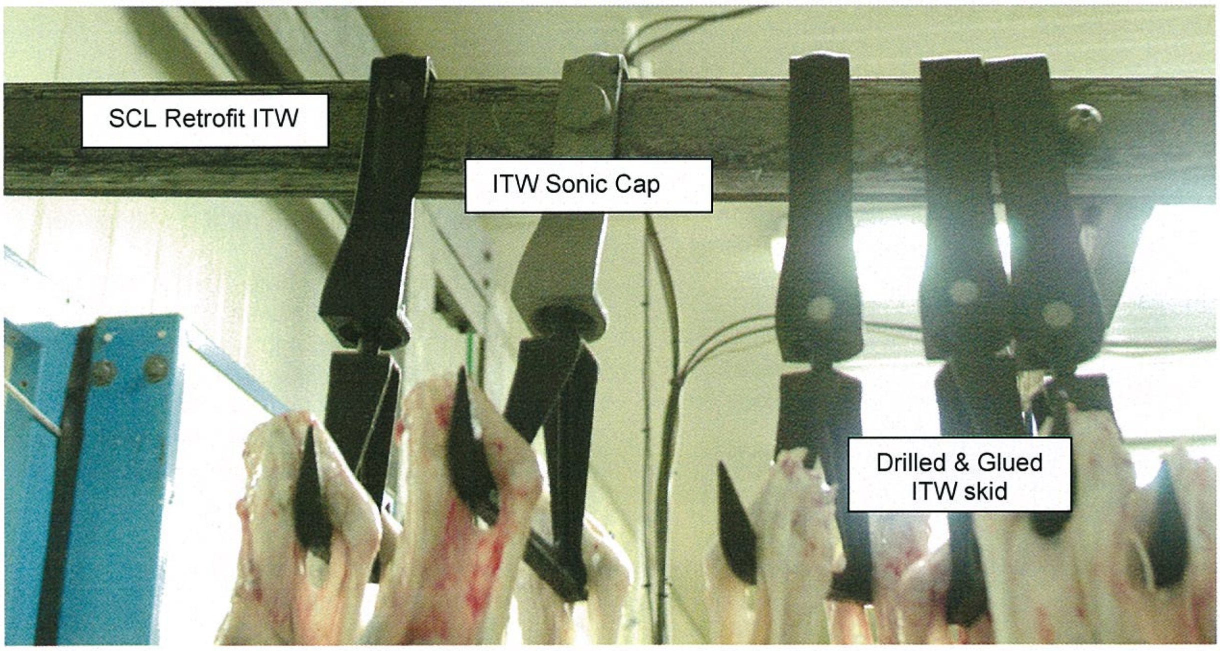
Testing of the skids indicated that some would snap like a carrot wilst others were unbreakable. This was due to the variations in the original moulding process causing the skids to behave slightly differently. Although all the skids were made of black acetyl, there was a great variation in the colour of shavings when you drilled a hole in the skid.

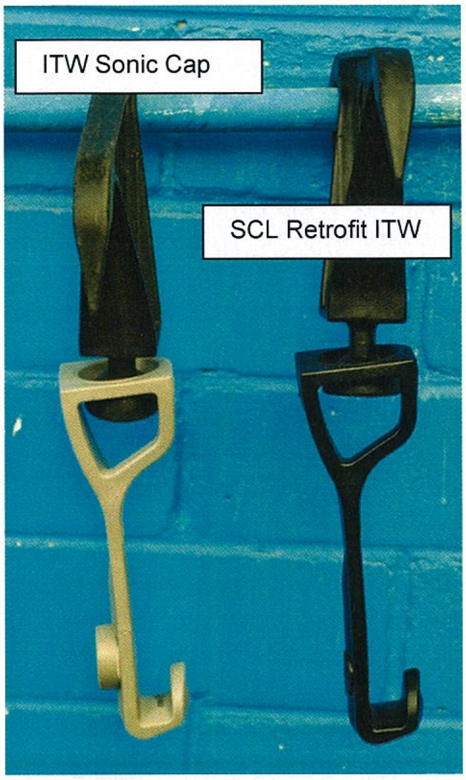
4.2.2.3 The caps were then welded lower on the triangle section of the skid. As the skid does not flex at this point, the LogiTags were glued in a 4mm deep a countersunk hole.

The gluing technique involved priming the skid with Loctite 707 primer. When this dried the hole was flooded with Loctite 406 glue and the chip pressed into place. It was then immediately dusted with baking soda to set it solid.


Machining 16mm hole to glue LogiTag

1700 skids were fitted with LogiTags using this method. The system worked well initially, however it was discovered that the daily hot caustic wash was slowly permeating the LogiTags. An audit of ‘live’ skids after 6 months operation highlighted that a number of transponders had limited reads or had failed completely. A daily audit was added to the monitoring software and the failing chips could be observed on a daily basis.





4.2.2.4.1 Three companies were approached for a solution to the problem. Two companies came up with potential solutions. ITW-Fastek the company that manufactures the skids and gambrels in use at Hillside came up with new idea of welding a cap over the chip. We pointed out the issues we had previously with welding acetyl and they said that as they were using a sonic welding process the skid should not be affected. There were two issues with this solution. Firstly they could not get the caps to seal completely so the LogiTags were potentially exposed to the caustic wash. Secondly as predicted some of them broke after leaving the chillers. ITW-Fastek are developing a new fully moulded skid. This product should be available in the second half of 2007.

Damage in chillers to sonically welded

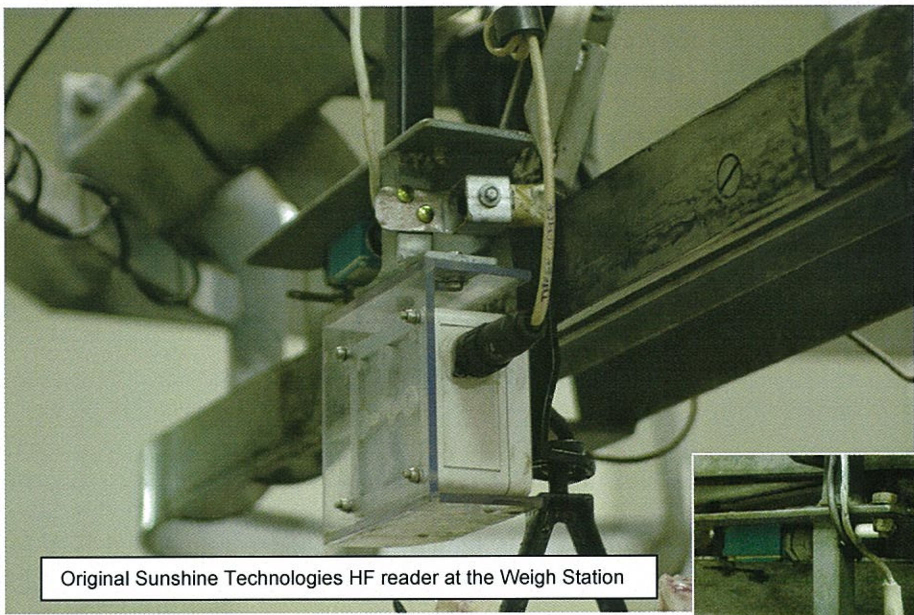
4.2.2.4.2 The second company SCL (System Controls Limited) supplied a retro-fitted ITW-Fastek skid. SCL had routed a reverse dovetail hole into the top section of the skid where there is no flexing and injection moulded the LogiTag into place. The process fully encapsulated the LogiTag in an impervious plastic and held in place by the dovetail joint. 1420 skids have been injection moulded with transponders. 400 more are being fitted.

The SCL retro-fitted injection moulded skids are currently the recommended solution for the tracking system.

4.3 Skid RFID Readers and Antennas

4.3.1 RFID Readers

The original HF 13.56MHz was supplied by Sunshine Technologies. It was single unit that had the antenna, read controller and serial interface all mounted on the one printed circuit board (PCB). This was housed in a standard mounting box. The output of this unit was RS485 (Hex) and connected to the host system via a 4 port RS485/USB hub. The system was a development kit and was supplied with a demonstration programme. Communication to the readers was through an 'Ingot' that has limited programmable flexibility and embedded in the main programme.



Original Sunshine Technologies HF reader at the Weigh Station

The continual contact of the skids on the reader face was wearing away the reader cover.

