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The Importance of Utilising Electronic Identification for Total Farm Management: A Case Study of Dairy Farms on the South Coast of NSW

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Abstract

The introduction of the National Livestock Identification System (NLIS) within Australia empowers authorities with rapid and precise information however, it also provides Australian farmers with the opportunity to derive additional benefits for themselves via enhanced farm management practices. Radio Frequency Identification (RFID) is becoming globally recognised as the technology to implement animal identification and has become a mandatory form of livestock management in many countries. In accordance with this global trend, Australia has introduced the NLIS for the identification and tracking of livestock, subsequently placing Australia at the forefront of cattle traceability in the world. However, it is proposed that producers go beyond mere compliance, and take advantage of the RFID technology used in the NLIS to leverage additional benefits for themselves through enhanced farm management practices. This research investigates this concept and provides an ideal framework for the use of RFID technology for total farm management. At the core of this research are two case studies, undertaken on dairy farms on the South Coast of New South Wales. These case studies differ with regards to the use of RFID technology in their farming operations - from utilising little to no RFID technology, to a dairy farm with strong integration of RFID technology in their daily operations. It is believed that dairy farmers may be able to relate to these case studies in terms of their own current situation, or future plans for their dairy, subsequently aiding them to decide on their own utilisation of electronic identification for farm management. As a final endeavour, the research undertakes a cross-case comparison to provide a proposed framework with the aim to maximise the advantages and return on investment for farmers by utilising RFID technology for farm management. Some of the potential advantages explored include increased efficiencies, greater information availability, reduced feed and labour costs, improved milk quality and volume, improved herd health, ease of herd management and more. With the rapid growth of RFID technology for animal traceability, this research takes a step towards resolving the current gap in academic research, while also aiding to inform farmers of the range of opportunities provided by utilising RFID technology for farm management.

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Acronyms

BSE – Bovine Spongiform Encephalopathy (scientific name for ‘mad cow disease’)

EU – European Union

GPS – Global Positioning System

ID – Identification Devices

ISO – International Organisation for Standardization

IT – Information Technology

KPI – Key Performance Indicator

LCD – Liquid Crystal Display

National FAIR - National Farm Animal Identification and Records

NLIS – National Livestock Identification System

NSW – New South Wales

PDA – Personal Digital Assistant

QLD – Queensland

RFID – Radio Frequency Identification

RLPB - Rural Lands Protection Board

Abstract

This research aims to explore how the electronic identification technology of RFID (Radio Frequency Identification) can be utilised on dairy farms to enhance total farm management. There is a growing worldwide trend for countries to implement whole-of-life traceability systems for livestock, and RFID is clearly the dominant technology being chosen to achieve this. In line with this global trend, and to meet the requirements of key trading partners (such as the EU), Australia has implemented the NLIS (National Livestock Identification System) to provide whole-of-life traceability for livestock – a system based on the use of RFID devices. As such, it is proposed that dairy farmers utilise RFID so as to not only comply with NLIS requirements, but to extend the use of RFID onto their farms so as to provide additional benefits for themselves through subsequent enhancements in farm management practices.

This research is based upon two case studies of dairy farms located on the south coast of NSW (Australia). These case studies vary in their degree of electronic identification integration – ranging from having no use of RFID technologies to aid in farm management practices, to a dairy farm which may be considered advanced in their use of RFID technology, given the current state of the dairy industry and the technology. From these case studies it is believed that a pattern of increased benefits through the use of RFID technology is evident. Utilising these case studies as a basis, a theoretical framework for implementing RFID on dairy farms is then proposed, identifying mandatory and optional components for RFID implementation. Possible enhancements and future developments for RFID components are also identified and suggested throughout this framework.

It has been found that RFID technology provides the possibility for dramatic enhancements for total farm management, and thus is something that dairy farmers should investigate. However it is important that dairy farmers do not attempt to implement this technology simply because it appears the new trend. Rather, farmers should investigate the available technologies and associated benefits, and select an implementation of this technology that best suits their specific aims and requirements.

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Chapter 1 - Introduction

1.1. Introduction

Radio Frequency Identification (RFID) is becoming globally recognised as the technology to implement animal identification, and has become a mandatory form of livestock management in many countries (such as Canada, and some states of Australia), while other countries have begun trials of the technology (such as the United States of America). In the current global livestock environment, awareness, fear and recognition of animal borne diseases such as ‘mad cow disease’ have driven calls for reliable and effective systems for individual identification and tracking of livestock throughout the animals’ entire lifecycle. Such systems empower authorities with rapid and precise information (such as the animals’ farm of origin, cows it has been in contact with etc.), aiding them to take prompt and direct action to reduce the possibility of a disease outbreak. Considering this global trend towards the use of RFID for individual whole-of-life animal tracking, it appears that farmers will soon be utilising this technology, whether by choice or to meet a mandatory/obligatory requirement. As such, it is important that research be undertaken to identify how the electronic identification technology of RFID may be utilised to enhance total farm management, derive additional benefits and maximise return on investment for the farmer. The following thesis has been undertaken to address this need, specifically focussing upon RFID usage within dairy farms.

1.2. Background

1.2.1. What is RFID?

RFID is defined as “… a system that transmits the identity (in the form of a unique serial number) of an object or person wirelessly, using radio waves” (RFID Journal 2005a). This technology is commonly implemented using a system of reusable and programmable RFID tags (also known as transponders) and readers (also known as interrogators). These tags can be attached/built-in to virtually any good/object and provide a storage capacity of up to 2 kilobytes of data (RFID Journal 2005a). This allows more than just a unique identifier to be stored on the tag, but may also allow additional information pertinent to the object to be stored (such as expiration date, manufacture date, owner information etc.). The receiver can be a mounted or hand-

held computer-controlled device, and when a tag is brought within the reading range of a receiver, the receiver captures the data stored on the tag and forwards this to the host computer (Ames 1990, p. 1:5; RFID Journal 2005a; Williams 2004).

1.2.2. Characteristics of RFID – Active Vs Passive Tags

There are two main forms of RFID tags – active and passive. The primary difference between the two is that active tags have their own power source (typically a battery), and also incorporate a transmitter to enable communication, whereas passive tags do not. This power source provides active tags with a greater and more reliable read range, as well as greater data storage and transfer capacity than their passive counterparts. Active tags however, are significantly larger than passive tags (currently, the smallest active tag is approximately the size of a coin) and also come at a much higher cost. Active tags usually operate at frequencies of 455 MHz, 2.45 GHz, or 5.8 GHz, and have a typical read range of about 20 to 100 meters (RFID Journal 2005c).

Instead of utilising their own power source and transmitter, passive tags generate enough power from the RFID reader's signal to transmit their information. They do this by manipulating the energy (radio waves) sent from the reader, simply reflecting the energy back to the reader in a manner that the reader can interpret into data. Not incorporating a power source or transmitter enables passive tags to be much smaller (in 2004, the smallest commercially available device was 0.4mm x 0.4mm and thinner than a sheet of paper) and also dramatically cheaper. Sacrificing the power source however, means that these tags have a shorter read range, and cannot store as much information (Hecht & Hecht 2004; Ames 1990, pp. 1:15-16; RFID Journal 2005b). Passive tags operate at a range of frequencies, primarily low frequency, high frequency, and ultra-high frequency. Low frequency tags operate at 124kHz, 125kHz, or 135kHz, and have a read range up to 0.33 meters. High frequency tags operate at 13.56MHz and have a read range of up to one meter. Ultra-high frequencies operate anywhere from 860MHz and 960MHz, providing a read range of up to 3.3 meters (RFID Journal 2005b).

1.2.3. Advantages of RFID

RFID provides many advantages over other electronic identification technologies such as barcodes. These advantages include the ability to store more information, strong machine readability, fast read speed, and having no operating costs once implemented. Further, as their usage relies upon radio waves rather than line-of-sight technology, RFID tags do not need to be visually seen to be read – they simply must enter the scanning field of the reader. This therefore dramatically increases ease of use, as well as providing greater reliability in light of general wear and tear, and environmental elements such as dirt and dampness (Finkenzeller 1999, pp. 6-8). Such elements may render other line-of-sight identification technologies such as barcodes unreadable. Consequently, RFID systems have a wide range of applications in a number of industries.

1.2.4. Animal Identification and RFID

Animal identification is one of the most common applications of RFID technology, and one that has been pioneering the technology for almost 20 years (Accenture 2005; Finkenzeller 1999, p. 245). Focussing on the livestock industry, there are four main ways in which RFID can be used for animal identification – attaching a transponder to the collar, attaching a transponder in a tag form to the animals ear (similar placement to current ear tagging however utilised vastly differently), injecting tiny glass transponders under the animal's skin, or via a 'bolus' where the RFID transponder is mounted within an acid resistant, cylindrical housing which is inserted permanently within the animals stomach (Finkenzeller 1999, pp. 245 – 250).

1.2.5. RFID for Traceability and Farm Management

There is currently a worldwide trend towards improving traceability systems within livestock industries, and RFID is the primary technology of choice. Spurred by disease incidents from around the world, such as the Bovine Spongiform Encephalopathy (BSE, more commonly known as 'mad cow disease') outbreaks in the late 1990's, countries such as those within the European Union (EU) have enacted policies to ensure livestock can be traced through their entire lifecycle (Animal Health Australia n.d.). Programs such as these are designed to minimise or eliminate the spread of disease as authorities are able to trace origins of diseases, identifying farms and animals that may have been affected and subsequently they are able to take direct

appropriate action to minimise further spread (Food Production Daily 2004). Other countries such as Canada have enacted electronic identification legislation requiring all livestock to be tagged with approved RFID devices by September 1, 2006 (CCIA 2005), while America is currently operating voluntary trial operations utilising RFID tags as they consider a full individual animal identification proposal (Animal Health Australia n.d.; Goth 2005).

1.2.5.1. The Australian National Livestock Identification System

In accordance with this global trend, Australia has introduced the National Livestock Identification System (NLIS) for the identification and tracing of livestock. This system is a "… permanent whole-of-life identification system that enables individual animals to be tracked from property of birth to slaughter for food safety, product integrity and market access purposes" (Meat and Livestock Australia n.d.a). Utilising RFID tags, this system is designed to record and communicate all movement of cattle from a property (whether it be from farm to farm or throughout the livestock chain) to the central NLIS national database. This system will not only ensure compliance with the EU trading standards (and likely any other countries who may develop similar standards for whole-of-life traceability in the future) (Meat and Livestock Australia n.d.a), but the NSW Department of Primary Industries – Agriculture (2004) states that,

> *"Permanent identification will benefit the livestock industries by:*
>
> - *improving livestock traceability to reduce the impact of livestock disease and residue incidents;*
> - *making access to overseas markets more secure;*
> - *maintaining consumer confidence in Australian beef and dairy products;*
> - *offering producers improved herd management options; and*
> - *providing better proof of ownership to reduce stock theft."*

1.2.6. Focus Benefit of RFID

An important benefit listed above (section 1.2.5.1) is that of offering producers improved herd management options. As the global push towards mandatory RFID identification and whole-of-life traceability systems continues, it is proposed that farmers should take advantage of this situation, and extend the usage of this technology to enhance farm management practices. This research will investigate this concept and attempt to derive a possible ideal framework for the use of RFID technology for total farm management.

1.3. Literature Review

An abundance of literature is available regarding the technology of electronic identification, with its application for animal identification included as a topic in much of this literature. Entire websites such as RFID Journal (2005c), AIM Global (the Association for Automatic Identification and Mobility) (2005), RFID News (2005), RFID Times (2005), and many more sites are dedicated to electronic identification, providing an abundance of information, international news stories and developments regarding both the technology and the industry, including its applications for animal tracking. Authors such as Finkenzeller (1999) and Gerdemen (1995) devote entire books to the subject of electronic identification and RFID, while Finkenzeller (pp. 245-252) also briefly demonstrates its usage for the purposes of animal identification and tracking.

The major authors in this field are Geers et al. (1997), who devote an entire book to electronic identification, monitoring and tracking of animals. Providing information on current animal tracking technology, how they work, current applications, and possible future direction, Geers et al. demonstrate the growing awareness and importance of electronic identification for farm management. Considering improved disease and fraud controls, combined with the desirable and dominant cost-benefit ratio that can be derived from the utilisation of electronic identification for farm management, Geers et al. (pp. 26-28) provide a clear message that electronic identification is the likely path of animal identification in the future.

Michael's thesis (2003) further supports this view, providing an in-depth review of a wide variety of electronic identification technologies (including smart cards, barcode, biometrics etc.). A section regarding animal identification using RFID demonstrates that traditional forms of animal identification are considered inferior in comparison to RFID technology, while the application of RFID identification to improve farm management practices is also touched upon (pp. 239 – 240). Karnjanatwe (2005) provides an insight into an actual application of RFID technologies used to enable enhanced farm management of pigs, such as automating the feeding process and regulating how much each pig eats. Ishmael (2001) tells of the economic benefits achieved by a group of farmers resulting from utilising RFID technology to provide individual identification and subsequently enhanced farm management operations on their beef farm in America. James (2004) states how electronic identification can be used to reduce the labour required for the milking process, providing large cost savings, while Davies (1997) demonstrates the ability to improve the quality of milk yields through controlled feeding processes based on electronic identification. This literature demonstrates the rising recognition of electronic identification for animal identification and farm management practices, while also demonstrating that it does have practical applications for farm management and the ability to provide economic benefits for farmers.

1.3.1. Gap in the Literature

While there are vast amounts of literature on the technology of electronic identification and significant amounts of literature on its application for animal identification, there is a large gap regarding documentation of electronic animal identification for the purposes of improving total farm management practices, especially on dairy farms. Articles such as Ishmael (2001) and Karnjanatwe (2005) provide a glimpse of the possibilities for utilising electronic identification for enhanced farm management, however these articles are not focussed upon the dairy farm industry, nor do they provide an in-depth look at the total farm management operations used at these farms. Geers et al. (1997) do likewise, devoting a chapter to the electronic identification of farm animals, however this chapter does not have a dairy industry focus nor specific details of workflows etc. for farm management practices at such farms. Davies (1997) and James (2004) provide more information on deriving benefits specifically related to the dairy industry, however also lack depth

and explanations of the farm management practices undertaken to gain these benefits. This research project is intended to fill this gap, as it investigates and documents total dairy farm management practices with varying degrees of electronic animal identification integration, subsequently highlighting achievable benefits derived from such practices. The research will also provide a theoretical framework that may serve as a long term goal for the dairy industry to maximise benefits from further integration of individual electronic animal identification with farm management practices.