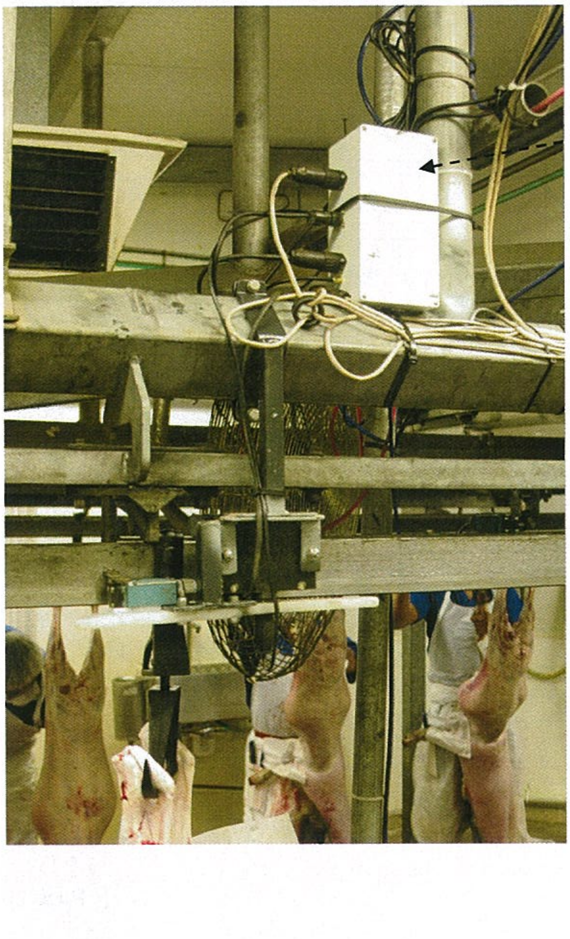
Intermittent reads and limited read range caused problems with reliable data capture.

To protect the HF reader from the harsh environment the reader was encapsulated in plastic (by SCL). The plastic used is very hard wearing and is used in the mining and farming industries in highly abrasive situations. The encapsulation was successful but did not address the limitation of the read range of this HF reader.

SCL Encased Sunshine Technologies HF reader on the Kill Floor

A FEIG MR101 13.56MHz HF reader was sourced from Electrocom to overcome the read range problem on the Kill Floor. The FEIG reader can be supplied with a 300mm x 300mm IP65 antenna, but as we were looking for a more compact reader Electrocom supplied an antenna they had manufactured in house. The antenna was a 76mm x 76mm printed circuit board antenna encased in black HDPE. The read range was significantly improved, and at the test site at the entry to the retain rail 100% reads were achieved. This reader was then moved to the location on the kill floor to try and achieve similar read success. This was not achieved as the operator in front of the reader would occasionally pull the carcass quickly through the reader, missing the RFID.

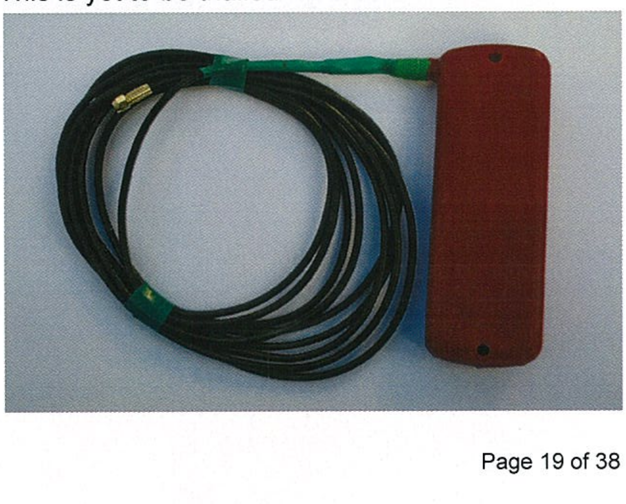
FEIG HF RFID antenna at the entry to the retain rail: Lower position for original chip location



Electrocom then supplied a larger antenna; 100mm x 76mm. This has been installed on the kill floor to replace the original reader.

The FEIG reader is housed in a box with a controller that intercepts the output from the FEIG reader and checks for duplicate reads, and reads the skids that have passed. The controller communicates with the host computer. The FEIG reader and controller will need to be housed in a stainless steel cabinet mounted on the wall.

SCL have produced a 120mm moulded antenna. This is yet to be trialled



4.3.2 Carcass Detection

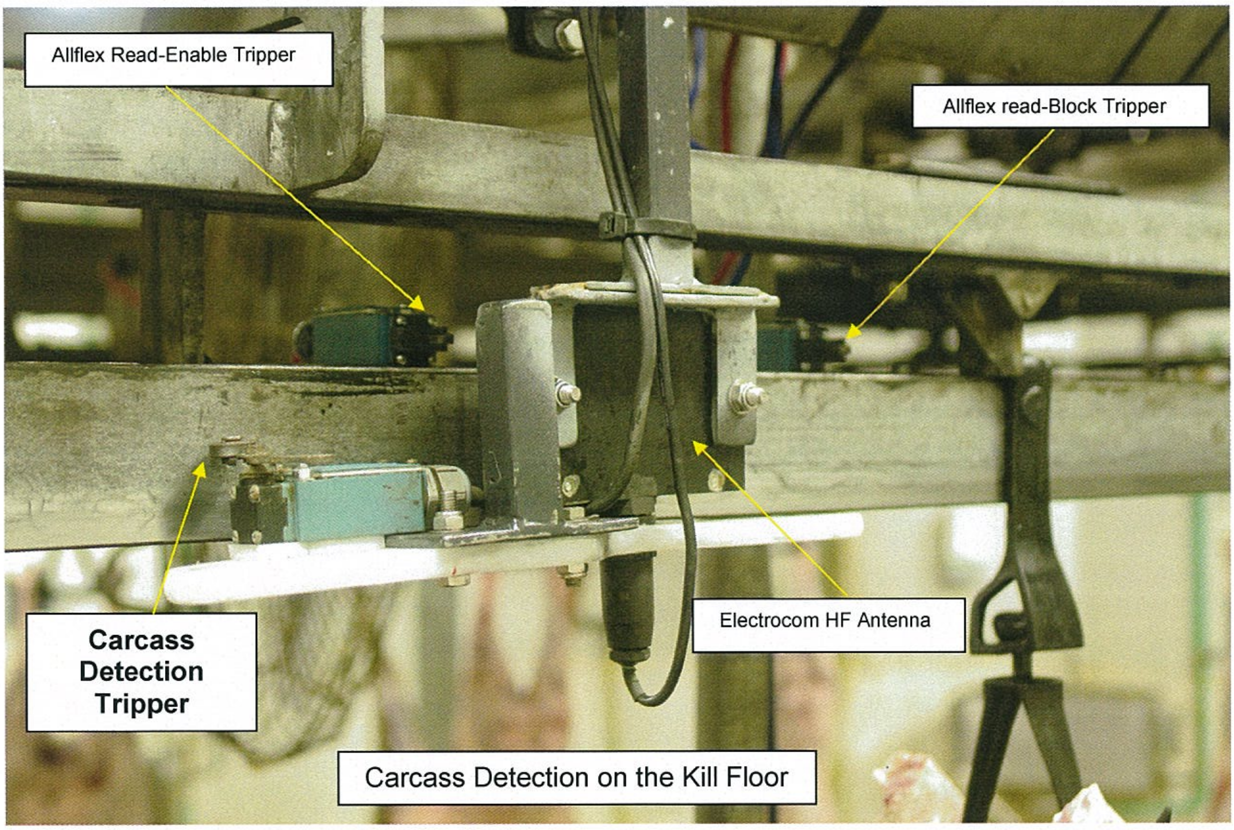
Each HF RFID reader has a carcass detection tripper to indicate the arrival of a new carcass.

The tripper forms a series of functions; these are:

- signify the arrival of the new carcass
- finalise the previous record
- check the functionality of the skid RFID

4.3.2.1 Tripper on kill floor
The kill floor tripper detects the arrival of the new carcass and clears the previous record. If the previous skid RFID did not read, the host system records it as a failed skid. The new record is date time stamped.

4.3.2.2 Tripper at the Weigh Station
The weigh station tripper also detects the arrival of the new carcass.
The previous record is updated and cleared. The carcass stopper (see Section 4.4) is activated to prevent the next carcass entering the scales.



Carcass Detection on the Kill Floor

4.4 Weigh Station Carcass Stopper

At the weigh station there is considerable difference between operators and the ability of the tracking system to match up the kill data to the correct carcass. Ironically the better operator caused more errors with data match up than the slower operator. This was caused by the fast operator entering the fat-depth and capturing the weight, and before the printer printed the ticket he would have removed the old carcass with his left hand and slid the new carcass into place with his right hand. This would trip the hook tripper; finalising the record and read the new hook RFID before the data came through from the printer. As far as the tracking system was concerned, the data belonged to the new sheep. This will be less of a problem when the carcass tracking is an integral part of the abattoir software.

To prevent the possible mix up of data a pneumatic hook stopper was developed. The hook stopper is activated by the carcass detection tripper. Initially it was installed to prevent the carcass leaving the scales until the carcass ticket was printed. This was annoying to the weigh-station operator, as the delay on the print is about 3 seconds, and it made no difference to the accuracy of the record if the carcass had left the scales.

The hook stopper was re-located to the entry of the weigh station so it stops the carcasses before entering the tripper and RFID reader. This now allows the carcass on the scales to be removed and prevents the next carcass entering until the ticket is printed and therefore the record is updated. As soon as the ticket has been printed the stopper releases, allowing the next carcass to enter the scales. As soon as the tripper senses the presence of the carcass the stopper resets and prevents the entry of the next carcass.

The hook stopper can also be set to check the functionality of the HF chip in the skid. If the skid fails to read the hook stopper can be set to prevent the next carcass entering the scales until the current skid is dealt with.