1.4. Objectives

1. To review the current literature on electronic identification for animals, with a view to identifying key methods of application (and the positives and negatives of each), subsequent management practices enabled, and possible future uses of such technology.

2. Through the use of case studies, investigate and document farm management practices with varied degrees of electronic animal identification integration on two dairy farms on the South Coast of NSW.

3. From the case studies of objective 2, identify and highlight demonstrable advantages that may be achieved through the use of electronic identification technologies at varying levels to enhance farm management practices.

4. Develop a theoretical total farm management framework for deriving the maximum benefits from integrating electronic animal identification technologies with farm practices.

1.5. Methodology

1.5.1. Research Design

The primary research method involved in this research project will be that of case studies undertaken on two dairy farms on the South Coast of New South Wales.
As Yin (2003, p. 14) describes,

> *"… the case study as a research strategy comprises an all-encompassing method – covering the logic of the design, data collection techniques, and specific approaches to data analysis."*

The data collection techniques utilised within this case study will include structured, semi-structured and unstructured interviews, observation, and document analysis. Utilising this range of complementary data collection techniques will help to overcome inherent weaknesses of each individual technique, thus providing a more accurate and reliable case study. The data gained from each case study will be analysed and documented using primarily workflow diagrams and descriptions (Yin 2003).

1.5.2. Case Selection & Characteristics

These case studies of dairy farm management practices will take place on two dairy farms on the South Coast of New South Wales, Australia. These case studies will differ in their use of electronic identification in their farming operations, from utilising little to no electronic identification (Case study A – 'Traditional'), to a dairy farm with strong integration of electronic identification in their daily operations (Case Study B – 'Advanced RFID'). At both levels, process flows are expected to differ, and demonstrable benefits are expected to be identified and highlighted as the usage of electronic identification increases.

1.5.3. Cross-Case Comparison

A theoretical framework will then be derived to illustrate a suggested approach to the use of electronic identification technology (primarily RFID technology) for total farm management (Yin 2003). This cross-case comparison will be designed with the aim to gain maximum advantages and return on investment for the farmer from utilising electronic identification and tracking practices for farm management.

While the cross-case comparison study will be designed so as to be functional and practical, it may be considered idealistic in the current farming environment and technological environment. As such, the framework suggested may be considered a possible long term goal for dairy farm management practices, considering developments in electronic identification technology such as RFID technology are

expected to bring about both a reduction in costs for the technology and increased functionality.

1.5.4. Feedback and Validation

An important element of this research will be continued interaction, feedback and validation from the owners of both farms. After documenting each of the case studies, the farmers will be requested to provide feedback and approve the documented workflows. This will also be repeated for the proposed framework, in which both farmer's insights and feedback will be sought to provide another perspective to aid in validating the proposed model.

1.6. Limitations/Scope

There are two main areas of limitations associated with this research project. These are the geographical limitation, and the industry type.

This research project is focused on dairy farms located in the geographical area of the South Coast of New South Wales, Australia. However, as dairy farm practices are expected to be similar throughout the whole of Australia (and possibly the world), it is expected that this research will be relevant to the whole dairy farming industry of Australia, despite it's original limited geographical area of study. Similarly, it is expected that this research may be adaptable and useful to other countries in which electronic animal identification is being explored or is mandatory, however regulations and precise workflows may differ.

Regulations currently also differ slightly between states, and as such, elements of this research regarding regulatory requirements and methods of compliance are specifically related to dairy farms in the state of New South Wales. Despite this current issue, this research will be easily adaptable to suit specific regulatory differences between the various states of Australia.

Further, this research is specifically focused upon the dairy industry. Other farming industries such as beef, sheep, pigs and the like may find some relevance and derive some usefulness from this research, however they are not the primary focus group.

1.7. Justification

RFID is becoming globally utilised for implementing individual whole-of-life identification and tracking systems for livestock. Such technology and systems are now mandatory in many countries such as Canada and some states of Australia, while countries such as the United States of America are currently trialling the concept. Whether by choice or to comply with a regulatory requirement, it appears evident that farmers will soon be investing in, and utilising the technology of RFID for the purpose of individual livestock identification. Considering this, it is important that research be undertaken to identify ways in which farmers can derive additional advantages from their utilising this technology. This research has been undertaken to address this need.

Chapter 2 – Literature Review

In order to understand the topic of utilising electronic identification for total farm management, it is important to review the current literature in the field. This section aims to achieve this, providing the reader with an understanding of the topic, while identifying and evaluating the relevant literature. Section 2.1 will provide an overview of the technological foundations of RFID. Section 2.2 will detail the characteristics and advantages of RFID. Section 2.3 will describe the benefits of using RFID for farm management. Section 2.4 will detail Australia's traceability system. Section 2.5 will define the RFID standards relevant to electronic animal identification. Section 2.6 will demonstrate the possibility for RFID to be utilised as a temperature sensing device. Section 2.7 will demonstrate the current application of RFID technology on farms, while section 2.8 will provide an alternative technological approach to farm management that incorporates, but is not limited to the use of RFID. Section 2.9 will identify the literature gap that this research will attempt to fill, before section 2.10 concludes the chapter.

Geers et al. (1997) is certainly the most comprehensive literature on the topic of electronic animal identification. Dedicating an entire book to the topic, Geers et al. cover many of the concepts, ranging from the basic technical design of RFID tags and their transmission characteristics, through to documenting real life cases where animal identification is currently being used and how it may be used in the future. As such, this work will be referred to commonly. Geers et al. are brief on some topics however, and occasionally become quite technical, possibly too technical for the majority of people to understand. This work from 1997 is ageing also, as RFID developments move forward rapidly, and hence it is also important to investigate other literature to gain additional perspectives and keep in touch with modern times.

2.1 RFID – The Technology

2.1.1. RFID History

Want (2004) points out that RFID has actually been around since World War II. RFID Journal (2005a) elaborates, demonstrating that RFID was first used by the British as a way to identify their own planes on radar. However since this time it has kept

somewhat of a low profile, being utilised in relatively small deployments in narrow, yet high-value areas that the public rarely knew about.

2.1.2. Growing Popularity

In recent years however, RFID has been one of the major headlines in technology. Want (2004) claims that this recent popularity is due to the 'window of opportunity for deployment' (which all technologies go through) having arrived for RFID. This window is related to the scope of the problem being solved, the maturity of the technology, and the cost of deployment. On all of these fronts, the world has changed over the past forty years, bringing RFID into the limelight in current times. The need for more efficient inventory tracking, improved RFID tag capabilities such as greater reading range, faster data transfer speeds, the development of standards and of course, the fundamental factor of reduced costs (as discussed in the section 2.1.3) are all factors that have played a key role in bringing RFID to it's current state of growing popularity and adoption.

2.1.3. Reduced Costs

As Want (2004) notes, one of the most fundamental factors to RFID's growing popularity is a drastic reduction of cost. In modern times, the cost of deploying the technology is now becoming justifiable, with tags now priced at less than 50 cents per tag for small quantities. RFID Journal (2005b) confirms this claim, stating that tag prices currently vary from as little as 20 cents to a few dollars for the most basic passive RFID tag, while active tags may range from $10 to $50.

Want (2004) places these costs into perspective, comparing RFID to the cost required to print some lines on an object, as is required for bar code systems. Analysts believe that a tag must cost less than 5 cents (some say one cent) for RFID to truly be competitive with barcode technology – a price which RFID has not quite reached, however it is also noted that the current price could be reduced in the future if adoption of RFID continues as expected. RFID provides a number of advantages (as described later) that assist it to overcome the cost boundary.

2.1.4. Factors Slowing Uptake

ICF Consulting (2004) states that despite RFID's growing popularity, it is still somewhat in the early adoption phase of the technologies life cycle. Several factors currently exist that are preventing RFID from launching into mass adoption. These include the fact that tags are still more expensive than bar codes, and also that RFID performance is affected by antenna patterns, environmental interference and tag orientations (readers cannot communicate effectively with tags that are oriented perpendicular to reader antennas (Want 2004)).

2.1.5. Moving Forward

Want (2004) shares this viewpoint on current obstacles, however concludes that RFID is a technology that can provide considerable value due to increased efficiencies and subsequent reduced labour time. He believes issues such as those aforementioned are likely to be resolved as interest and funding grows, and that enough progress has now been made so that large-scale deployment of this technology is beginning.

Byteline Desk (2005) supports Want's viewpoint, as the author believes that RFID will become more common in business and government in 2005, resulting in increased efficiency and productivity. Several industries are identified to likely increase adoption of the technology in varying ways this year, including the supply chain, logistics operations, transport, pharmaceutical industries and most relevant for this research – the area of farm management. The article claims that RFID heralds a new era in animal husbandry, as livestock can easily be identified and traced for recording, reproduction and feeding information. Considered to be most commonly implanted in the ear, RFID tags can contain information enabling animals to have their own tailored diet, varying the times and amount of feed provided depending on the attributes of the animal, such as age, weight and health. Such data can be further utilised with specialised farm management software, enabling improved disease control, calculations on food conversion etc.

Wants' positive perspective on RFID entices the audience to believe in RFID and its legitimate future uses. This perspective however, can be seen to be supported from a number of authors, including Byteline Desk (2005). Suitably, Want also weighs up his discussion by recognising the current issues that must be addressed for RFID to truly

reach mass adoption for a range of industries, a viewpoint shared by ICF Consulting (2004). This adds credibility to his work, as does his position as a member of Intel's research department.

2.1.6. Desired Frequency for Dairy Farm Management

Agri Signal Inc. (n.d.) advises that,

> *"When using RFID to identify livestock, do not be too concerned with the specified read range. The most important criteria should be that the RFID system is designed so that it is nearly impossible to not obtain a valid read of the tag. Numerous presentations, extended time in the read field, tag/reader orientation concerns and excessive environmental interference are some of the problems that should not be tolerated."*

This certainly appears sound advice, and Agri Signal Inc. back up their statement with statistics, stating that when properly engineered, the short read range (low frequency) technologies will give read probabilities approaching 100%. Longer read range (high and ultra-high frequency) systems can provide a read probability of as little as 50-60%. Phillips, TAGSYS & Texas Instruments (2004) concur with this issue. Considering this advice and the characteristics described of the three different ranges, it appears that then low frequency RFID is best suited for animal identification and farm management applications.

2.1.7. The RFID System

RFID Journal (2005c) provides a simple description of what is involved in an RFID system, stating that,

> *"The concept is simple: Place a transponder—a microchip with an antenna—on an item and then use a reader—a device with one or more antennas—to read data off of the microchip using radio waves."*

This simplified view is expanded upon by Geers et al. (1997), who provide a strong overview of the elements involved in an electronic identification and monitoring system for animals. They state that three functional aspects are required for such a

system to operate - firstly, a device that is associated with the animal or object (such as an RFID tag); secondly, an activating/reading device (such as an RFID reader); and finally software (something to store/manipulate the data gained from the devices into information useful to the user). Geers et al. further stipulate that the device associated with the animal should be small, lightweight, robust, and should have an operational life span greater than that of the relevant animal. RFID technology provides devices to cater for all of these desires and requirements, as well as providing additional benefits.

2.2. Characteristics and Advantages of RFID

While catering for all of the above requirements for an electronic identification and monitoring system for animals, RFID also provides other distinct advantages over competing technologies such as barcode. These advantages include the ability to store more information, strong machine readability, fast read speed, and having no operating costs once implemented (Finkenzeller 1999, pp. 6-8). The key advantage of RFID is that it does not require line-of-sight for effective communication. Instead, RFID tags just need to be within range of an RFID reader so as to facilitate communication of data via radio waves (rather than being visually read from the tag as occurs with technologies such as barcode). This means that even in the presence of dirt, grease etc. readers will still be able to communicate with the tags, whereas such conditions would render many other technologies inoperable. Similarly, surface damage to the tag does not affect reading performance or accuracy, and the case material can even be selected to withstand chemical attack (Sirit n.d.).

Greater accuracy is provided by RFID tags/transponders, as many feature error checking procedures so as to ensure reliability of data transmission. Similarly, RFID tags are characterised by improved security over many other technologies, as data stored on tags/transponders cannot be unintentionally changed, and tags are not easily replicated. Additional benefits are also derived as the tags can serve as portable databases, storing information on the animal they are attached to. A transponder can store its unique unalterable identification code, together with additional variable information (Sirit n.d.). Some tags (such as Sensormatic's SmartEAS tag) provide the capability for information to be read, deleted and updated by readers (just like a computer hard drive) from these tags (Sensormatic 1998). Phillips, TAGSYS & Texas

Instruments (2004) support the above advantages, while adding a further unique advantage of RFID, in that it is the only technology that facilitates simultaneous identification of objects. Unlike other technologies where objects must be read individually, numerous RFID transponders provide the ability to read data from multiple transponders effectively at the same time.

The above listed literature – Sensormatic (1998), Sirit (n.d.), Finkenzeller (1999) and Phillips, TAGSYS & Texas Instruments (2004), all appear to support each other's perceptions of advantages for RFID. Some list advantages that others don't, and some focus on specific areas, however combined they complement each other to provide a solid list of advantages provided by RFID technology.

2.3 Benefits of Using RFID for Farm Management

There are several strong factors driving the use of RFID for farm management.

2.3.1. Financial and Managerial Benefits for the Farmer

The first reason is for increased profitability for the farmer, and assistance with managerial procedures on the farm. Geers et al. (1997) note that despite electronic identification of farm animals being more expensive than traditional forms of identification, it allows for a faster payback on investment through exploiting a wider range of possible applications. Identification can be used to facilitate control activities on farms, including:

> *"... follow-up of premiums, milk-record control, tracing back of transit and disease prevention, progeny testing and herdbook administration, electronic feeding stations, automatic gating in group housing facilities, accountability to markets and slaughterhouses, animal health control, public health control, animal welfare surveillance, prevention of fraud, tracing back of stolen stock, facilitating trade, central database facilities"* (Geers et al. 1997, p. 39).

Geers et al. continue, stating that in the modern farm environment, farming needs to manage more animals to be cost-effective. Consumers also have an impact on what

farm management should be, and subsequently, management processes become increasingly difficult for the farmer. Electronic identification can strongly aid a farmer in their managerial efforts, while also deriving financial benefits from exploiting an increased range of possible applications.

2.3.2. Worldwide Trend for Traceability

A second primary driver for the move to RFID for farm management is to conform to the current worldwide push to introduce individual whole of life tracking programs for livestock.

In the wake of recent disease outbreaks amongst livestock (such as 'mad cow disease' and foot-and-mouth disease), countries around the world are implementing policies and procedures to ensure individual whole-of-life traceability for all livestock. RFID is the technology of choice for these solutions. Countries such as those within the European Union have enacted policies to ensure livestock can be traced through its entire lifecycle (Animal Health Australia n.d.), Canada has enacted legislation requiring all livestock within Canada to be tagged with an approved RFID device by September 1, 2006 (CCIA 2005) and America is currently operating voluntary trial operations utilising RFID tags while considering a full animal identification proposal. (Animal Health Australia n.d.; Goth 2005). Rizoli (2003) notes that trials of RFID technology for identification and tracking of livestock have been taking place in America since 1998, when the National Farm Animal Identification and Records (National FAIR) pilot project was launched.

2.3.2.1. Purpose of the Programs

These whole-of-life traceability programs are designed to record and present accurate and up-to-date information regarding all cattle movements. Such systems enable authorities to rapidly trace the origins of any cattle diagnosed with a serious contagious disease (should one ever occur), identifying farms and animals that may have been affected, or even been the source. Subsequently, they are able to take direct appropriate action to minimise further spread (Food Production Daily 2004). Rizoli (2003) further notes that such traceability systems are required so as to reduce the possible impacts of a terrorist attack upon the livestock industry. Rizoli quotes National FAIR Director Robert Fourdraine as stating in regards to terrorism that,

> *"One outbreak of disease (among livestock) can be isolated and contained… But if someone were to introduce foot-and-mouth disease in several different places at once it would shut down the food supply".*

This viewpoint is also recognised by Nagl et al. (2003), and raises an interesting point and benefit of the current systems being implemented.

2.3.2.2. Infeasibility of Traditional Identification Methods

Geers et al. (1997, p. 26 - 27) notes that traditional identification methods certainly could not provide the reliability and accuracy being sought by current requirements. Traditional ear tags are reported to be lost 5 to 60% (Aarts et al. 1992) of the time, while brands or tattoos on cattle can be damaged or fade away. A further key drawback of such traditional systems is that they require visual detection and must be recorded manually, which can easily introduce human errors, while the labour cost of such a practice is also high. Reading errors are estimated to occur in six of every 100 animals processed via traditional mechanisms, while electronic devices are estimated to produce only one error for every 1000 animals (Austin 1995 quoted in Geers 1997, p. 27). From such estimations, it is blatantly obvious that electronic identification provides dramatic advantages and enhancements that traditional farming identification technologies can not provide.

The need to control disease outbreaks is obvious, and it is no surprise to see many of the authors describing the systems being put into place as being from Government departments. This aids to demonstrate the recognition within Government of the requirements and issues currently involved in RFID for livestock. Authors Rizoli (2003) and Nagl (2003) make an interesting point regarding terrorism, which is not something immediately obvious within livestock, however upon consideration it appears entirely possible that such an attack could take place. Subsequently, their points regarding the requirement for RFID traceability programs so as to reduce the threat or impact of a terrorist attack appear quite valid.

2.3.2.3. Cost of Implementing Nationwide

Forster (2003) provides an estimate of how much it would cost to implement a whole-of-life electronic identification system in America. The cost of implementing such a system is estimated to range from $US2 to $US10 per head of cattle. Considering the 96 million head of cattle in America turning over a rate of approximately 35 million a year, top of the range chips are expected to cost about $US350 million per annum. Administering and maintaining the national database of information on each animal will provide a further cost, and understandably, debate over who will pay for such a system is quite intense. Considering such costs, it is likely that similar debates will be ongoing in many countries in the near future.

The figures quoted in this article are from 2003, and considering the trend of RFID costs to decrease over time, it can be considered that the costs for the present time will be less than the values specified in this article. The amount of cattle may also have changed, rendering the already wild estimate further unreliable. However the figures do provide a good example of the large costs involved in implementing such an RFID system.

2.4. The Value of the Australian Dairy Industry

The Australian dairy industry is valued at approximately $8 billion (Dairy Australia 2005). In 2004, this industry was composed of 9, 611 registered dairy farms, hosting an estimated 2, 028, 000 dairy cows. Internationally, Australia ranks third in terms of world dairy trade (Dairy Australia 2004). Thus, it can be seen that the Australian dairy industry is certainly large and valuable.

2.5. Australia's Traceability System

2.5.1. The National Livestock Identification Scheme (NLIS)

In order to maintain trading relations with major customers and competitors (primarily the EU), Australia has developed its own individual whole-of-life traceability program for livestock – the National Livestock Identification Scheme (NLIS). This system is a "… permanent whole-of-life identification system that enables individual animals to be tracked from property of birth to slaughter for food safety, product integrity and market access purposes" (Meat and Livestock Australia

n.d.a). Utilising RFID tags, this system is designed to record and communicate all movement of cattle from a property (whether it be from farm to farm or throughout the livestock chain) to the central NLIS national database. This system will not only ensure compliance with the EU trading standards (and likely any other countries who may develop similar standards for whole-of-life traceability in the future) (Meat and Livestock Australia n.d.a), but the NSW Department of Primary Industries – Agriculture (2004) states that,

> *"Permanent identification will benefit the livestock industries by:*
>
> - *improving livestock traceability to reduce the impact of livestock disease and residue incidents;*
> - *making access to overseas markets more secure;*
> - *maintaining consumer confidence in Australian beef and dairy products;*
> - *offering producers improved herd management options; and*
> - *providing better proof of ownership to reduce stock theft."*

2.5.2. Devices Utilised in the NLIS

There are currently only two types of devices approved for use in the NLIS – a rumens bolus or ear tag utilising a low frequency RFID transponder. Both of these devices may be read while attached to the animal. No microchips (RFID devices placed under the animal's skin) have been approved for use in the NLIS as yet.

2.5.3. State Control but National Scheme

This system is coordinated at a state level, and has been compulsory in the state of Victoria since 2002 (Animal Health Australia n.d.), while New South Wales has enacted legislation to ensure state compliance with this system by the 1st of July 2005 (NSW Department of Primary Industries – Agriculture 2004), the same date that Queensland initiated the first of three phase-in stages (QLD Department of Primary Industries and Fisheries 2005). For the other states within Australia the system is currently only voluntary. However, the system will be implemented nationally in the

near future, as all states/territories have agreed to progressively implement the NLIS (Victoria Department of Primary Industries – Agriculture and Food 2005).

2.5.4. New South Wales NLIS Regulations

The following information pertaining to the NSW NLIS database (including approved NLIS devices and costs section) is drawn from the NSW Department of Primary Industries – Agriculture (2004) information website for the NLIS. Under the current NSW arrangements,

> *" - For the "phase in" year to 30 June 2005, cattle born from 1 July 2004 will have to be identified before they leave their property of birth.*
>
> *- From 1 July 2005, all cattle, irrespective of age, will have to be identified before they leave any property.*
>
> *- From 1 July 2005, saleyards will be required to notify the NLIS database of all cattle being sold. Abattoirs will be required to notify the database of all cattle slaughtered.*
>
> *- From 1 January 2006, all movements of cattle between properties must be notified to the NLIS database."*

Once fully implemented, all cattle that leave a property for any reason must be identified with an RFID tag and notification of the movement must be provided to the NLIS. Cattle that stay on their property of birth (as may happen for dairy cows) are not required to be identified, however the department states that the identification process may still be used if farmers wish to use the NLIS system for management purposes or to help with the recovery of cattle should they ever be stolen.

2.5.4.1. Moving Cattle and Who's Responsible

When cattle leave the farm, even if on the way to an abattoir, they must be tagged and registered. From the 1st of July 2005, if cattle move to a saleyard or abattoir, it is up to the saleyard, agent, or abattoir to notify the NLIS of the movement of the cattle. From 1st of January 2006, if cattle move directly between properties for any purpose, it is the responsibility for the owner of person in charge of the cattle at the receiving property to notify the NLIS database of the movement.

2.5.4.2. Approved NLIS Devices

To be approved for use in the NLIS, RFID devices must move through a process of examination and authorisation by a standards committee. This committee is charged with ensuring that proposed devices are of the correct electronic type, and meet national standards for quality and data retention. Approved NLIS devices are clearly identifiable as they feature the NLIS logo printed on them. It is an offence to use an unapproved RFID device, and also illegal to remove a functioning NLIS tag from an animal.

RFID identification devices (tags or boluses) are mandatory under the NSW NLIS scheme, however other available RFID components, such as readers, are not. Use of these additional components is left to the farmer's discretion.

2.5.4.3. Pricing & How to Purchase the Devices

Currently, all devices are available for purchase from Rural Lands Protection Board (RLPB) or from the farmer's rural merchant. The cost of an NLIS approved ear tag is approximately $3.50 per tag, while rumen boluses are slightly more expensive. There are no price estimates available for microchips as none have been approved to date.

The above information (section 2.5.4) is provided by the NSW Department of Primary Industries – Agriculture (2004). As such, it is the most credible source of information for the NSW NLIS, and provides a comprehensive wrap-up of the key issues and questions in implementing this system.

2.5.5. International Recognition of the NLIS

RFID vendor Aleis International speak highly of Australia's NLIS, stating that "The eyes of the world are firmly fixed on Australia as it continues to pioneer cutting-edge traceback and integrity management systems… It [the NLIS] is the largest and most sophisticated livestock database and management system currently in the world" (Aleis International n.d). Carrying such glowing statements through international markets will surely aid to promote Australia's ability for RFID adoption and disease-free animals throughout the world.

This glowing recommendation can be considered highly credible, as it would be expected that international RFID vendor Aleis International would be well aware of the various identification schemes adopted by various countries around the world. Being an Australian based company may pose a question of bias in their views however. Australian company Electro-com provide a degree of support for Aleis's statement, as they also state that the "Australian NLIS is the largest implementation of animal tracking in the world" (Electro-com 2004). This statement may also not be free of bias, however the two do back one another up, aiding to provide validity for the comments.

2.6. RFID Standards

There are two main standards that are relevant to electronic animal identification. These have been defined by the International Organisation for Standardization (ISO):

ISO 11784 – This international standard represents the structure of the radio frequency identification code for animals. This standard allows the bits communicated by the transponder to be interpretable by the transceiver (Geers et al. 1997, pp. 32-33; Eradus 2001, pp. 16-17).

ISO 11785 – "This international standard describes the accepted protocol for transmission between the reader/scanner/interrogator and the transponder (tag)" (BeefStocker USA 2004). A central aim in the development of this standard is to facilitate communication with transponders from a wide range of manufacturers with a common receiver (Finkenzeller 1999, p. 160).

As these are defined by the ISO, they are voluntary standards, and as such, there is no guarantee that vendors will elect to take up these standards if they feel that their own standard will achieve greater benefits for them. However, as consumer desires for compliance increase, and co-operation between vendors continues to grow (Anonymous 1999, p. 25), it can be seen that these standards are likely to play a dominant role in the future of RFID technologies.

Currently, a large number of vendors now design their readers and transponders to conform to these standards, aiding to remove incompatibilities between manufacturers. Such companies include the popular Texas Instruments (2004), and Allflex Australia (n.d.a) (who consider themselves the number one company in livestock identification). With such strong backing these standards look certain to have an impact and remain involved in the development of RFID devices for animal identification. They are also well documented, with three credible sources such as Geers et al. (1997), Finkenzeller (1999) and BeefStocker USA (2004) all featuring the standards. As the popularity of these standards grow, those vendors that elect not to comply risk being outcast from the market, as consumers will desire the device (tags and readers) that offer the most compliance with other devices (Anonymous 1999, p. 25; Ishmael 2003b, p. 16).

2.7. RFID Temperature Sensing (Bio-thermo RFID)

"Temperature is the most important parameter to monitor in livestock" (Higgins 2003). Higgins (2003) interviews Digital Angel's CEO Randolph Geisler, so as to gain an understanding of Digital Angel's relatively new bio-thermo RFID microchip. These microchips are injected into the animal (under the skin), and provide temperature readings when interrogated by an RFID receiver/scanner. The article considers temperature fluctuations to be a great indicator of health problems in livestock.

Hostetter (2003) also interviews Geisler, and subsequently provides a similar view of the technology. The article notes that if any unusual temperature readings arise, then a farmer can be notified and take appropriate actions, such as removing this animal from the rest and checking it for illness. Hostetter notes that Digital Angel is looking to advance this technology in the future, so as to possibly provide information on an animal's hormonal changes, blood pressure and even possibly disease identification. Conceding that most serious diseases may not be identifiable without extensive testing such as brain tissue, Hostetter notes that Geisler hypothesises that if someone can find a way to identify such diseases from another more measurable attribute of an animal then RFID may be the devices to perform this monitoring.

This bio-thermo technology provides a large range of benefits and possible uses. The ability to detect ill health before it progresses enough for visual signs to be evident is

a highly useful device, and may be able to prevent the spread of illness through a group of livestock. These two articles are quite similar in their explanation and examples of the technology, however this is to be expected when they both interview the same person. Hostetter takes the discussion a little further however, and allows Geisler to reveal that they plan to provide further advances in livestock monitoring, which would be a great advance for RFID technology and livestock management on the whole.

2.8. Current RFID Farm Applications

The following are existing farm management practices that are deriving benefits from the use of electronic identification technologies. These applications provide examples of ways in which electronic identification can be used to exploit new opportunities, as stated by Geers (1997) (noted in section 2.3.1).

2.8.1. Reducing Labour Requirements

James (2004) provides an article describing direct benefits found by dairy farmers derived from the use of electronic identification. James states that ear tag recognition can be used to segregate cows as they pass through the milking parlour, reducing labour requirements on dairy units by up to £20, 000 per year. Providing a real life example of a milk producer, the article describes a farmer who fitted his cattle with an electronic ear tag costing £3 each. He utilises these tags to implement automatic segregation of cattle on their way to milking. As they head to milking, they pass through a race that contains gates to different areas, one to the milking parlour and one to another paddock. As the cattle move through the race, their electronic identification devices are read. The gate to the milking parlour will open for those cows specified to be milked on the computer, while the gate leading to the other paddock will be the one to open for the rest. To perform such a task would have previously required the farmer to hire additional labour, however this is no longer required with the use of automatic identification devices, and the farmer may continue to expand his herd.

In another example from James, a farmer utilises automatic identification techniques so as to facilitate expanding his herd size from 280 to 450 cows. Automatic identification devices are estimated to cost the farmer an additional £6,000, however

he estimates that it will reduce his labour bill by approximately £20,000 a year, thus providing an excellent cost-benefit ratio.