The hook stopper control unit is mounted on the frame of the SASTEK computer and there are two lights that indicate the status of the HF read and the print event. When the carcass trips the detector the controller activates the stopper and both lights go on. When the skid RFID is read the EID light goes off. When the printer prints the label, the print light goes out and the stopper releases the carcass. The switch on the left is used to override the RFID checker.

Operator procedural changes need to be implemented to use the hook stoper.

4.5 Computer System and Software

4.5.1 Carcass Tracking Programme

To link the carcass data that SASTEK computer system records with the sheep EID and carcass RFID, a linking programme was developed. The Carcass Tracking Programme was developed by Estock Systems. It is written in open source VBA (Microsoft Visual Basic for Applications) and is embedded in a standard Microsoft Excel spread sheet. Although this is not the recommended setup for a commercial system, this was ideal for the proof a concept trial. All data captured is visible in an excel spread sheet in real time. (See diagram **4.5.3.4** pg 28)

The carcass tracking programme is run on a host computer at Hillside Abattoir. This computer is a 2GHz IBM compatible PC running Windows XP and Microsoft Office 2003. It is located in the QA office that is adjacent to the boning room alongside the SASTEK computer and logging printer. It has two high speed hard drives (HD), one containing the host programme and primary data record and the second HD contains a backup data log of all data.

All the kill floor and weigh station equipment is connected by data cable to host computer system. A combination of serial RS232, RS422 and RS485 data links are used. The RS232 links are via PCI cards and the RS485 links are through a four port RS485 to USB hub.

AVR controllers (similar to a PLC) are used to monitor the equipment at each location and communicate with the host system.

The SASTEK system is a pre 2000 system and did not allow easy access to the data collected at the weigh station. This is not an issue with later versions of SASTEK. Data is therefore intercepted as is sent to the data logging printer in the QA office. This data is then processed to retrieve the individual carcass number along with hot carcass weight, fat depth, regrade information and cypher and destination. This data is then recorded against the skid number an eartag EID if present.

4.5.2 Data capture process

4.5.2.1 Kill Floor

Each data transaction is recorded on the excel spread sheet and is date time stamped (DTS) to allow trace back and data verification. Each animal is recorded on a new line on the spread sheet.

A new record is started by the carcass detection tripper being activated (Diagram 4.5.3.1a pg 23). This trip event finalises the previous record and inserts a new line with a DTS for the new record. If the skid has an active RFID chip attached, the RFID number is recorded along with a DTS (Diagram 4.5.3.1b pg 24). The pre-read blocker will prevent the eartag EID from being sent until the carcass is in the ideal location to be read (see 4.1.3 pg 13). If there is a eartag EID, this is recorded on the spread sheet against the skid RFID along with a DTS. The next carcass trip event then finalises this record. A skid RFID and or animal EID can also initiate a record if the carcass detection tripper fails.

4.5.2.2 Weigh Station

If the hook stopper is in use (see 4.4 pg 22), it will prevent a carcass entering the weigh scales until the previous record has captured all the data required. When the carcass detector is tripped it clears the record on the screen and records the DTS. If the hook stoper is in use the pneumatic cylinder activates and prevents the next carcass entering. If a skid RFID is read, the RFID is looked up on the spread sheet and the DTS is recorded. At this stage a signal is sent to the carcass stopper to signify the skid RFID is OK and the skid light goes out on the control box. (See Flowchart 4.5.3.2 pg 25).

When the body data is captured it is recorded on the spreadsheet against the skid RFID if it exists. If the skid RFID has not been recorded a new line is created at the bottom of the spreadsheet, along with a read fail record.

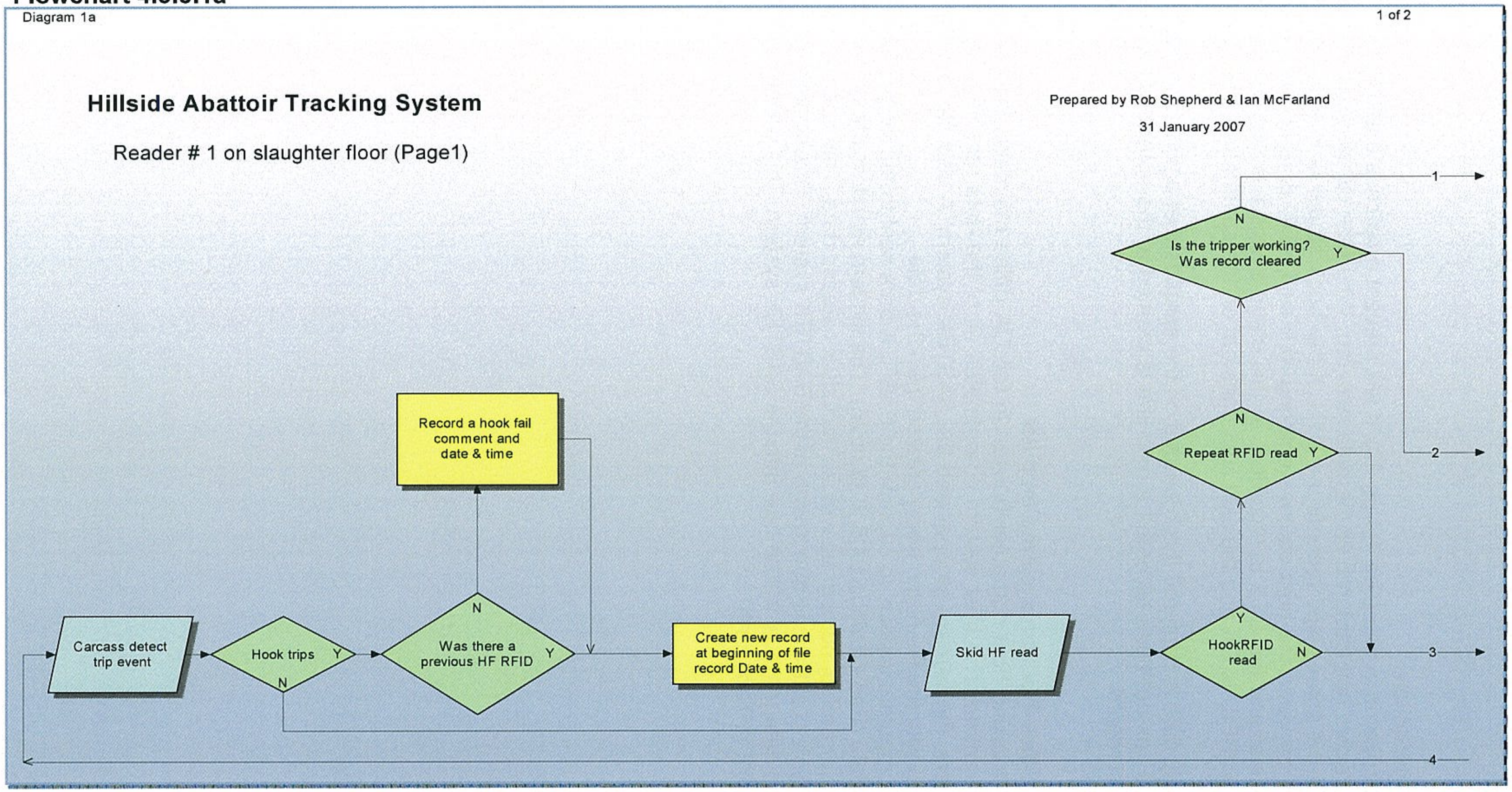
4.5.2.3 QA Office Tracking system Computer

The carcass tracking host computer housed in the QA office maintains the excel spreadsheet and tracking programme. The host system co-ordinates all of the data received from the AVRs, the LF and HF readers, the carcass stopper and the SASTEK system. A new file is created each day (just after midnight) with the file name being created from the date.

One of this computers tasks is to capture the SASTEK data sent to the logging printer and retrieve the relevant data (See Flowchart 4.5.3.3a pg26). The system monitors the printer line by line and sorts out grower and lot number as well as individual carcass data. This solution was developed for the existing system at Hillside due to age of the SASTEK system. This system will be updated in mid July 2007 and data retrieval will be built into the SASTEK system. This will be a similar system that is in use at PVE in Tamworth.