It can be seen from this article that electronic identification is providing real savings for dairy farmers. In these examples, the savings are being realized primarily due to a reduction of labour costs. This author has obviously targeted the article towards those in the dairy industry, as she uses terminology that is specific to this industry. It would have been beneficial if she explained these concepts and terminology, especially considering it may be read from others outside the industry due to the importance of the information being presented.

2.8.2. Controlled Feeding

An article produced by 'Yoke-L' (n.d.) – a dairy cattle feeding system designed for operation inside a feeding parlour - describes the advantages that it offers for improved management of feed for the herd through electronic identification. The Yoke-L system can identify cows and provide individual cattle their specified rations, according to their lactation 'calendar'. Many electronic identification systems can do this, however Yoke-L defines itself as being unique as it can mix forage and high protein additives. The feeding design features feed barriers with moving bail arms that provide access to the food. Mixed feed is spread along the trough or floor behind the feed barrier and supplements are added to this.

The farmer can vary the quality of the feed each stall, placing high quality feed in some, and lower quality feed in others. This variation enables the high yielding cows to be given higher quality food whilst cheaper food can be given to those cows nearing the end of their lactation cycle, and producing less milk – obviously a more cost effective feeding system, while maximising the potential for milk production.

Yoke-L identifies and distinguishes between cows by electronic identification ear tags placed on each cow. As the cow approaches the feed barrier, the tag is electronically read, and the cow's identity number is compared with a database to derive her milk yielding value. A computer then

> ***"…*** *decides whether she is entitled to the quality of feed at that position; if she is the bail arm opens and she can eat; if she is not,*

> *the bail arm stays closed and she wanders off to try her luck elsewhere"* (Yoke-L n.d.).

Despite demonstrating cost savings through electronic identification, this article is somewhat misleading. The article initially identifies Yoke-L's ability to 'mix and match' ingredients as the key aspect that gives this feeding system its advantage over others. Similar language and writing style to this leads the reader to believe that Yoke-L is actually mixing the feed for each cow and providing it in the trough as per individual requirements or rules depending on the amount of milk the cows are yielding, readable from their RFID tags. However when the reader approaches the bottom of the article it becomes apparent that Yoke-L is not mixing the feed, but rather it is essentially mixing the cattle who are allowed access to the already varied feed. It is up to the cows themselves to find a feed barrier with food behind it that is of correct quality for their current needs, and not the other way around. Coupled with the cows changing lactation cycle (and thus varied milk production output), this may be a tricky concept for them to grasp, as they may be unable to identify a pattern in feeding arrangements. Additionally, information regarding how the feeding barriers are programmed to allow or deny cows entry would have been beneficial for this article. If such a system does work however, the cost benefits of saving high quality food could be significant for the farmer.

2.8.3. Improved Milk Yields and Reduced Operator Stress Through Controlled Feeding

Davies (1997) provides an example of how electronic identification has been used to provide measurable results in improved feed efficiency and increased milk yields. The article describes an electronic identification setup worth £9, 000 that was implemented in 1996 by large dairy RFID vendor Agricultural Technology Ltd. The system utilises individual passive RFID tags on each cow, combined with antennas at each stall within the feeding parlour. When a cow moves into a stall, these antennas interact with the tags to generate the required electromagnetic energy field, and a reader installed within the parlour receives the data. A unique piece of this design is that it utilises only one reader for the parlour, which can read data from up to 1000 antennas. The computer control unit for this system manages parlour feeding and milk yield records.

Davies also states that the unit can store animal health information, and can be connected to a standard personal computer, thus enabling two way data exchange.

Under this system, cows enter the feeding parlour, and must enter the feeding stall directly beside the cow in front (which they apparently learn to do very quickly). Once they enter the stall, feed will only be released if the stall in front of them is occupied, and that occupant has been identified by the system and fed. Once this occurs, a predetermined amount of feed is automatically released to the newly identified cow. The farmer notes that the investment into electronic identification wasn't a luxury, but rather a necessity, so as to reduce his stress levels and provide improved feeding accuracy. He states that measurable benefits have been realised, as,

> *"Before the change rolling average yield was 6500 litres a cow, of which 1932 litres came from forage. It is now 7300 litres, including 3000 from forage. Margins over purchased feeds have increased from £1300 a cow to £1438. Milk quality has also improved"* (Davies 1997).

Obviously this demonstrates significant benefits gained from the usage of electronic identification. The farmer also claims he is much happier since the technologies introduction, and the cows are also more relaxed. However, he doesn't attribute all of these benefits to electronic identification, as he states that his farm is trying hard to improve all areas of management, but this system certainly assists as at least know they know that the cows are receiving the right amount of feed every time.

It is certainly obvious from this article that significant gains were realised due to automating the feeding procedure through electronic identification. However, Davies leaves a lot of gaps in the article, and many assumptions have to be made to gain a comprehension of it. Davies doesn't provide any information regarding how the system determines what feed to be released, hence it is assumed that the user enters the amount of feed for certain cows into the computer controlling the RFID system. The specified amount of food and concentration is then provided to each cow depending on the individual specifications. The article also fails to identify the unit of measurement for the average amount of milk yielded from each cow. It is blatantly obvious that 6500 litres cannot be drawn from a cow in one milking session, leading to the

assumption that the rate is measured per annum, however this is not confirmed anywhere in the article. Nor does the article explain the concept of the increased margins over purchased feed, or what has caused the rise in margins (other variables such fluctuating prices could achieve this). Mid-way through the article Davies also states that the system is capable of storing health information on the animals, however he doesn't define what health information this may be, or how it is derived and stored – perhaps manual entry or some automated process of detection and storage. The benefits identified look appealing, however a full comprehension of how these benefits are derived and their true significance cannot be achieved due to the brevity of this article.

2.8.4. Pig Farm Feed Management

An article by Karnjanatwe (2005) explains a pig farm feeding system similar to those discussed above. Utilising electronic tags on individual pigs, automatic feeding stations are placed in the pen. When a pig approaches the feeding station through a one-way gate, an RFID reader will detect it and receive information from the tag. This will check the pigs ID, and gain it's characteristics including it's age and weight. The system will also determine if the pig has already eaten that day. If it is found to have already eaten, the gate to the feeding station will remain closed, however if the pig has not yet eaten, the system will open the door to the feeding station and deliver the desired amount of food based on the pigs age and weight. When the pig has finished its food, an exit gate will open and the pig will exit. This technology is now a few years old however, and Karnjanatwe notes that maintenance costs are rising for the owners. As such, they are looking to update their RFID technologies.

Benefits of this system include increased efficiency as staff will know which pigs are fed and which are not, thereby reducing repeat consumption, while each pig has enough food for its needs. It was designed to subsequently reduce labour costs, while improving accuracy of the food quantity delivered to the pigs and to reduce food spillage that often occurred when food was distributed manually. This article provides a good description of this system, allowing the reader to gain a solid understanding of the systems operation. While the article is not directly related to dairy farms, the concepts of operation can be considered applicable to a dairy farm context.

2.8.5. Improved Management Options Generating Large Savings

Three brothers who own a beef farm in the United States of America claim to have dramatically increased their profitability as a direct result of utilising RFID to track and manage cattle on an individual basis rather than groups. Ishmael (2001) reports that by using electronic identification tags to identify individual cattle, then sifting through the data using a specialised information system (AgInfoLink's 'Beeflink'), they believe they are saving between $US35-$US60 per head of cattle. "We're already using this to our advantage to make money. This isn't a theory; we've done it." States Tigh Cowan (one of the three brothers). They perceive the savings to be mainly related to the information they now have access to and can utilise to manage the farm. For example, they can get rid of poor performing cattle and keep the good ones, tell which paddocks have the most nutrition, evaluate mineral supplements in feed etc. These management capabilities, as well as possessing actual data relating to the cattle's life and development, have enabled the farmers to gain a higher than average price for their cattle at auctions. Treg Kusserz, another farmer utilising RFID states that "The more information you have, the better decisions you can make".

While Ishmael's (2001) article relates to the beef industry, it bears strong relation to the management operations of dairy farms also. It can be seen from this article that there is certainly money to be made from the use of electronic identification technology for improving farm management practices. However, this article simply provides the reader with an overview of the benefits these farmers are receiving. The article does not detail precisely what the farmers are looking for in the data, how they gain the data, what ways they use the data etc. This crucial information remains unrecorded.

2.9. Alternative Approaches

Attempting to move beyond basic identification, Nagl et al. (2003) undertakes a project for the design of a remote health monitoring system for cattle. In this system, Nagl et al. attempt to use a range of sensors to constantly monitor cattle state of health, communicating biological information wirelessly to a base station through the use of Bluetooth technology. Nagl et al. identify the fact that at the time of writing, America had no mechanism in place to track animal identity in the fashion that Canada did, nor

did they have any means to assess past or present animal health. The system they develop attempts to provide the ability for the livestock industry to react to and predict disease onset and spread, whether from natural or terrorist events.

Through the use of a GPS (Global Positioning System) unit to gather location and movement data, a pulse oximeter to measure blood oxygen saturation and pulse rate, a core body temperature sensor, an electrode belt to monitor pulse rate, a respiration transducer, and an ambient temperature transducer (Nagl et al. 2003, p. 3012), the project developed a wearable unit for cattle. This unit was designed to extract the biological information of the animal and communicate it to a base station via Bluetooth technology (which supports a ten metre read range) where it could then be analysed for any patterns that may indicate illness in the animal.

This project was obviously an investigatory undertaking, with numerous limitations in the unit developed. These included the size of the unit being quite large, and the battery life of various components of the unit. Some interesting results were drawn however, and for most components, solid results were evident. Nagl et al. recognise the issues that arose, and state in their conclusion that there is a lot of research and development to be done on this topic, including the all-important ability to minimise the size of the wearable device and reduce power consumption to prolong battery life. The early prototype proposed by Nagl et al. is currently physically impractical and far too expensive for use, however the results of the project provide interesting prospects for cattle monitoring and tracking in future applications. Perhaps someday it may possibly integrate this project’s device with RFID devices should the desire for this in-depth health monitoring arise.

It is immediately striking that the authors related their project to the need for animal identification in America, and noted the Canadian RFID tracking system. However, they did not utilise RFID for individual identification in their project, nor did they attempt to state why their system is preferable or what advantages it provides over the rapidly growing RFID system. They also alluded to the desire to track animal identities in the introduction (a specialist function of RFID technology), however failed to demonstrate how their system would provide this unique identification capability. Inclusion of RFID tags for individual identity tracking (at a minimum)

appears quite possible however, and it would have been useful to see this integrated into this project. An alternative approach such as this does hold some intrigue and possibility for the future, however RFID remains the dominant technology of choice for providing individual cattle identification.

2.10. Literature Gap

From this review, it is apparent that there is a large amount of literature regarding the central topic of RFID technology. However, literature is evidently quite scarce in relation to the utilisation of electronic identification for benefits in total farm management, especially on dairy farms. Karnjanatwe (2005) and Ishmael (2001) demonstrate possible quality benefits of electronic identification, however these articles are very brief and do not provide any detailed descriptions or frameworks for others to learn from, nor are they tailored to the dairy industry. Davies (1997) and James (2004) demonstrate achievable benefits specifically related to the dairy industry, however also lack depth in their work and details that others may truly learn from. Vendor Yoke-L provides an insight into the possible benefits from their feeding systems, while the New South Wales Department of Primary Industries – Agriculture (2004) provides an example of the massive capabilities of RFID for identification and tracking, as they seek to participate in the largest livestock identification and tracking system in the world. With the worldwide trend towards the use of electronic identification for livestock identification and tracking, and with the NLIS deadline approaching, it is quite surprising to find the dramatic lack of academic literature and detailed studies on this topic. It is evident from the articles described that benefits are possible for farm management practices through the use of electronic identification, and that farmers are experiencing them in the current environment. However it is also evident that they are utilising only pieces of the possible total farm management practices available through the use of electronic identification. No literature has pieced together all of these beneficial aspects to form a complete framework for deriving benefits through the use of electronic identification, and there is certainly a dramatic lack of academic literature on this topic. It is this large gap that this research intends to address.

2.11. Conclusion

It seems evident that despite having been around for numerous decades, RFID technology is only now maturing and the time for mass adoption of RFID is nearing. Considering the worldwide trend towards whole-of-life identification and monitoring systems for livestock, it appears inevitable that RFID will have one of the biggest impacts on the livestock industries both in Australia and around the word. Considering the likely cost of implementing such a system ($3.50 per tag alone in NSW), it is important that farmers utilise this technology to derive additional benefits and return on their investment through exploiting new opportunities for farm management.

Chapter 3 – Methodology

3.1. Introduction

Chapter 2 has provided a detailed overview of the current literature in this field, while also providing an explanation of the concepts that will be used in this research. This chapter will detail the research methods that will be used to achieve the objectives of this thesis. Section 3.1.1 will identify the gap in the literature. Section 3.1.2 will identify the purpose of the research. Section 3.2 will define the approach taken, section 3.3 will define the strategy to be utilised, section 3.4 will outline what methods will be utilised, section 3.5 will provide details on the case studies to be used, section 3.6 defines the unit of analysis, section 3.7 defines the time dimension, and section 3.8 will identify the data collection techniques utilised, section 3.9 will define what a case study protocol is, and how it will be used, section 3.10 identifies feedback and validation procedures used for this research before section 3.11 provides a conclusion to the chapter.

3.1.1. Gap in Literature

It is evident from the literature review that there is a large gap in current research regarding the use of electronic identification technologies for total farm management, especially for the dairy industry. Subsequently, there were also no significant methodology sections identified in research relevant to this field that could be evaluated and possibly used to aid the methodology development of this research. Numerous articles were identified that relate to the technology itself, its developments and useful applications (including recognition of its use for enhancing farm management practices), however none of these articles provide detailed information on process flows, work practices and specifically how electronic identification technology can be used to improve total farm management on dairy farms. Several articles detail the use of electronic identification for traceability throughout the supply chain of the beef industry, however this literature is more focussed on the important beef industry initiative of whole-of-life traceability for cattle and not on the possible benefits that farmers can derive from its use. Of the literature that does pertain to the topic of using electronic identification to improve farm management, it is apparent that significant value can be generated through its use (for example improved feeding

systems). However, comprehensive documentation of such systems, workflows and how to best utilise electronic identification for improved farm management is still lacking.

3.1.2. Purpose of Research

The purpose of this research is to fill the aforementioned gap in literature. Through the use of two case studies (and associated methods and techniques) on the south coast of NSW, this thesis attempts to identify and demonstrate achievable benefits that may be realised through the use of electronic identification to enhance total farm management. It further aims to propose a framework for the most effective use of electronic identification for total farm management. The methodologies detailed in this chapter will illustrate how this research will be carried out to fill this gap, and achieve the objectives of this thesis.

3.2. Research Approach

There are three well-recognised approaches to research – exploratory, descriptive, and explanatory. Exploratory research is considered to be most suitable when an issue is new or researchers know little of it, and may be utilised to serve as a starting base for future research. Descriptive research provides a detailed, highly accurate picture of specific details of a situation, social setting, or relationship. Explanatory research is intended to build on exploratory research and identify the reason as to why something occurs. Considering the current lack of detailed research in the area of this thesis, as well as the objective to document farm management practices, workflows etc., a combination of exploratory and descriptive approaches will be utilised for this research. The suitability of this approach is further evident when considering that this research attempts to address 'what' and 'how' questions, which are typical characteristics addressed by exploratory and descriptive approaches (Tellis 1997; Neuman 2000, pp. 21-23; Yin 2003, p. 5- 7).

3.3. Research Strategy

The main strategy that will be used to accomplish this research is to perform two case studies of dairy farms on the South Coast of New South Wales (NSW). As Yin (2003, p. 9) states, the situation in which case studies have a distinct advantage over other

research strategies are when *a "'how' or 'why' question is being asked about a contemporary set of events, over which the investigator has little or no control"*. This makes case studies the logical research strategy, as this thesis focuses on *how* dairy farm management practices can be enhanced through the use of electronic identification technologies, and demonstrating *why* they should be used (direct benefits etc.). This research is also addressing a contemporary issue, and one in which the investigator has little control, providing further evidence of case studies being the most suitable strategy to address the aims of this research. The empirical nature of case studies is also suited to this research (Robson 1993, p. 52).

Yin (2003, p. 14) further notes that,

> *"… the case study as a research strategy comprises an all-encompassing method – covering the logic of the design, data collection techniques, and specific approaches to data analysis."*

This ability to use multiple methods in case studies provides strong advantages, as it enables the researcher to overcome weaknesses inherent in each research method, thus providing a more accurate and reliable outcome. The data collection techniques utilised within this case study will include structured, semi-structured and unstructured interviews, observation, and document analysis (these will be further discussed in section 3.8). The data gained from each case study will be analysed and documented using workflow diagrams, and descriptions (Yin 2003).

3.4. How this Thesis Will Achieve its Objectives

This section demonstrates how the use of the case studies, and associated methods and techniques will be used to achieve the objectives of this thesis. These objectives (stated in section 1.4) are repeated here for convenience.

1. To review the current literature on electronic identification for animals, with a view to identify key methods of application (and the positives and negatives of each), subsequent management practices enabled, and possible future uses of such technology.

To meet this objective, the results from the literature review will be used, as well as ongoing document analysis.

2. Through the use of case studies, investigate and document farm management practices with varied degrees of electronic animal identification integration on two dairy farms on the South Coast of NSW.

To meet this objective, case studies will be utilised. Data collection techniques of observation, semi-structured and structured interviews and document analysis will be utilised. The data gained from each case study will be analysed and documented using workflow diagrams and descriptions.

3. From the case studies of objective 2, identify and highlight demonstrable advantages that may be achieved through the use of electronic identification technologies at varying levels to enhance farm management practices.

To meet this objective, the demonstrable advantages will be identified from the output of objective 2, and noted in the documentation.

4. Develop a theoretical total farm management framework for deriving the maximum benefits from integrating electronic animal identification technologies with farm practices.

To meet this objective, the output from objectives 1, 2 and 3 will be considered. A cross-case analysis of the cases will be undertaken so as identify the most effective methods of utilising electronic identification used in these cases. The literature review and document analysis will also serve to provide a better understanding of the technologies and their application, and possibly identify utilisations that have not been undertaken in the case studies. Utilising this combination of information will aid to derive the most beneficial framework.

3.5. Case Study Details

The case studies will involve two key aspects – firstly, the process flows and operations involved in the management of the herd; and secondly the process flows and operations involved in managing the milking operations of the farm. The first aspect will document the basic processes involved in herd management, from the introduction of cows to the farm (purchased or born), through the cow's life cycle till

it departs the farm. This may include the frequency of milking, feeding of calves, vaccination periods, paddock movement etc.

The second aspect of these case studies will document the milking process that is undertaken at each farm. This section will identify the precise process for milking, from moving the herd to the milking station, through the milking process, and returning them to their respective paddock.

The studies will also identify and highlight any pieces of information the farmers need to record as well as regulatory requirements they need to comply with, and how they do so.

3.5.1. Case Selection & Characteristics

Case study 'A' (low RFID implementation) is intended to demonstrate the traditional basic processes for the aforementioned two aspects of dairy farm management. This case study will involve a dairy farm that uses little to no electronic identification in their operations, perhaps just utilising RFID for identification purposes (in accordance with the NLIS regulations soon to be enforced). This case will serve as a control case for the research, as it is expected that this study will result in documenting traditional (non-RFID) dairy farm management practices. Areas in which the farmer maintains manual records on the herd or during the milking process will be identified and highlighted so as to provide an insight into what can be considered pivotal pieces of information for farm management, considering the farmer is taking the trouble to record them manually.

Case study 'B' (advanced RFID implementation) will involve a dairy farm that is strongly integrated with electronic identification technology as part of its daily operations. This case study will serve to highlight how electronic technologies are currently being used at a level that may be considered best practice by current standards. The process flows are expected to differ from case study A as a result of this farm's utilisation of electronic identification in its operations. Such areas will be highlighted and it is expected that demonstrable benefits will be identified as a result of their usage. These may include increased efficiencies, greater information availability, easier and more organised herd management etc.

These two case studies were selected as they demonstrate the current utilisation of electronic identification on dairy farms, both at a minimum and advanced level of utilisation and integration. It is believed that by utilising these bounds, a trend of increased benefits will be identifiable as the level of electronic identification integration increases. It is also believed that dairy farmers may be able to relate their current or planned future situation at or within these bounds, and subsequently enable them to use this research to aid in deciding on their own utilisation of electronic identification for total farm management.

3.5.2. Cross-Case Comparison

A theoretical framework will then be derived to illustrate a suggested approach to the use of electronic identification technology (primarily RFID technology) for total farm management. Cavana, Delahaye & Sekaran (2001, p. 91) describe a theoretical framework as,

> *"… a logically developed, described and elaborated network of associations among the variables that are deemed relevant to the problem situation and have been identified through such processes as interviews, observations and a literature survey."*

The dependent variable for this framework (the variable of primary interest) will be 'advantages for farmer', and the independent variable will be 'level of RFID integration'. It is expected that as the level of RFID integration increases, that the advantages for the farmer will increase accordingly (Cavana, Delahaye & Sekaran 2001, pp. 83-84). The dependent variable 'advantages for farmer' is intentionally quite an open concept, as the advantages to the farmer may take many forms, including reduction of labour, lower stress, increased profits, more efficient movement of cattle, increased milk yields, increased information etc.

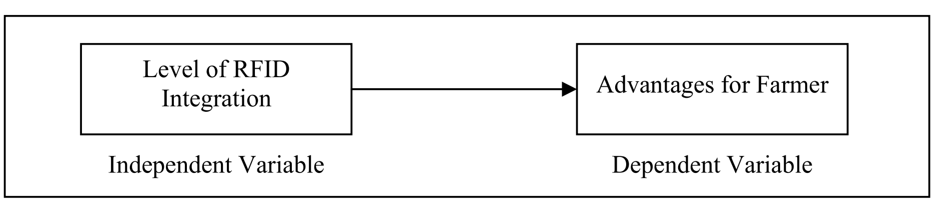

Diagram 3.1 Independent and dependent variables of theoretical framework

Utilising the data gathered from the two case studies, this cross-case comparison will be undertaken with the aim to gain the maximum advantages and return on investment for the farmer through their use of electronic identification and tracking practices for farm management.

While the cross-case comparison study will be designed so as to be functional and practical, aspects of it may be considered idealistic in the current farming and technological environment. As such, the framework suggested may be considered a possible long term goal for dairy farm management practices, considering developments in electronic identification technology such as RFID technology are expected to bring about a reduction in costs for the technology as well as increased functionality. This framework may also serve to provide possible direction for future research into this field.

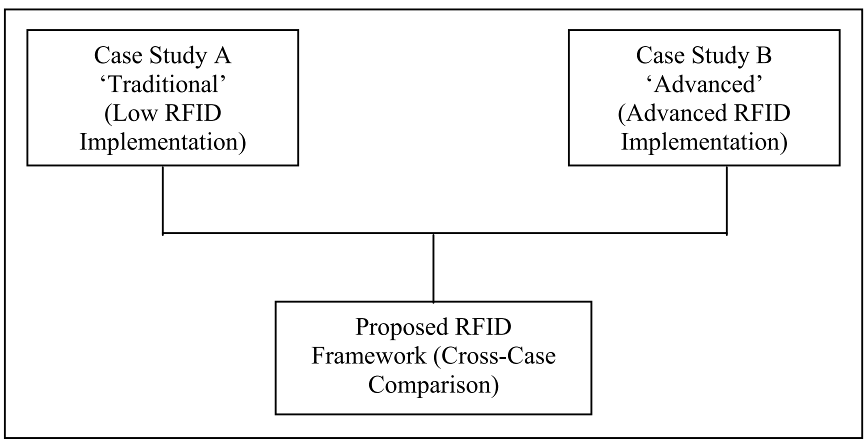

Diagram 3.2 Case study connections

3.6. Unit of Analysis

The 'unit of analysis' is defined as the major entity to be analysed in a research project (Trochim 2002; Yin 2003, pp. 22-24). It is important to note that although this research will involve undertaking two case studies of dairy farms and their use of electronic identification technologies, it is not the farms or the technologies themselves that are the unit of analysis for this research. Rather, this research is focussed upon farm management practices, and the subsequent impacts of electronic identification on these practices. As such, it is the management practices on these dairy farms that are the unit of analysis for this research.

3.7. Time Dimension

There are two main time dimensions recognised in research: cross-sectional research and longitudinal research. Longitudinal research involves the study of subjects over an extended period of time. For example, a longitudinal study of academic development may involve an examination of the same sample of students every six months, over a ten year period. Cross-sectional research on the other hand, involves studying the unit of analysis once, at the one point in time (Neuman 2000, pp. 30-31, AllPsych 2004). This research project will be utilising a cross-sectional approach, as each case study will only be studied the once at the same point in time. This will enable the best demonstration of current use of electronic identification technologies on dairy farms and is the most suitable time dimension to achieve the objectives of this research. A longitudinal study would be useful for research aimed at monitoring the evolution of farm management practices and the integration of electronic identification, or possibly even as a follow-on to this research so as to monitor the adoption of the proposed framework, however it is not suitable to meet the objectives of this research.

3.8. Data Collection Techniques

This research will utilise qualitative research methods in gaining data. Maxwell (2005, p. 22) states that the strengths of qualitative methods lie in their focus on specific situations or people, and their emphasis on words rather than numbers (as opposed to quantitative research). This illustrates that qualitative methods are most appropriate for this case study research. Ragin (1994, p. 92, quoted in Neuman 2000, p. 32) supports this view, stating that while qualitative methods and case-study research are not identical, “almost all qualitative research seeks to construct representations based on in-depth, detailed knowledge of cases”. Marxwell (2005 p. 79) further notes that qualitative research allows virtually anything to be recorded, including anything seen, heard or communicated in any way while performing the case studies. This is valuable as Marxwell believes there is no such thing as ‘inadmissible evidence’ when trying to understand the issues or situations being studied. The following qualitative data collection techniques will be utilised in this research.

3.8.1. Interviews

Yin (2003, p. 89) states that interviews are an essential source of information for the case study method. Structured, semi-structured and unstructured interviews will all be utilised in the course of this research. Fully structured interviews entail the strict use of predefined questions. Semi-structured interviews on the other hand, also have predefined questions and an objective for the interview, however latitude is provided so that the interview may move to explore other areas of interest depending upon the interviewee's responses. Unstructured interviews are informal and relate to a general area of interest or concern, however the conversation is allowed to freely flow on this topic, rather than having any predefined questions. These interviews will take place with both farm owners, however may also take place with any additional employees of the farm if required, or if their expertise supersedes the owner on the relevant topic. These interviews will serve to identify relevant facts, enable a solid explanation of concepts and issues, while also providing an insight into the mindset and opinion of the interviewee. All interviews will be recorded on a portable recording device so as to provide a reliable verbatim of the interview, which will later be transcribed and provided as an appendix to the thesis (Walizer & Wienir 1978, pp. 287-288; Robson 1993, pp. 228-238; Gorman & Clayton 1997, pp. 44-45; Blaxter, Hughes & Tight 2002, pp. 171-176; Yin 2003, pp. 89–92).

3.8.2. Observation

"Observation studies typically involve systematic recording of observable phenomena or behaviour in a natural setting" (Gorman & Clayton 1997, p. 44). For the purposes of this research, the phenomena being observed will be the farm management practices, milking operations and (where applicable) the utilisation of electronic identification technologies to assist in these tasks on the selected dairy farms. These workflows will be observed and documented using a range of techniques, such as flowcharts, workflow diagrams and written descriptions. It is expected that most of the observation will take place without active participation in the processes from the researcher. However, considering the laborious nature of farming, and in the interests of gaining a greater understanding of procedures, the researcher may also occasionally engage in participative-observation, in which case they will play a role in the phenomena they are observing. It is expected that some of the aforementioned

unstructured interviews (as stated in section 3.8.1) will take place during these observation periods, so as to aid in the explanation of the processes being undertaken. An audio recorder will be carried during these observation periods, so as to allow for personal recordings (verbal note-taking) by the researcher, and also to record any possible unstructured interviews. Photos will also be taken during the observations so as to retain visual reminders of the processes. A pen and paper will of course also be taken so as to allow note-taking to be made during the observations (Robson 1993, pp. 190-225; Gorman & Clayton 1997 p. 44; Blaxter, Hughes & Tight 2002, pp. 176 – 179; Yin 2003, pp. 92-93).

3.8.3. Document Analysis

In addition to the literature review, this thesis will also entail analysis of any documents used on the farm that are relevant to the procedures being observed. Such an approach will aid to fill in any gaps that may arise from the observation and interview process, and will also aid to provide an understanding of the current data storage and monitoring requirements of the farms (Blaxter, Hughes & Tight 2002, pp. 167-171).