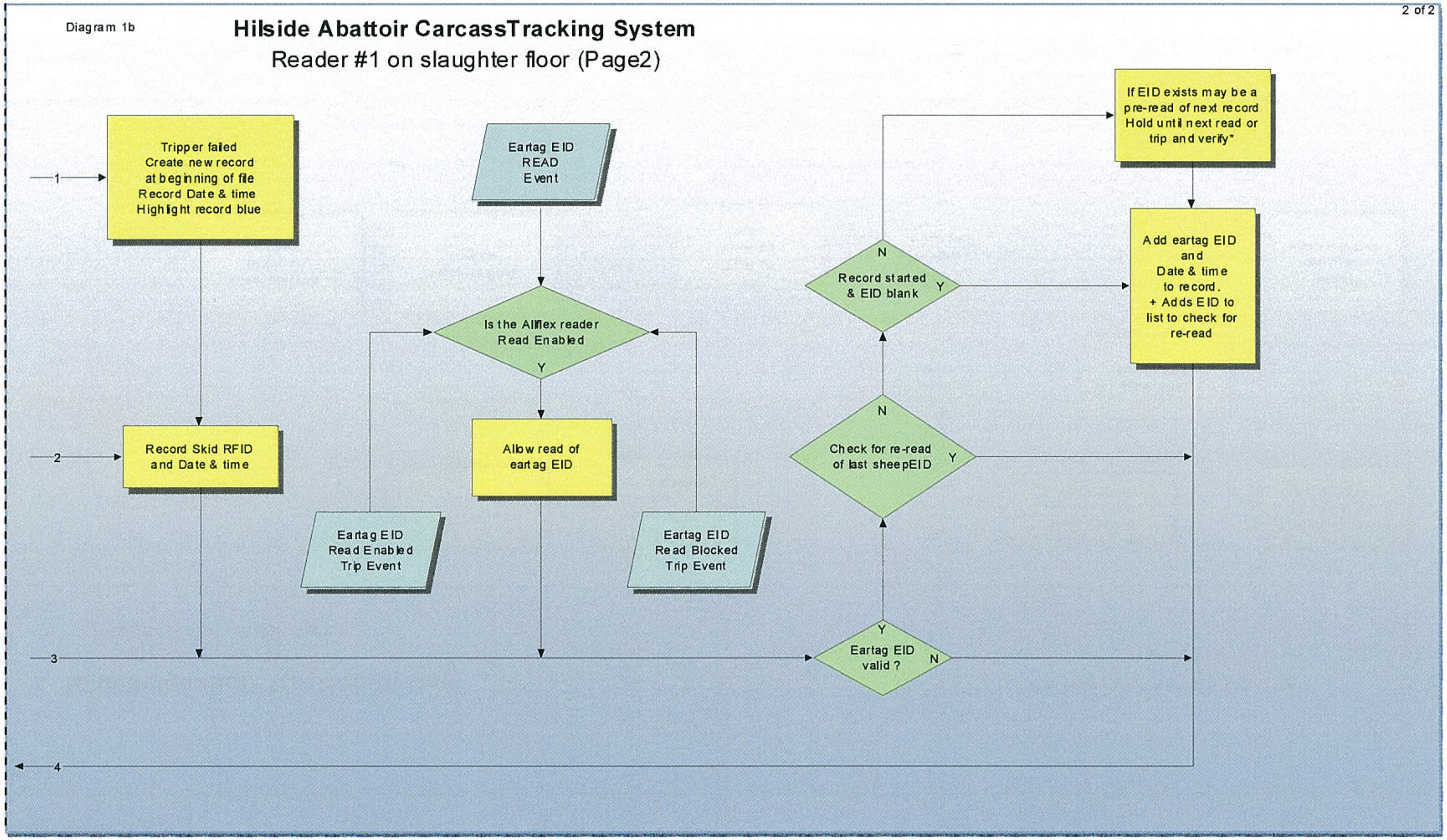
4.5.3 Flowcharts

Flowchart 4.5.3.1a



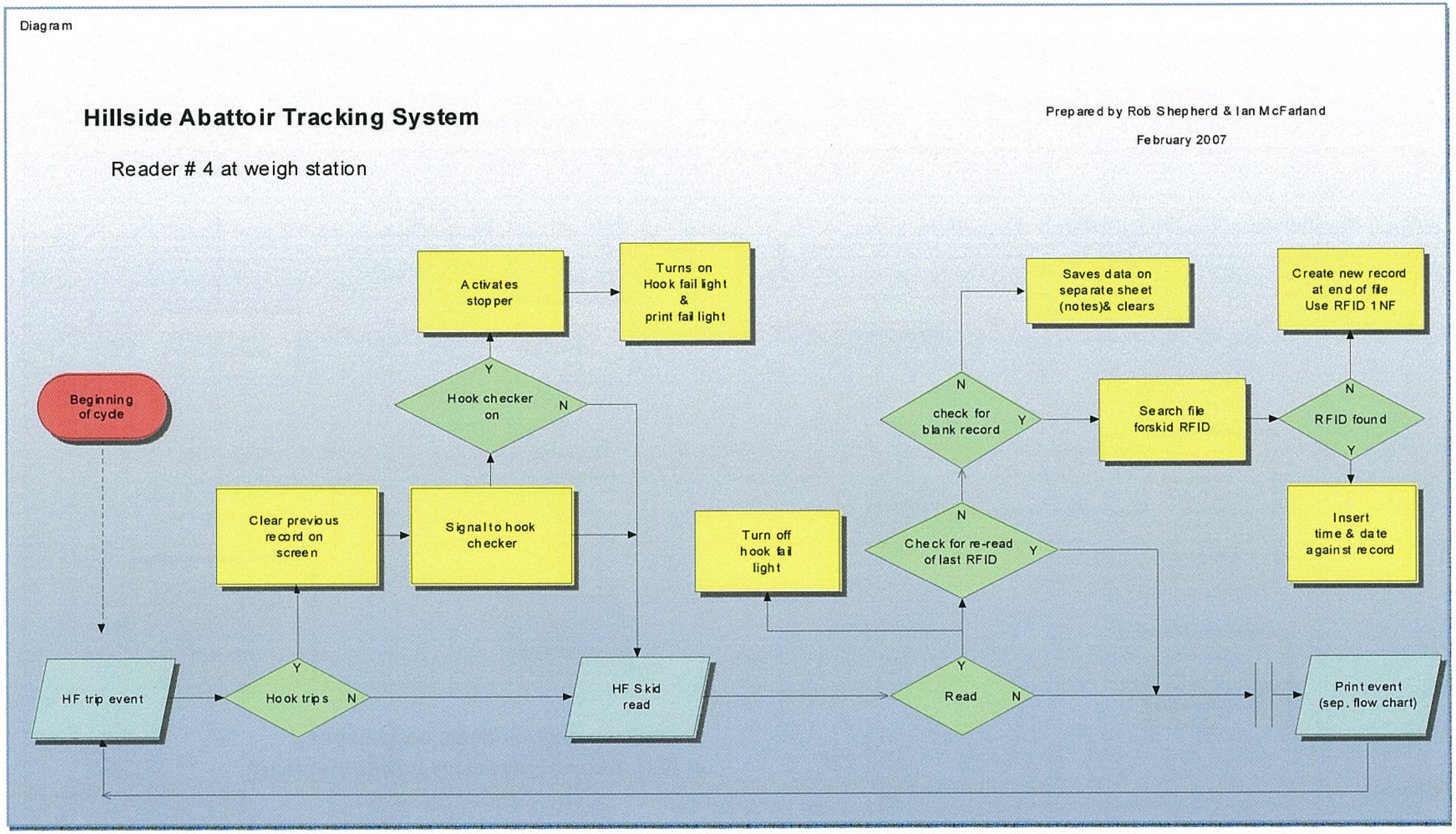
Flowchart 4.5.3.1a Flow chart of the equipment on the Hillside kill floor at the first reader. (adjoins 4.5.3.1b on next page)

Flowchart 4.5.3.1b



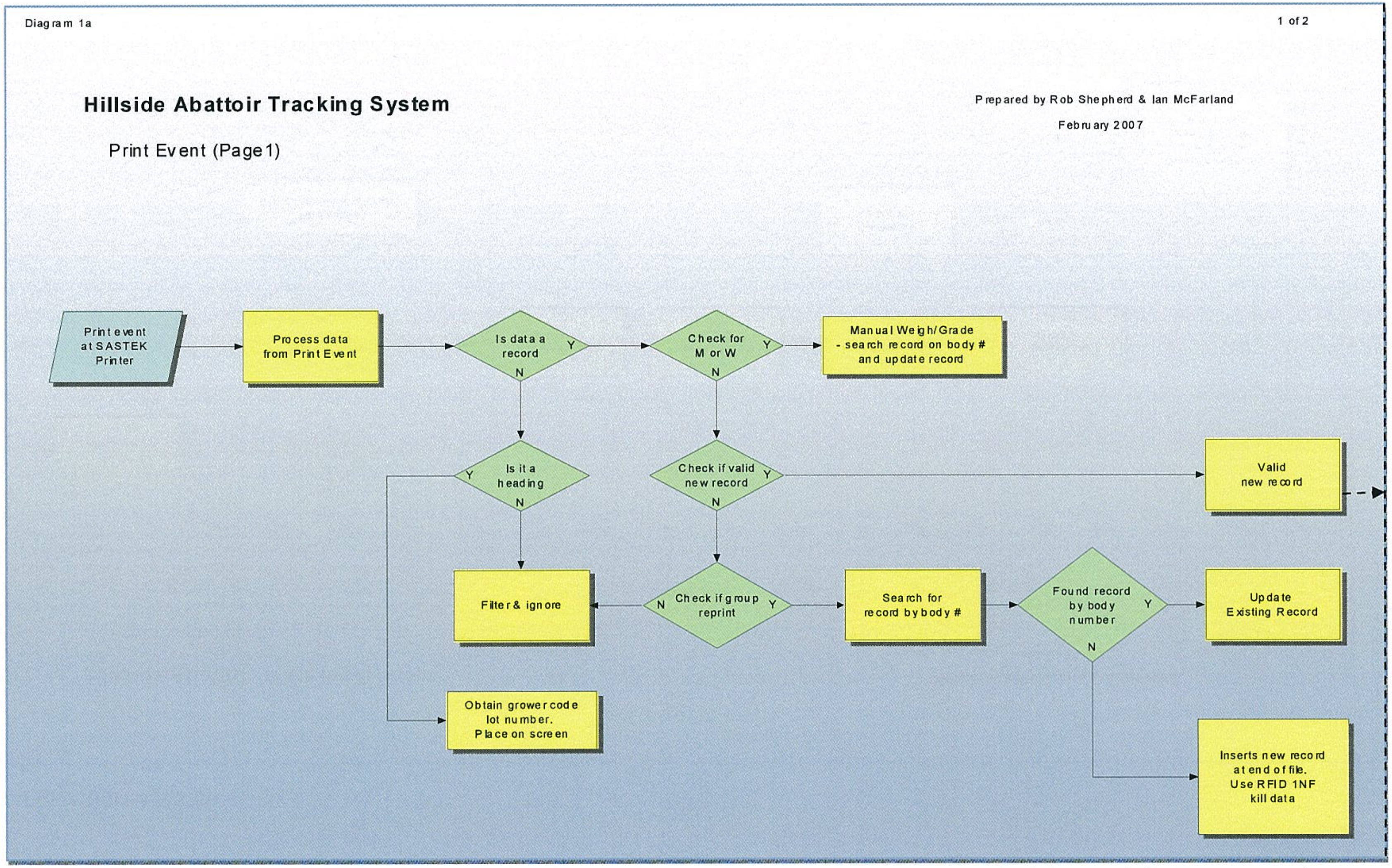
Flowchart 4.5.3.1b. Second half of flow chart of the equipment on the Hillside kill floor at the first reader. (cont. from previous page)