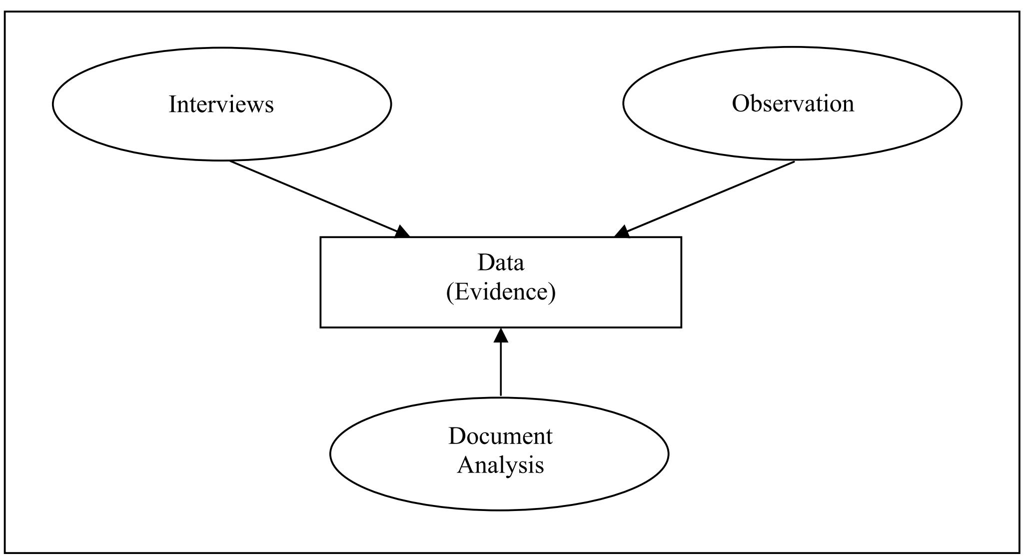

Diagram 3.3 Data gathering techniques

3.9. Case Study Protocol

A case study protocol, as outlined by Yin (2003, pp. 67–77) will also be developed, so as to increase the reliability of case study research. A case study protocol is designed to guide the researcher in carrying out the data collection for a single-case study (which will then be used at both case study sites). Yin (2003, p. 69) states that the case study protocol should have the following sections:

- *"An overview of the case study project (project objectives and auspices, case study issues, and relevant readings about the topic being investigated).*
- *Field procedures (presentation of credentials, access to the case study 'sites', general sources of information, and procedural reminders).*
- *Case study questions (the specific questions that the case study investigator must keep in mind in collecting data, 'table shells' for specific arrays of data, and the potential sources in information for answering each question).*
- *A guide for the case study report (outlines, format for the data, use and presentation of other documentation, and bibliographical information)."*

These sections will be incorporated into the case study protocol for this research, hence providing a strong guide for the research to be undertaken.

3.10. Feedback & Validation

Bosk (1979, p. 193, quoted in Maxwell 2005, p. 106) identifies an important aspect to case study (sometimes referred to as 'fieldwork') research, stating that "All fieldwork done by a single field-worker invites the question, Why should we believe it?" An important element to aid in validating this research is the continued interaction, feedback and validation from the farm owners of both farms. After documenting each of the case studies, the farmers will be requested to provide feedback and approve the documented workflows and operations. Any changes they believe should be made will be further discussed and documented. This process will continue until the farmer believes the documentation is a correct representation of the workflows and

operations on their farm. This process will be repeated for the proposed framework, in which both farmer's insights and feedback will be sought so as to aid in validating the proposed model. This is what Maxwell (2005, p. 111) recognises as 'respondent validation', and states that,

> *"This is the single most important way of ruling out the possibility of misinterpreting the meaning of what participants say and do and the perspective they have on what is going on, as well as being an important way of identifying your own biases and misunderstandings of what you observed."*

While such feedback still doesn't guarantee complete accuracy, it provides strong evidence to support the validity of the documentation. Utilising recognised methods for conducting this research also aids to strengthen its validity.

3.11. Conclusion

This chapter has demonstrated the methodologies that will be used in undertaking this thesis. The most appropriate research strategy to achieve the objectives of this research has been shown to be case studies. This strategy will be supported by qualitative data gathering techniques of structured, semi-structured and unstructured interviews, observation and document analysis techniques. Utilising this mix of strategies will aid to overcome inherent weaknesses that all data gathering techniques have, and as such aid to provide a more reliable and accurate case study. These techniques will provide a qualitative exploratory and descriptive approach to this research, which has been shown to achieve all of the objectives of this research. Details of the case studies have been provided and justified, with the unit of analysis being identified as farm management practices. The time dimension has been identified as cross-sectional, while feedback and approval will be utilised to aid in validation of this work.

Chapter 4 – Case Study 'A': The Strong Dairy Farm

4.1 The Strong Dairy

4.1.1. The Traditional Case Study (Low RFID Implementation)

This case study was conducted on the Mandelyn Holsteins dairy, owned and operated by the Strong family. This farm was selected as the traditional (low RFID implementation) case study, as they have a well established, highly reputable dairy, however do not currently utilise any RFID devices in their farm management operations. As such, this dairy provides a prime example of how dairy farms can operate currently without the aid of RFID devices.

4.1.2. Meet the Strongs

The Strong family own and operate the Mandelyn Holsteins dairy, located in Jamberoo on the South Coast of NSW. The farm is operated by partners Lynne and Michael, and their son Nicholas.

Despite currently not utilising RFID technology to facilitate any operations of their dairy farm, the Strongs have a keen interest in the use of RFID technology for this purpose. This interest has extended to the point that they are currently exploring the options available for implementing RFID technology to aid in farm management practices at a highly advanced level on their farm. They are currently of the view that full implementation of such a system would cost up to $70,000, and include automated milk meter monitors for individual cows (milk meters are discussed further in section 6.3.6). The Strong's feel at this stage that they have developed a simple manual system that optimises productivity in their herd and at this stage believe that they can't justify the financial outlay required. However, they will be closely monitoring both RFID advancement and the costs involved closely, and state that they look forward to the point where the former advantages outweigh the later disadvantages.

4.1.3. The Cows

The Strong farm manages approximately 360 head of Holstein cows of which 165 are currently in their lactation cycle. The Strong's moved to this breed of cow during the

period of 1997-2000, after previously having utilised Illawarra cattle. The Strongs have had experience in breeding Holsteins since the 1980s, and Michael has become quite renowned for his abilities to breed high quality and high yielding cows. Furthermore, the Strong dairy reputation has been bolstered by the fact that they have become one of the states leading production herds over the past five years (Semex 2005, p. 9), and are currently Australia's leading KPI (Key Performance Indicator) herd achieving 50, 000 litres/hectare.

4.1.4. The Tags

Currently, approximately half of the Strong herd have NLIS (National Livestock Identification System) compliant RFID tags attached to their ears. As their farm management procedures do not currently utilise these tags, the Strong's have elected not to take any special action to tag the majority of their existing herd until they leave the farm (as required by NLIS regulations). However, they do intend to utilise the tags in the future. Subsequently, they are now tagging their new-born calves rapidly after birth, and their older cows in the herd are being tagged as they enter their yearly pre-lactation cycle preparation three weeks prior to calving (this pre-lactation preparation involves the selected cow being drafted, and receiving a pre-calving regime of vaccinations and supplements). Utilising this approach, all cows on the farm will subsequently have RFID tags attached to their ears at some point over the next couple of years. Alternatively, all cows will receive the tags immediately if the Strongs elect to implement highly advanced RFID technology into the dairy and farm management operations – a decision they are continually evaluating.

The decision not to attach the tags to most of their existing herd en masse was based on the fact that such an action would require an unnecessary change in routine for the herd, thus possibly causing undue stress to the animals. The possible outcomes of such changes and stress have been felt first hand on the Strong farm, where they lost one of their highest yielding cows due to an injury she sustained after being spooked in the stalls during initial efforts to tag their herd.

Further to the RFID tags, each cow in the Strong herd has a large green tag placed in their ear, displaying their individual identification number (as assigned by the Strong for their own on farm identification). This number is printed on the tag so as to enable

it to be easily read from a distance of 2 metres. Despite the Strong's utilising these tags for their own purposes, it is interesting to note that the use of tags such as these also remains a requirement of the NLIS regulations until the 1st of January 2006, regardless of whether NLIS-compliant RFID tags are also attached (New South Wales Department of Primary Industries – Agriculture 2004).

4.1.5. The Dairy

The dairy was rebuilt approximately 4 years ago, on the site of a previous dairy that had undergone multiple restorations since originally being developed in the late 1800's (The Strong's have retained the original house building from this time, simply for historical interest). The current dairy contains a 14-a side Herringbone milking parlour (therefore providing a simultaneous milking capacity of 28 cows), and is situated centrally on the farm. The dairy features a high degree of automation, however these processes are triggered by operator actions rather than RFID technology.

The dairy contains the following features:

- Automated entry gate opening and closing
- Automated exit gate opening and closing
- Feed bins above bails
- Feed troughs for each milking bail
- Drop-down bail entry blockers
- Set of milking cups for each milking bail
- Milking controller units for each set of milking cups
- Multiple high pressure hoses throughout

4.1.6. Milking Times & Operators

The Strong's have quite a unique milking arrangement, in that they milk their cows three times a day - as opposed to the more common arrangement of milking cows twice a day. To facilitate this, milking takes place at 4am, 12pm (midday), and 8pm daily. Such an arrangement is not possible for many dairy herds, however the Strong's believe that they are able to achieve this additional milking session due to the high quality breeding of their cows.

Having this additional milking session has provided the Strong's with numerous benefits. Most notably, this additional session has enabled the Strong's to significantly enhance their milk output per cow - currently estimated to be providing an additional 1,500 litres of additional milk per cow every year (Semex 2005, p. 8). Subsequently, this increased production provides increased revenue for the farm.

However, there have also been other noteworthy benefits gained through this additional milking cycle. Interestingly, since adopting the additional milking session in April 2005, the Strongs have noticed a significant improvement in the health of their cattle, as well as the quality of milk being produced. On average, the somatic cell count of their cows has decreased by half (indicating a much lower risk of their cows gaining any infections or diseases such as mastitis), and many cows that were previously considered to be underperforming in terms of milk production have increased their output to meet or exceed expectations.

Each milking session is run by one operator. This person is responsible for the entire milking process – from dairy preparation, bringing the cows to the dairy, milking them, moving them back to the desired paddock, and taking any other actions that may be required for specific cattle. The operators rotate milking sessions regularly, however each operator will only take 1 or 2 milking sessions per day, thus enabling them enough time to undertake other duties or activities and to rest.

4.1.7. Strong Dairy Layout

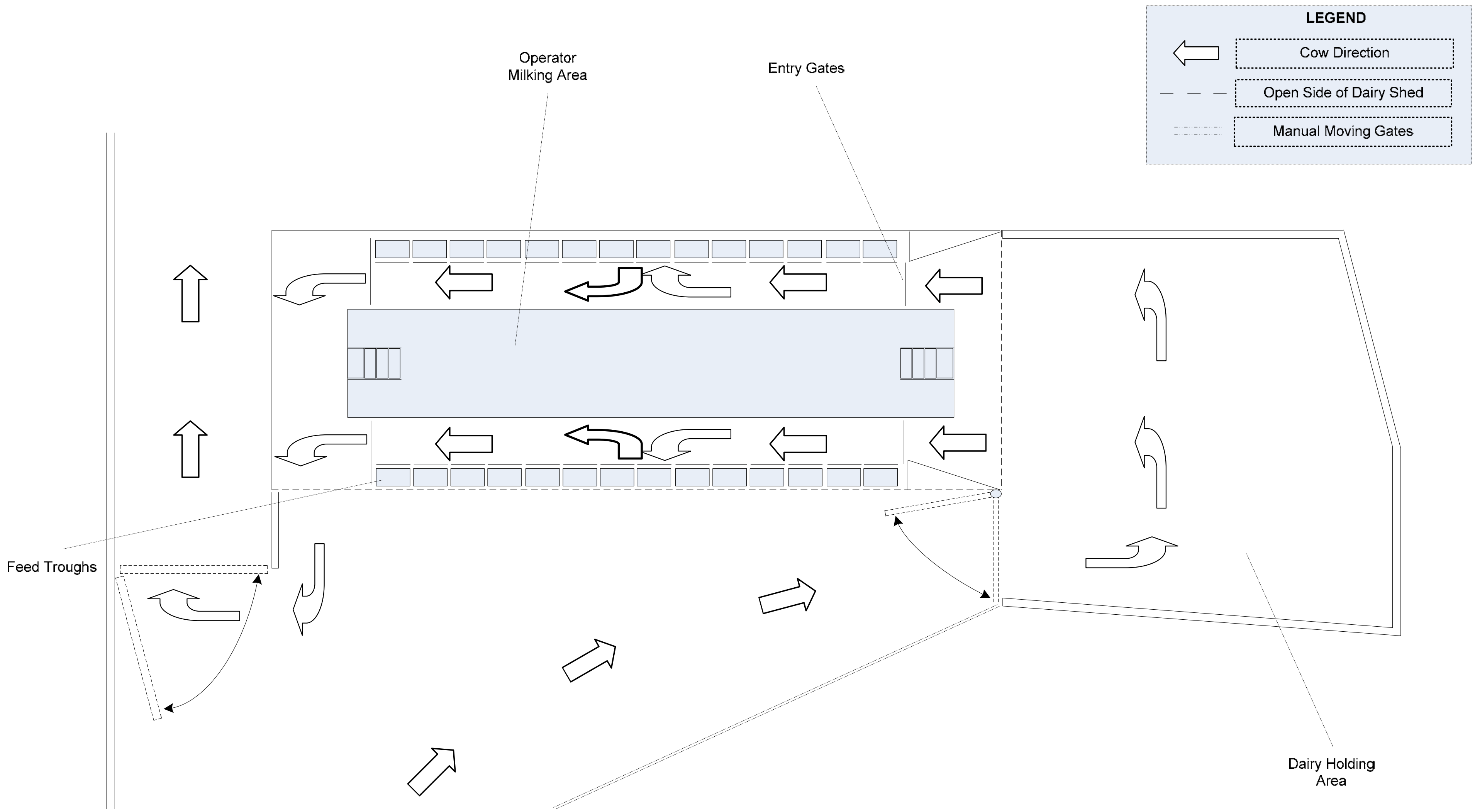

Diagram 4.1 Strong dairy layout

4.2. Milking Procedure

The milking procedure is a fundamental activity that is performed on all dairy farms. Subsequently, it is believed that this procedure will inevitably gain strong benefits through the development of RFID in dairy farm management. Furthermore, it is a procedure that can be directly affected by other farm management activities where RFID may be utilised in the future (such as recording cow injections, calving etc.). As such, a thorough understanding of how this process is currently being conducted is essential to understanding the operations of a dairy farm, and also to provide a solid basis for future development of RFID in the dairy industry.