Flowchart 4.5.3.2



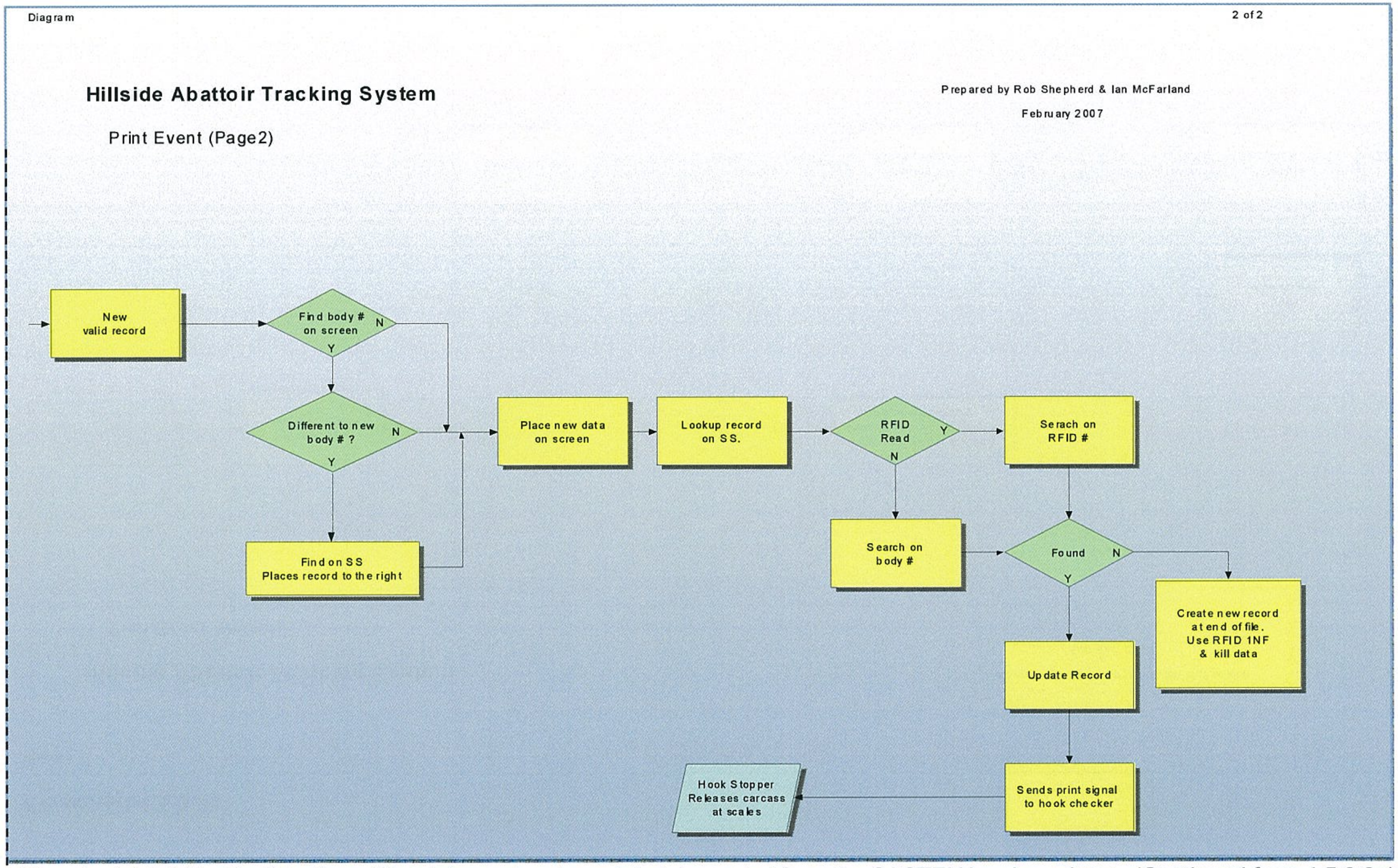
Flowchart 4.5.3.2. The HF Skid reader and Hook checker at the weight & grading station.

Flowchart 4.5.3.3a



Flowchart 4.5.3.3a. The data capture from data intercepted from the SASTEK logging printer. (Adjoins 4.5.3.3b on next page)

Flowchart 4.5.3.3b



Flowchart 4.5.3.3b. Continuation of the data capture from data intercepted from the SASTEK logging printer. (Continued from 4.5.3.3a)

Diagram 4.5.3.4

A2 | 22/06/2007 12:33:42 PM

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	ok Pass Ti	Hook1 #	look1 Tim	Animal EID	EID Time	[illegible]	RTAS	Grower	Lot	Date	Regrade	C _ Time	Body #	Cat	Sex	Dent	Fat Dpth	Fat Cl	Cy
2	########	E00215556053322D	########	982000062807866	########		########	TRE	389	007 12:33:		12:59	483	L	-	0	7	2.0	L
3	########	E002155560533483	########	982000062808486	########		########	TRE	389	007 12:33:		12:59	482	L	-	0	4	1.0	L
4	########	E00215556053320B	########	982000062813083			########	TRE	389	007 12:33:		12:59	481	L	-	0	8	2.0	L
5	########	E00401000894652B	########	982000062808644	########		########	TRE	389	007 12:32:		12:58	479	L	-	0	7	2.0	L
6	########	E002155560532B42	########	982000062813016	########		########	TRE	389	007 12:32:		12:58	478	L	-	0	2	1.0	L
7	########	E002155560531486	########	982000062813386	########		########	TRE	389	007 12:31:		12:58	477	L	-	0	10	2.0	L
8	########	E004010008946167	########	982000062808509	########		########	TRE	389	007 12:31:		12:57	475	L	-	0	7	2.0	L
9	########	E0021555605314DE	########	982009103609499	########		########	TRE	389	007 12:31:		12:57	474	L	-	0	3	1.0	L
10	########	E002155560530573	########	982000062808057	########		########	TRE	389	007 12:30:		12:56	473	L	-	0	7	2.0	L
11	########	E0021555605313E9	########	982000062808607	########		########	TRE	389	007 12:30:		12:56	472	L	-	0	7	2.0	L
12	########	E002155560533002	########	982000062808566	########		########	TRE	389	007 12:30:		12:56	471	L	-	0	6	2.0	L
13	########	E002155560532F40	########	982000062813687	########		########	TRE	389	007 12:29:		12:56	470	L	-	0	6	2.0	L
14	########	E0021555605314D1	########	982000062813684	########		########	TRE	389	007 10:59:		12:55	468	L	-	0	7	2.0	L
15	########	E0021555605308F3	########	982000062808426	########		########	TRE	389	007 10:59:		12:55	466	L	-	0	6	2.0	L
16	########	E002155560532581	########	982000062808053	########		########	TRE	389	007 10:58:		12:54	465	L	-	0	6	2.0	L
17	########	E00215556053148F	########	982000062813506	########		########	TRE	389	007 10:58:		12:54	464	L	-	0	12	3.0	L
18	########	E002155560531029	########	982000062808268	########		########	TRE	389	007 10:58:		12:54	463	L	-	0	3	1.0	L
19	########	E0040100089462C8	########	982000062807960			########	TRE	389	007 10:58:		12:53	462	L	-	0	6	2.0	L
20	########	E0021555605332F3	########	982000062808012	########		########	TRE	389	007 10:57:		12:53	461	L	-	0	6	2.0	L
21	########	E004010008940C3C	########	982000062813737	########		########	TRE	389	007 10:57:		12:53	460	L	-	0	6	2.0	L
22	########	E0021555605312BE	########	982000062813611	########		12:49:58 PM	TRE	389			12:52	459	L	-	0	4	1	L
23	########	E002155560533167	########	982000062813710	########		########	TRE	389	007 10:56:		12:52	458	L	-	0	8	2.0	L
24	########	E002155560530739	########	982000062813287	########		########	TRE	389	007 10:56:		12:52	457	L	-	0	8	2.0	L
25	########	E004010008942553	########	982000062809325	########		########	TRE	389	007 10:56:		12:52	456	L	-	0	6	2.0	L
26	########	E004010008944EC0	########	982000062813565	########		########	TRE	389	007 10:56:		12:51	455	L	-	0	6	2.0	L