4.2.1. Workflow Diagram of the Strong Milking Procedure

The following workflow diagram summarises the milking procedure undertaken on the Strong dairy. Detailed information regarding each of these steps is provided in the following section (section 4.2.2).

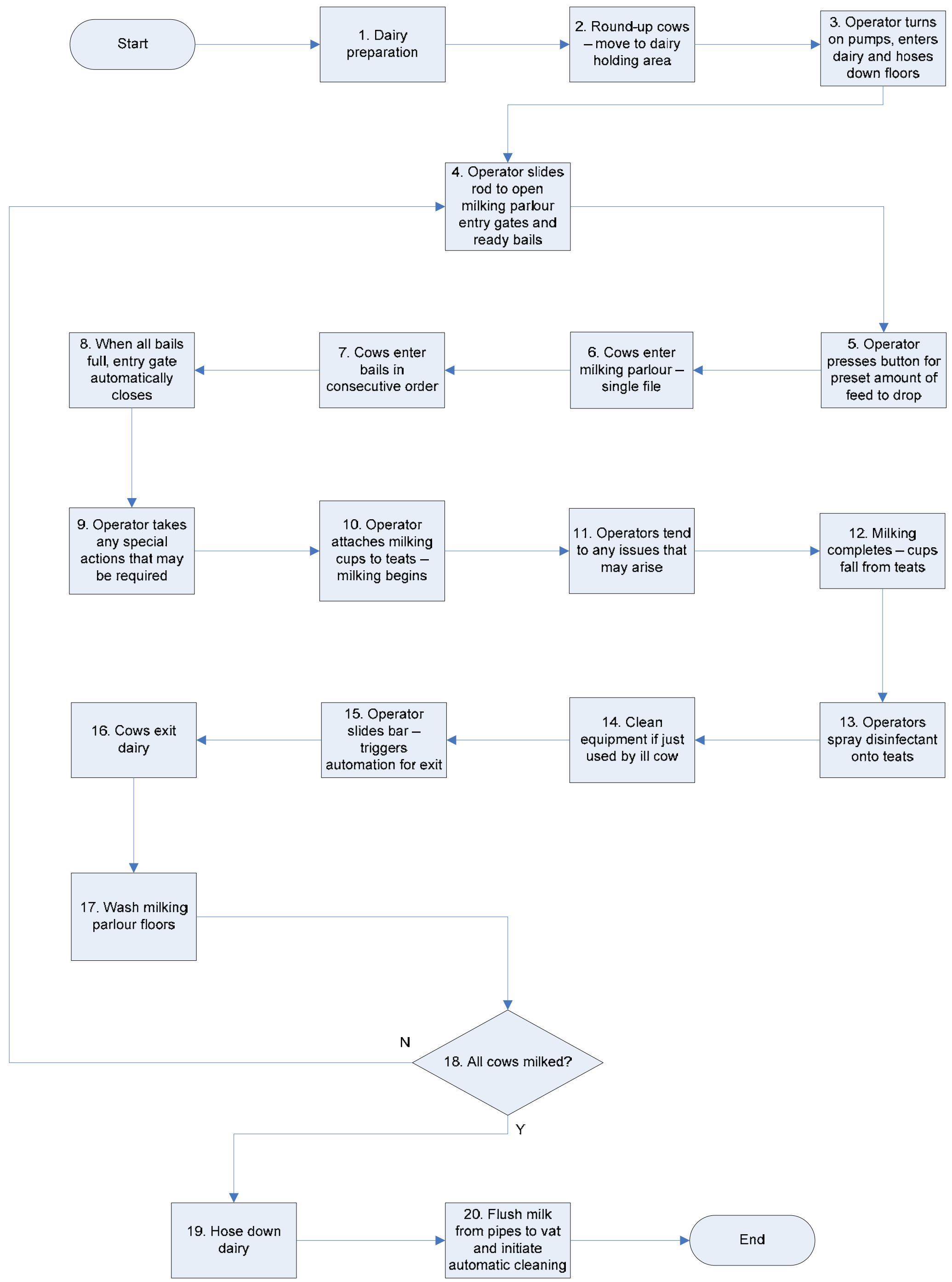

Diagram 4.2 Strong dairy milking procedure

4.2.2. Details of the Strong milking procedure

For each milking session on the Strong farm, the following steps are taken:

4.2.2.1. Dairy preparation

This involves the operator ensuring that the dairy is ready for milking. The operator will then open the gates to the dairy holding paddock, and place guide ropes across all other open thoroughfares, so as to provide the cows with a direct path to the dairy holding area.

4.2.2.2. Round-up cows – move to dairy holding area.

Utilising a quad-bike, the cows are rounded up from their current paddock and moved to the dairy holding area. This may take some time, as the cows may have to be walk from a paddock hundreds of metres away. They are allowed to walk to the dairy at their own pace, and the operator on the bike simply follows them from the rear.

As they arrive at the dairy, most cows enter the dairy holding area of their own accord. Some of the herd may initially remain just outside the holding area, exploring, or taking advantage of a water trough situated just prior to entry to the holding area. Once all cows have arrived near the dairy, the operator will move them all into the holding area, and close the gate. This will ensure that all cows due to be milked are located in the one location, and cannot leave without being milked.

During the process of moving cows to the dairy holding area, the operator will keep a watch for any cows that have been identified as being on heat. To identify cows on heat, the Strongs utilise a device known as a Karmar. This device is attached to the loin (backside) of cows that they believe will be on heat in the near future. Subsequently, when a cow with a Karmar is mounted (as will occur to a cow on heat), this Karmar changes colour from green to red. As such, the operator will identify any cow with red Karmars, and note their identification numbers. If the selected cow is past their first 60 days in their current lactation cycle, the cow will be extracted from the herd at the completion of the milking session for artificial insemination. The Strongs wait until the cow is past their first 60 days of

lactation as inseminating cows after this time provides the cow with two months in which they do not provide milk after their current lactation cycle completes, before giving birth again and returning to milking.

Exhibit 4.1 Cows waiting in dairy holding area

4.2.2.3. Operator turns on pumps, enters dairy and hoses down.

The operator then finalises preparations for milking. This involves activating the computerised milking system (this allows the milking cups to be utilised for milking, controls the flow of milk to the vat etc.). The operator then places an apron on and enters the dairy. One of the high-pressure hoses located in the dairy is then used to hose down the floor of the milking parlour. Taking this action at the start enables the easier removal of cow faeces that will inevitably be dropped during milking.

4.2.2.4. Operator slides rod to open milking parlour entry gates and ready bails

When the operator is ready for a batch of cows to enter the milking parlour, they pull a rod that spans the length of the milking parlour to the right. Movement of this rod to the right will trigger a number of simultaneous automated actions - the entry gate to the milking parlour will open, the exit gates will close, and the bail entry barriers for each bail will reset to their ‘closed’ position (this position is discussed further in section 4.2.2.7).

4.2.2.5. Operator presses button for preset amount of feed to drop.

The operator then presses a button to begin the release of a pre-defined standard amount of mixed feed into the feed trough of each bail. This feed is dropped from feed holders that are placed directly above each bail, and serve as intermediate storage locations for feed (between the main feed silos and each feed trough). The standard amount and composition (mixture) of this feed is set by the operator before milking (and is rarely changed).

The feed holders do not drop the total amount of feed into the feed troughs immediately, but rather the release of this feed is broken down into timed intervals. This interval can be selected by the operator to be every 5, 10 or 45 seconds, at which time a small amount of feed will be delivered to the trough until the allocated amount of feed has been provided. Dropping the feed in this manner ensures that the cows receive a regular, fresh supply of feed into their troughs during milking.

Initially, all cows will receive the same standard amount of feed. This feed is a mixture of 70% grain and 30%, and the standard amount provided is a total of 10 kilograms per cow per day. However, the operator is provided with a button for each cow bail that will allocate an additional amount of feed to that bail for each press of the button (approximately an additional 0.7kg of feed per press). This button is utilised to provide high producing cows with the additional feed that their bodies require in order to continue to produce a higher than average volume of milk. Elite production cows (those producing over 60 litres per day) will receive up to 4 kilograms of additional feed per day.

Cows that have been identified as high milk producers are distinguishable by a green tag having been placed onto their tail. Thus, when an operator sees this coloured tail tag on a cow, they know to press the button for additional feed to be dropped specifically to her feeding trough. In addition to this form of identification, the operators also utilise their own tacit knowledge of the herd to recognise these high producing cows, and to decide upon how much extra feed each of these cows should receive.

Cows in their first day of lactation on the Strong dairy are able to receive the full standard amount of feed due to a transition program that cows undertake in the three weeks leading up to their giving birth (calving). This program provides cows with a feed mixture that prepares the rumen (the first of a cows four stomachs) for full grain feeding from the first day of their lactation, while also aiding to prevent metabolic diseases. Preparing this stomach in this way is important, as if a cow is provided a large amount of grain without their stomach having built up the required bacteria to handle it, a cow can die of grain poisoning. Utilising this pre-calving program prevents such an event from occurring, while also enabling a cow to take in the full standard amount of grain on their first milking session - thus optimising the cows milk production potential from the first day.

4.2.2.6. Cows enter milking parlour – single file

The milking operator will then encourage the cows to enter the milking parlour, moving single file from the dairy holding area and into the milking parlour.

4.2.2.7. When all bails full, entry gate automatically closes

The cows will enter their bails in consecutive order, from the first bail in the row to the last bail (the first bail being the bail furthest from the entrance gate to the milking parlour). This consecutive bail entry order is enforced by utilising bail entry blockers that are setup so as to provide access to only one bail at a time. These entry blockers are composed of a large metal sheet that is placed horizontally in the bail, extending to both cover the bails feed trough and prevent entry to the bail.

Initially, the only bail that does not have one of these blockers in place is the bail furthest from the milking parlour entry gate (bail number 1). Thus, the first cow to enter the milking parlour only has the option to enter this open bail. As the cow enters the bail, she nudges a light bar that bridges the entrance to the bail. The movement of this bar releases a catch on the next bail (bail number 2), causing it to gently lower down, thus providing the next cow in line with access to this bail. Again, as the next cow enters this newly presented bail, they nudge the light bar bridging the entrance to this bail, thus causing the third milking bail to open. This

relay procedure is repeated for all bails until the row is full. Enforcing this entrance procedure is important to ensure easy access to bails for the cows, and to ensure that all bails are occupied during each batch of cows milked.

Exhibit 4.2 Milking parlour entry (featuring bail entry blockers)

4.2.2.8. Entry gate automatically closes

When a cow enters the last bail in the row, the entry gate to the milking parlour automatically closes, thus preventing other cows from attempting to enter the dairy during milking.

4.2.2.9. Operator takes any special actions that may be required

As the cows enter the bails, the operator is able to take any additional actions that may be required for specific cows. For example, if a cow has had a penicillin injection and it is still within the milk withholding period for her treatment, action must be taken to separate her milk from the rest of the herd, thus allowing it to be disposed of and not contaminate the rest of the herds milk. To achieve this, the hose connecting the milking cups to the main milk flow pipe is detached from the milk flow pipes, and attached to a designated barrel instead. This allows the cow to be milked through the usual actions (from the cows perspective, it is milking as usual) however their milk will be separated from the quality milk, and later disposed of.

There are three main methods employed by the Strongs to identify cows requiring any special actions to be performed. Firstly, all cows requiring particular attention will have a green leg band on one of their legs. This will signify to the operator that there is a problem with this cow. The operator then uses their own tacit knowledge of the herd to recall what the problem is, and take the required action. Alternatively, the operator may refer to the second identification method utilised by the Strongs – a whiteboard at the end of the milking parlour displaying the identification numbers of cows that are on a treatment regime or require any other particular attention (each cows identification number is printed on the green tags placed in each cows ear, as noted in section 4.1.4). This board also provides relevant data on the subsequent actions required for each of the cows listed. Thus, the operator can refer to this board prior to, and during the milking process to identify cows requiring particular attention and also to establish what action is required. Thirdly, cows that have received a penicillin injection (or other treatment that requires their milk to be withheld) are identified by a green leg band combined with a coloured dye mark on the back of the cow's udder. This dye is placed onto the udder at the time of injection, and serves as a further visual notice to the milking operator to dispose of this cow's milk.

Exhibit 4.3 Bail Components

4.2.2.10. Operator attaches milking cups to teats – milking begins

Each bail has a set of milking cups associated with it, and a milking controller unit that controls the operation of these milking cups. The operator presses a button on the milking controller to begin the suckling motion and suction in the milking cups. This suckling motion provides the required action to extract the milk from the cow, while the suction moves the milk through the pipes to the main vat, while also ensuring that the milking cups remain attached to the cows teats. The operator then attaches the four milking cups to the teats of the cow, thus beginning the milk extraction process. The extracted milk from the cow will be pumped through to the main storage vat throughout this process. For slow milking cows, the operator will begin the milking process by hand so as to get the milk flowing. Slow milking cows are identified by the operators own tacit knowledge of the herd and each cows characteristics.

The milking controller unit provides three modes for milking. The first of these is the standard automatic milking. Under this mode, the cow is milked by the machine until it detects that she has stopped providing milk (the flow of milk is gauged by an automatic detection unit placed in the milking lines). At this point, the cups cease suckling and suction, subsequently falling from the cows udder. The frequency of the suckling motions also varies under this mode. When the cups are first attached, the suckling begins at a relatively slow pace (approximately 30

pumps per minute), thus allowing the cow to adjust to the milking and release her milk. The pace of the suckling then increases to the standard rate for the majority of the milking (approximately 50 pumps per minute). As the flow of milk is detected to decline again, the pace of milking will return to the reduced speed (30) until the milk has reached a flow rate considered to indicate the end of the milk flow from the cow. This ensures an easy and comfortable finish to the milking for the cow.

The milking controller unit also provides a function for manual release of the cups. Under this mode, the milking will continue until the operator presses the button to cease milking, thus ensuring the cups stay on the cows teats until the operator elects to remove them.

The final available function is for full-paced milking for the whole time that the cups are attached (approximately 50 pumps per minute). This may be utilised for cows that have an udder formation that result in the milking cups having difficulty staying attached. As such, this faster paced milking is associated with greater suction, which aids to ensure the milking cups to do not fall from the cows teats unnecessarily. This array of milking functions is quite useful, and the operator uses his own tacit knowledge of the cows to determine which function to use for each cow.