Sheet1 | Sheet2 | Sheet3

Ready | 100%

Diagram 4.5.3.4 A screen capture from the Excel spread sheet on the Carcass Tracking System computer in the QA Office. Skid (Hook) number is in column B, the animal EID is in column D and the captured SASTEK body number is in column M. Fat depth is in Column Q and carcass hot weight is in column V. This spreadsheet is updated in real time during slaughter.

4.5.4 Future tracking system components

4.5.4.1 AQIS inspection station

The original system was designed to have a terminal at the AQIS inspection station to record retain and condemn information. A HF reader was installed in this position and initially monitored passing skids. Discussion with AQIS staff deemed it inappropriate to install a terminal at this location as it would impede on their operations.

4.5.4.2 Entry to retain rail

The entry to retain rail was planned to be automated in the future. It was envisaged that carcasses identified at the AQIS station for retention would automatically enter the retain rail.

The location was used to test the alternative HF skid readers. Reads at this location could be verified against reads on the kill floor and the weigh station.

4.5.4.3 Exit of retain rail

The exit of the retain rail is the ideal location to install the regrade recording terminal. Plans have been formulated for installation of this terminal in the future. A touch screen computer would record this information against the skid RFID and forward it to the host computer system.

4.5.4.4 Beyond the weigh station and chillers

Recent results from a lean meat yield trial have indicated a reasonable correlation between carcass lean meat yield and specific primal cuts. This provides the opportunity to value add the current tracking system and track carcasses beyond the chillers into the boning room and to specific primal cuts. At Hillside the leg pairs remain on their skid and gambrel up to the point of processing.

5 Success in Achieving Objectives

5.1 Success in Achieving Objectives

The project achieved the objectives of designing a tracking system for sheep carcasses within a traditional non-inverted sheep abattoir. This project proved that it is possible to read individual sheep eartag EID and correlate this to another RFID encapsulated in a gambrel skid. The carcass remains on this skid to the weighing scales and beyond into the chiller or boning room enabling the relating of carcass information to the live sheep EID. This allows identity of an individual sheep to be retained throughout the abattoir to load-out or the point of carcass sectioning at the band saw.

The system design and components for reliable use in an abattoir have been documented for use in other locations.

6 Impact on Meat and Livestock Industry – now & in five years time

6.1 Impact on Meat and Livestock Industry – now & in five years time

Previously the sheep industry has been able to record and provide feedback to producers on the carcass attributes of lots of sheep with no relationship of information to individual sheep. This project allows for the immediate application of the proven system and its components into other sheep abattoirs. Commercial suppliers of components have been identified and these have shown interest in supply of both hardware and software components for installation in other abattoirs.

The Australian sheep industry is currently implementing a National Livestock Identification System (NLIS) for Sheep and Goats. The current system is based on visually readable plastic tags and movement documents. If this system proves inadequate in meeting national traceability criteria set down by Safemeat, the industry may consider implementing an electronic identification system for sheep and goats. The system proven in this project would be appropriate if benefit:cost and associated industry technology for tracking sheep on property and in saleyards proves similar efficacy.

The system will allow abattoirs/processors to be able to track the performance of supplier's sheep or lambs through their abattoir. This would allow improved feedback, for example progeny testing of sires or groups of sires of known genetic merit. This may also encourage the use of individually numbered RFID eartags in sheep or lambs supplied

Research to be conducted in the CRC for Sheep Innovation , to commence July 2007, will investigate the potential for RFID to be retained on carcasses to the boning room band saw and then potentially transferred via bar codes to indicator cuts to allow their measurement and prediction of carcase yield and relative profitability between carcasses and between sites on carcasses.

7 Conclusions and Recommendations

7.1 Conclusions

An electronic tracking system for sheep carcasses within a traditional non-inverted sheep abattoir has been achieved with the ability to read individual sheep eartag EID correlate this to another RFID encapsulated in a gambrel and to relate carcass information to the live sheep EID.

For the system to be attractive for other abattoirs to implement further research is needed into ways in which the electronic tracing can be used to improve abattoir profitability. One such way may be to develop or incorporate systems for estimating boning room yield, such as VIAscan ® or the measurement of indicator cuts. Improved feedback systems may benefit both the processor and producer.

7.2 Recommendations

7.2.1 High Speed Abattoir

The Australian sheep industry, through MLA and the CRC for Sheep Innovation now need to test and prove the same technology within a high speed inverted chain sheep abattoir.

7.2.2 Boning Room Yield

The Australian sheep industry, through MLA and the CRC for Sheep Innovation develop or incorporate systems in conjunction with electronic carcass tracking, for estimating boning room yield, such as VIAscan ® or the measurement of indicator cuts.

7.2.3 Feedback Systems

The ability to monitor individual animal performance on-farm and then link this with individual carcase data in the abattoir could prove an important tool for improving profitability of both the processor and producer. Feedback systems need to be designed to make the best use of the data collected through the use of RFID technology.

7.2.4 Promotion

MLA and the Australian Sheep CRC promote the results of this project to the Australian sheep industry.

8 Bibliography

8.1 References and Reports (on accompanying DVD)

The following documents and reports are available on the accompanying DVD.

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Shepherd, McFarland, O'Halloran (2007) Linking Live Sheep and Carcass Data via RFID – Traditional (Non-Inverted) Chain Final Report June 2007 (This Report)

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9 Appendices

9.1 Appendix 1

9.1.1 DVD

Accompanying this report is a DVD to demonstrate the carcass tracking system at Hillside Abattoir in Narrogin Wester Australia. © Estock Systems 2007 this DVD may be reproduced and distributed with acknowledgement of author.

9.2 Glossary of Terms

AVR - Programmable micro-controller made by Atmel (see PLC)

EID - Electronic IDentification eartags and rumen bolus are used for the identification of livestock. In Australia a low frequency of 134.2kHz is used in two similar systems: FDX-B and HDX

FDX-B - Full Duplex. Full duplex transponders continuously communicate with the scanner, simultaneously receiving and transmitting data. A FDX tag will not transmit until there is sufficient energy received from the transmitter. Uses Amplitude Shift Key (ASK) – similar to AM radio.

Gambrel - The device by which a carcass is suspended by the back legs for slaughter and dressing in an abattoir. It is attached to the abattoir rail by a skid. (From Medieval Latin – 'gamba' – hoof or leg of animal)

HDPE - High Density Polly Ethylene. A petroleum derived polyethylene thermoplastic. The Neutral (white) grade is approved for use in the food industry. It is machinable and easily welded.

HDX - Half Duplex. A HDX transponder receives a signal form the scanner and alternates between transmitting and receiving at very high speed. The HDX transponder is equipped with a capacitor that accumulates energy from the transmitter. As soon as there is enough energy the HDX tag transmits. Uses Frequency Shift Key (FSK) – similar to FM radio.

HF - High Frequency. Radio Spectrum Frequency between 3 MHz and 30 MHz

Inverted chain – carcass held initially by rear legs, then all legs horizontally and then by the fore hocks until evisceration. They are then returned to the rear leg suspension position.

kHz - kilo (10^3) Hertz measurement of frequency of signal in cycles per second.

LF - Low Frequency. Radio spectrum Frequencies between 30 kHz and 300 kHz

MHz - Mega kilo (10^6) Hertz measurement of frequency of signal in cycles per second.

NLIS - National Livestock Identification System (NILS) is a system that has been developed to enable lifetime traceability of Australian livestock in the event of a disease outbreak of food safety or residue contamination issue. NLIS Sheep & Goats is based on a system of visually read eartags imprinted with the owner's brand registered to the property where the tag was applied.

NVD and **Waybill** - National Vendor Declaration is a document that producers use to declare valuable information about the food safety status of the livestock being sold and transported. Buyers rely on the NVD/Waybill for accurate information on the livestock purchased and processors rely on the information to ensure only the safest food enters our food chain.

Optical isolator circuit – a device that is interposed between two systems to prevent one of them from having undesired effects on the other, while transmitting desired signals between the systems by optical means.

PLC - Programmable Logic Controller. A multi input/output digital industrial programmable micro-controller, usually with non-volatile memory.

RFID - Radio Frequency IDentification refers to any device that responds to a radio frequency

RTV - silicon sealer – Room Temperature Vulcanising sealer

Skids -The section which attaches the gambrel to the overhead rail and 'skids' along it. The skids in this case have been manufactured by ITW-Fastek. They are injection moulded black acetyl.

Traditional chain – animals dressed while hanging from the hind legs and remain in this posture throughout the slaughter process.

Transponder – an automatic device that receives amplifies and retransmits a signal on a different frequency.

9.3 Acknowledgements

This project could not have happened without the encouragement and enthusiasm of the Hillside plant owner Peter J. Trefort and his family. It was Peters unwavering faith that we could provide individual carcass feedback to his Q Lamb members that kept the project alive. His objective is to provide feedback to Q Lamb members on breed and bloodline differences in relation to carcass and meat yield.

Hillside provided the electrician, maintenance staff and access to workshop for the initial install and subsequent upgrades of equipment. The original project had no provision for software so Hillside covered the cost of the development of the original Carcass Tracking programme.

The staff at Hillside have been amazing despite some inconveniences. Rex (Hillside's McGyver) is always there to construct another component or adapt an item to fit without once saying "you want what?" Stevo who drilled, glued, pulled apart and re-assembled the skids and gambrels *many* times. The sparky, how he got the cables where he got them will go to his grave. Wayne at receivals, who somehow managed to slot in our trial sheep in whenever we wanted to track them. Jacko and Ticko, the floor bosses, went out of their way to make the project possible. If something wasn't right they would diplomatically point it out and usually come up with a solution.
Davo in the weight and grade area made things happen. He had a good understanding of what we were trying to achieve and he knew who to ask. His help in some of the trial work was invaluable.
The administrative staff in the office deserve special thanks. There were numerous times we needed to book a truckload of lambs for the trial or chase down information, they were always there. Finally Scotty, our little ray of sunshine on the scales. He was our 'Buster' (Myth Busters test dummy), if there was a way of making the system fail Scotty could find it. And for those who came in late, he does actually speak.

Special thanks must go to Rod and Jenny Shaddick who EID tagged all their lambs from the 2006 drop and sent lambs through Hillside for us to monitor.

Reg Crabb from Q Lamb contributed a considerable amount of his valuable time and expertise. He was always available and his support and advice was invaluable. Reg will be an integral part of the feed back to Q Lamb growers and their implementation of the recommendation from the enhanced information that will be provided.

Finally sincere thanks to the *Sheep CRC* and the *Department of Agriculture and Food of Western Australia* (DAFWA) for the support, guidance and funding of the project.

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Linking Live Sheep Data via RFID

Traditional (non-inverted) Chain

case study

Abattoir Sheep Carcase Tracking System

Aim

The aim of the MLA SCT.0005 project was to demonstrate a system linking live sheep carcase data via Radio Frequency IDentification (RFID) on a traditional (non-inverted) abattoir chain.

Background

Hillside Meats owner Peter Trefort wanted to be able to monitor the performance of individual lambs supplied to him by the producer members of the 'Q Lamb' alliance (see MLA supply chain case study #3/2005) so that he could provide them with better feedback on carcase performance. The Q lamb alliance and Hillside Meats have a very innovative partnership however feedback to suppliers was limited to individual carcase information by lines of sheep only. Information could not be related to the individual live animal.

Project Development

An automatic sheep carcase tracking system was designed to enable individual live sheep fitted with Electronic IDentification (EID) ear tags to be tracked throughout the abattoir and linked to their individual carcase data.

The development and demonstration of the Carcase Tracking System (CTS) was supported by the Sheep Cooperative Research Centre (Sheep CRC), Meat & Livestock Australia (MLA) and Hillside Meats at Narrogin in Western Australia.

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Project Results
The carcase tracking system is designed to be used in conjunction with both full duplex (FDX) and half duplex (HDX) industry standard 134.2 kHz low frequency (LF) animal electronic identification (EID) ear tags. These are the EID ear tags currently being supplied to the sheep and cattle industries in Australia.

Gambrel Transponders
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1: SCL injection moulded HF transponder on gambrel

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The sheep on the abattoir chain are approximately 900mm apart, and can be closer if they are swinging. This causes possible misreading of sheep EID ear tags. To overcome this, a pre-read/post-read EID blocker was developed in conjunction with a white Nitrile 'contact' Allflex flexi-antenna and Allflex panel controller. The flexi-reader panels are placed at 45° to each other to de-tune and reduce the read range. As a carcase pushes between the flexi-panels they re-tune, and proximity sensors allow the eartag EID to be read by the pre/post EID blocker. The pre/post EID blocker then checks the EID with a list of previous EID's recorded and only sends the ID if it is a new one.

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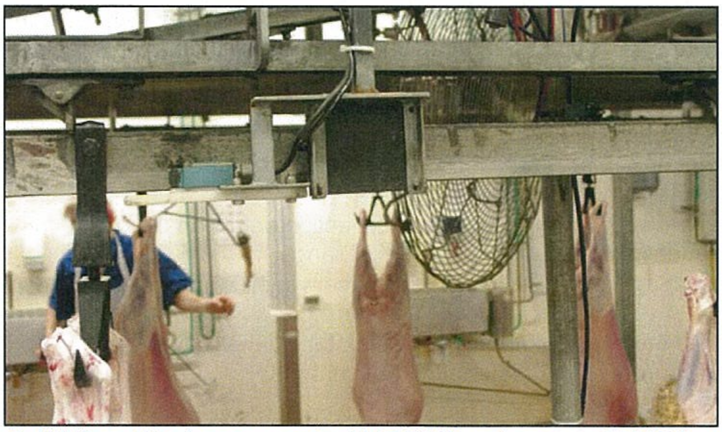

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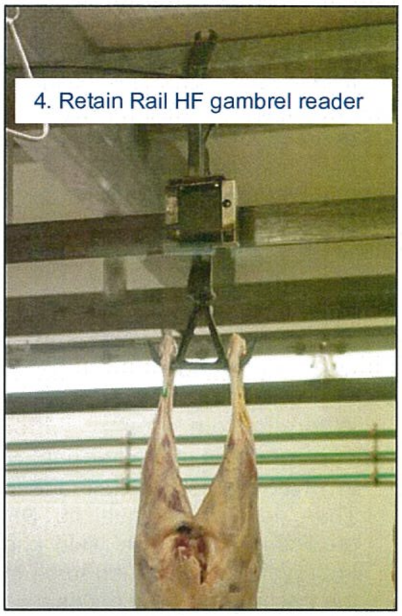
Any carcase entering the retain rail is recorded on the system by a HF gambrel reader at the entry to the retain rail. The system was designed to have a touch screen at the end of the retain rail to record the retained reason, but at this stage it has not been installed. The inspector would only have to tap the screen to record a comment against a carcase. Until the screen is installed, the comments are manually entered at the weigh station. Only obvious retain reasons can be recorded using the manual method.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Weight & Grade Station
At the weigh-scales a tripper detects the arrival of a new carcase, finalising the previous record and initiating the new record. The HF transponder in the gambrel is read by an elongated SCL HF antenna connected to a FEIG® HF reader.

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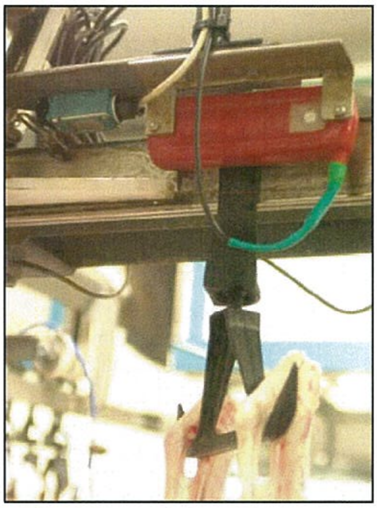
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Summary of system components:
- Gambrel RFID: 16mmØ Sokymat 161 13.56MHz Logi-Tag laundry transponders
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The system will allow producers who deliver RFID ear-tagged lambs to receive carcase information on individual lambs. This includes carcase weight, fat depth or score and potentially any fault and disease information. The ability to track individual animals through the abattoir will allow producers to compare different management or treatment regimes. For example, if producers wish to progeny test meat sires with known genetic merit (ie Australian Sheep Breeding Values - ASBV) over randomised ewes they could then evaluate the performance of the lambs from each sire. The use of superior sires for growth and leanness has been shown to significantly increase gross margin and decrease turn-off time.

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Where to from here

The principals of the tracking system can be adapted to most small animal abattoirs. It will need to be tested in an inverted chain abattoir and those that run at faster chain speeds (up to 10 carcases per minute).
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Full Report

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Further information

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Linking Live Sheep Data via RFID
Traditional (non-inverted) Chain

case study

Abattoir Sheep Carcase Tracking System

Aim
The aim of the MLA SCT.0005 project was to demonstrate a system linking live sheep carcase data via Radio Frequency IDentification (RFID) on a traditional (non-inverted) abattoir chain.

Background
Hillside Meats owner Peter Trefort wanted to be able to monitor the performance of individual lambs supplied to him by the producer members of the 'Q Lamb' alliance (see MLA supply chain case study #3/2005) so that he could provide them with better feedback on carcase performance. The Q lamb alliance and Hillside Meats have a very innovative partnership however feedback to suppliers was limited to individual carcase information by lines of sheep only. Information could not be related to the individual live animal.

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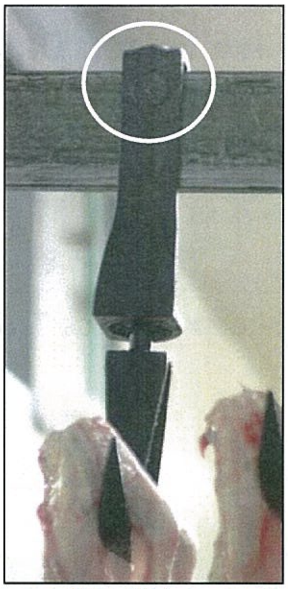

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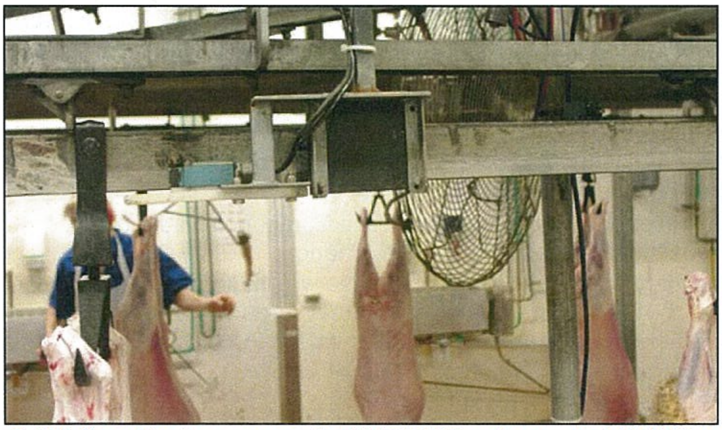

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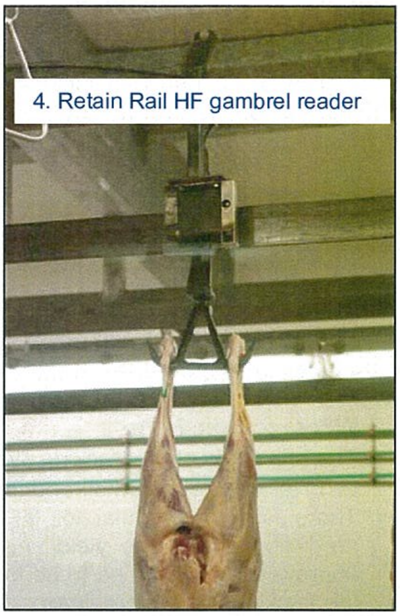

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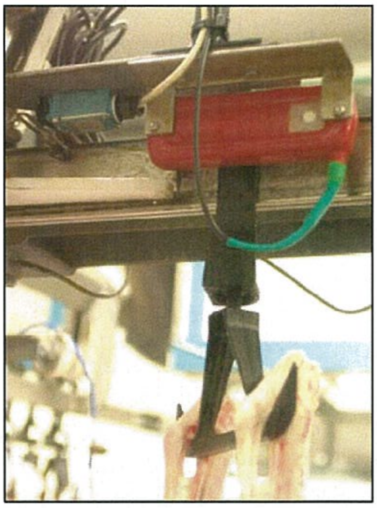

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Full Report
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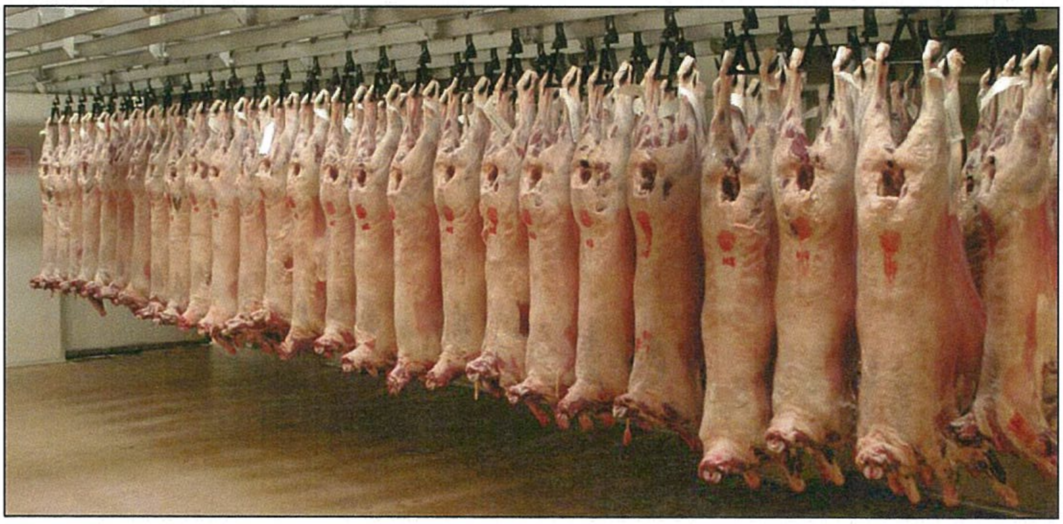

Linking Live Sheep Data via RFID

Traditional (non-inverted) Chain

case study

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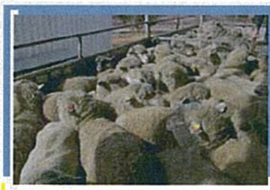

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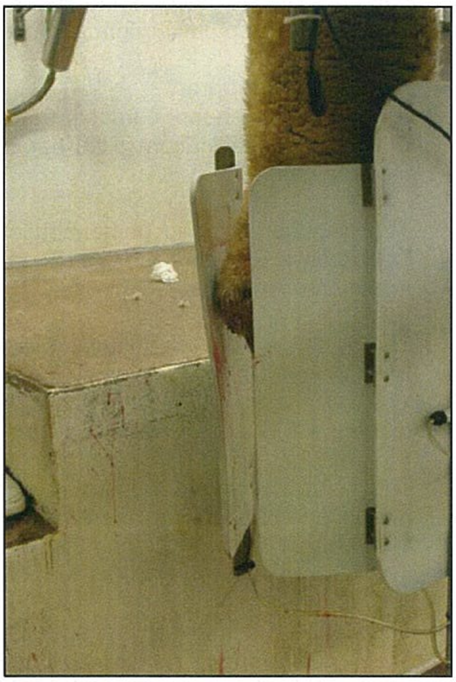

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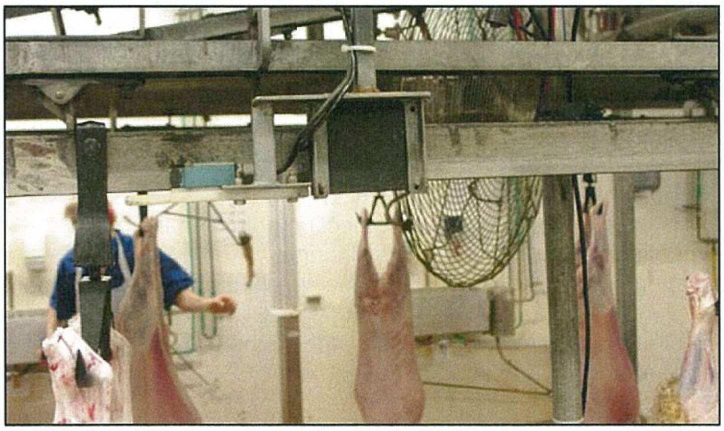

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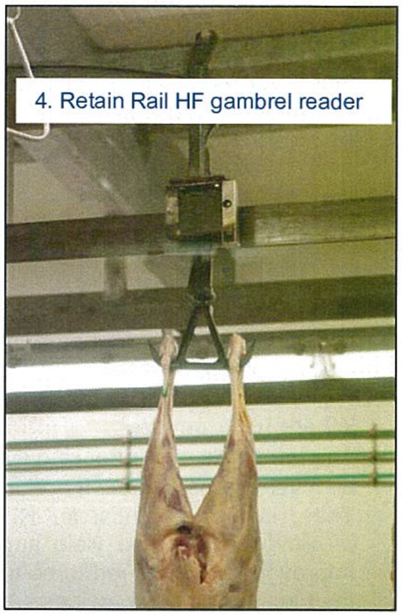
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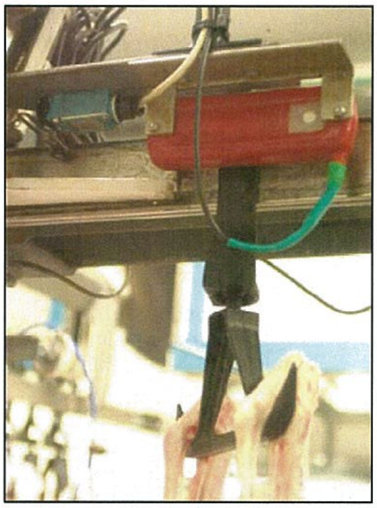
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