4.2.2.11. Operators tend to any issues that may arise (e.g. Milking cups coming off, cups not retracting correctly).

There are occasionally unpredictable events that will require the operator’s attention. An example of this may include instances where cows manage to shake or kick the milking cups off before they have finished milking. Another example is provided when a cow may elect not release her milk. In such a situation, the milking cups will rightfully not detect any milk flow, and thus will fall from the cows teats in belief that the cow has finished giving milk. Cows may elect to withhold their milk for a range of reasons, including being fearful of the environment, if it is their first time being milked etc. In this situation, the operator utilises an injection of a stimulant (synthetic oxytocin) to entice the cow to release her milk. This works quite rapidly and she will then release her milk.

4.2.2.12. Milking completes – cups fall from teats

As mentioned previously, depending on the function selected on the milking controller unit, the cups will either fall from the teats automatically, or will be removed manually by the operator when the cow has finished providing milk.

4.2.2.13. Operators spray disinfectant onto teats

When the cows are finished milking, the operator will spray an iodine-based disinfectant onto each of the cows teats. This will protect the teats for about twenty minutes after milking while the teats re-seal. This is an important step to help prevent foreign bodies from entering the teats, and subsequently aiding to reduce the possibility of infection or disease in the teats (e.g. mastitis).

Exhibit 4.4 Milking parlour in action - cows on left side continuing to be milked, cows on right side completed milking; Operator spraying disinfectant onto teats

4.2.2.14. Clean equipment if just used by ill cow

If a cow with an illness has just been milked, the operator cleans the inside of the milking cups that were used on that cow. This is achieved by rinsing the cups

thoroughly with one of the high pressure hoses located in the dairy, before dipping them into an iodine-based disinfectant solution to complete the clean. Conducting this cleaning process after an ill cow has been milked is an important step in aiding to prevent transfer of disease between cows.

The Strong's keep both their ill cows, freshly calved cows and show cows in a separate paddock beside the dairy. This aids them to identify cows that will require special treatment, as they only allow these cows into the milking parlour after the regular herd have completed milking.

4.2.2.15. Operator slides bar – triggers automation for exit

When all cows in a row have been milked and any additional actions that may be required are taken, the operator will trigger the dairy to be arranged for the cows to exit. This is achieved by simply sliding the control rod to the right, resulting in two automation actions being triggered. The first of these is to open the exit gate to the dairy. This gate will lift up and outwards, thus providing an exit for the cows. Secondly, the sheets of metal that act as bail blockers upon entry are then raised slightly, thus providing a gentle nudge to the cows to indicate that it is time to leave the bail. The operator verbally provides instructions and encouragement to the cows to exit the dairy throughout this step.

4.2.2.16. Cows exit dairy

The cows then exit the dairy, moving outside to a large holding area where they are free to move about, and have access to a water trough.

4.2.2.17. Wash milking parlour floors

As each row of cows are released, the operator uses one of the high pressure hoses to hose down the floor where the cows were standing. This keeps the floor clean and ensures cow faeces are quickly removed.

4.2.2.18. Repeat process until all cows milked.

The above milking process is repeated until all cows have been milked. This includes milking the cows from the nearby paddock containing those that require particular attention (sick cows, freshly calved cows etc.).

4.2.2.19. Clean Dairy

After the milking process has been completed for all cows, the cleaning process must then take place. Firstly, this involves a final wash down of the dairy floors and equipment with the high pressure hose.

The automated cleaning process is then initialised. To begin this phase, the milking cups must be placed back into their holding/cleaning position (four prongs at each bail). During the next step the operator will select automated cleaning from the dairies computer controller unit to complete this cleaning process.

4.2.2.20. Flush milk from pipes to vat and initiate automated cleaning

The operator then exits the milking parlour and enters a separate room in which the vat and computerised milking equipment is housed. Here, the operator makes a selection on the automated cleaning system control unit (entitled Hygenius 2000 – which controls the flow of liquids through the milking pipes) to flush water through the pipes to push the milk currently left in the pipes through to the vat (can be a large quantity due to the distance between vat and milking parlour). A clear section of pipe several metres from the vat allows the operator to view the movement of milk through these pipes. When they see water begin to come through the pipes, the pipe leading to the vat is disconnected, ensuring water does not enter the vat, and the pump is turned off. The main filter leading to the vat is then cleaned.

To facilitate the automated cleaning process, the pipe that previously led to the vat is then plugged into the cleaning system connection, thus creating a complete loop within the pipes and milking equipment in the dairy. The operator then selects 'cleaning' mode on the cleaning system control unit, which will subsequently begin the automated cleaning process. This process involves circulating a variety of water and chemicals through the pipes, at varying temperatures and pressure rates, thus providing a complete clean of all the pipes and equipment that milk flows through. Once this cleaning process has been initiated, the operator is then free to exit the dairy, and begin moving the herd to their next grazing paddock.

The automatic cleaner will manage itself and turn off when the cleaning cycle has completed.

Exhibit 4.5 Automated cleaning system controller unit

4.3. Calf Feeding

Managing the amount of milk and feed provided to calves is another important management aspect of a dairy farm. This process is integral to the development and health of a calf, and as such must be handled appropriately. The Strongs undertake this task by grouping their calves into similar age groups, and manually providing each group with a specific amount of milk via buckets at designated feeding times. The calves are also always provided with a solid feed mixture, fresh running water and hay in their pens, allowing them to eat or chew on this feed as they desire. The calves are provided this treatment for the first twelve weeks of their lives, during which time they are also provided shelter.

This manual approach to calf feeding enables the farmers to provide the required amount and type of milk to encourage and maintain solid calf development and growth. For the first week of a calf's life, they are fed with milk from freshly calved cows. This milk contains the required amount of colostrum and nutrients to aid in the calf's early development. This milk is not necessarily provided from the calf's direct

mother, but from whichever of the freshly calved cows is producing the best quality milk for this purpose. This cow usually continues to provide the milk for the calves for the first few days, as changing the source of the milk will certainly change the composition of the milk, which can subsequently make the calves sick.

After this first week, the calves no longer require this solid amount of colostrum, and subsequently they are then fed with milk that is being produced from cows with high somatic cell counts. This milk is considered to be of lower quality than the rest of the herds milk, however is still certainly safe for consumption. Utilising this lower quality milk in this fashion ensures that the farm is optimising their use of the milk produced by their herd - only providing high quality milk to the manufacturer, while still utiliser the lesser quality milk for the valuable purpose of calf feeding.

The age group of the calves will define the amount of milk that they are provided. Initially, each calf is provided with 4 litres of milk, before this amount is gradually increased as they get older to a maximum of up to 8 or 9 litres, depending on the amount of milk the dairy has available at the time. The amount of milk available to the calves is then gradually decreased as they approach time to exit the calving environment. At this time, they are provided with pellets and given access to pasture for grazing until the time comes for them to join the rest of the herd in the grazing paddocks (approximately 12 weeks).

4.4. Herd Information Storage and Retrieval

4.4.1. Herd Management Software

To aid in supporting their herd management activities, the Strongs utilise a software application entitled Dairy Store, produced by Dairy Express. This application is specifically tailored to suite the data storage and herd management needs of the dairy industry. Information such as date of artificial insemination, treatments and a wide variety of other information and individual characteristics pertaining to each of the Strongs cows can all be stored by the application. This data can be accessed and updated based upon the cow’s identification number as assigned by the Strongs at the time of birth. As there are currently no automated procedures for writing daily

information to this database, it is up to the Strongs to enter daily information into the database themselves.

4.4.1.1. Manual Recording Processes

In order to record information relating to individual cows on a daily basis, the Strongs currently utilise a manual working diary to record any action taken on cows, or other information pertaining to the cows that they feel should be recorded. This may include information such as the date of artificial insemination for a cow, date calved, date received a form of veterinary treatment etc. This data is then manually entered into the herd management software, thus providing the information both in hardcopy and on the computer.

This approach subsequently requires duplication of information recording, however having this data stored on the computer enables the information to be easily stored, viewed and manipulated (for reports etc.), thus justifying the duplication of effort. Having the data stored in these two locations also provides a valuable form of back for this information.

4.4.1.2. Dairy Express Herd Recording

A great deal of data pertaining to each cow is also input into the herd management software via electronic data files that are produced as a result of the Dairy Express herd recording services. The Strongs utilise this herd recording service to gain information pertaining to each of their cows individual milk quality and production. This service involves a company representative visiting their farm once a month, and taking a sample of each of their cows milk for analysis.

To gain this sample, the representative sets up quite a large amount of additional equipment at each bail in the dairy. This equipment will catch a designated amount of the milk produced by each cow in a small container (for example, 2.5% of the total amount of milk they produce). As each cow finishes milking, the farm identification number of each cow is written onto the container, and it is retained by the Dairy Express representative. This sampling is performed for all cows, and over two of the standard milking sessions.

These samples are then taken back to the Dairy Express laboratory for analysis. This analysis can provide the following information pertaining to each individual cow sampled:

- Somatic cell count (important for detecting the likelihood of mastitis)
- Litres produced per day
- Fat components in milk
- Protein components in milk
- Other optional information – including pregnancy testing

The results of the two samples taken on the day are averaged to provide the final results. This information can be accessed via the Internet within 48 hours of completed sampling. Results can also be printed and sent to the consumers within a brief period. These printed result sheets also provide historical information related to each cow, such as the information from the last test day, when a cow went dry, their age, calving date etc.

When these results become available online, the Strong's are able to download them to their home computer. They then import this data directly into their herd management software, thus providing regular monthly updates to the information pertaining to each cow. This information can provide a valuable insight into the health, milk quality and production of each cow in the herd. These results can also be compared against national, state and regional results, providing the ability to benchmark themselves against the industry.

4.4.2. Daily Collected Milk Sampling

Information similar to that provided by Dairy Express is also provided by the Strong's milk manufacturer 'Dairy Farmers' on a daily basis. This information however, is provided in regards to the milk production of the herd as a whole, rather than on an individual basis (as Dairy Express provide). This information is gained by taking a sample of the milk from the vat daily, when the Dairy Farmers tanker arrives to collect the milk from the farm. The tanker driver takes a milk sample from the vat, and returns this to the laboratory at the processing plant. This sample can then be analysed as representative of the whole milk batch collected. The results of this

sample analysis are then provided over the Internet to the farmer within 12 hours, providing them with feedback regarding the total amount of litres collected, fat and protein percentage and other figures. This sample also serves as a basis for Dairy Farmers to track the source of any impurities if they are found in the milk contained in the tanker (such as traces of penicillin).

Chapter 5 – Advanced Case Study: The Cochrane Dairy

5.1. The Cochrane Dairy

5.1.1. The Advanced Case Study

This case study was undertaken on the Cochrane dairy farm, located in Pyree (minutes from Nowra) on the NSW South Coast. This farm has been selected as the advanced case study, as it has a strong use of RFID technology, and is well known in the region as one of the most advanced RFID setups. As the farm also utilises RFID tags that are compliant with Australia's NLIS (National Livestock Identification System) system, the farm provides a currently applicable example of how participants in this system can derive additional benefits through the use of RFID on their dairy farms.

5.1.2. Meet The Cochrane's

The Cochrane dairy is a family-run business, operated by partners Geoff and Cathy Cochrane, and two of their sons Tim and Tom. They are also currently training Jason, a young apprentice to assist in the milking and work on the farm.

The farm's core business function is dairy, however they have recently diversified, and begun experimenting with rearing steers until they are 2 or 3 years old. However, dairy certainly remains their core business function, and is likely to remain so in the future. The Pyree farm is one of several properties in the region owned by the Cochranes, however this is where the dairy is located, and thus serves as the location for this case study.

5.1.3. The Cows & RFID Tags

Established on approximately 360 acres, the Pyree farm supports around 350 head of lactating Illawarra cattle (their full herd size is approximately 420 including the dry cows they have on their other properties). All cows in the herd have an NLIS-compliant RFID tag attached to their right ear. This tag is applied to calves immediately (0-4 days) after birth, and plays an integral role in the total farm management operations of this farm.

This RFID tag is utilised to aid in farm management operations from early in a cows life. For a new born calf these tags are first utilised merely weeks after birth, as they

provide the identification mechanism to enable automated calf feeding. Later in the cows life (when they enter lactation), the RFID tags are also utilised in the dairy to identify each cow as she walks into the milking parlour. This identification subsequently facilitates a number of functions within the dairy. As each cow exits the dairy, these tags are also utilised to facilitate the use of automatic drafting gates. Further information regarding these practices is provided throughout section 5.2.

A separate plastic identification tag is also placed in the cow's right ear (traditional tag), which displays the cows on farm identification number (as opposed to the RFID tag number). This number is allocated by the Cochrane's at the time of a cow's birth, and used to identify the cow in relation to their own herd. These tags provide farmers with an important immediate visual identification mechanism for each cow, as they are currently not utilising portable RFID readers, and is traditionally one of the most common forms of identifying cows on farms that are not utilising RFID. Additionally, the Cochrane's are maintaining the use of these tags in order to comply with NLIS regulations, which state that farmers must maintain the use of either a tail or ear tag as a secondary identification mechanism until the 1st of January 2006 (New South Wales Department of Primary Industries – Agriculture 2004).

Exhibit 5.1 Cow identification tags

5.1.4. Herd Management Software

Similar to the Strongs (case study A), the Cochranes utilise a software package to aid in their herd management. The Cochrane's however, extend the use of this application to also provide the basis for their RFID operations. The software application utilised by the Cochrane's is entitled Dairy 2000, and is produced by Victorian company OnFarm Electronics. As with the Strong's software, Dairy 2000 has been specifically tailored to suite the data storage and herd management needs of the dairy industry, and provides the ability to store information pertaining to each individual cow in the Cochrane herd. Further details of this software application are provided in section 5.4.1.

5.1.5. The Dairy

The current dairy was built approximately two years ago, and features a twenty-five a side Herringbone milking parlour (25 bails on each side, therefore catering for up to 50 cows at once). The dairy features a high degree of automation, some of which is combined with RFID technology, while others are triggered by manual actions.

The dairy contains the following features:

- RFID reader upon entry to the milking parlour
- Automated entry gate opening and closing
- Feed bins above bails
- Feed troughs for each milking bail
- Rotating bail entry blockers
- Two LCD computer screens (displaying cow information)
- Audio speaker (to provide audio notification of particular cow attributes)
- Set of milking cups for each milking bail
- Milking controller units for each set of milking cups
- Automated raising of the feed trough to allow cows to exit milking parlour
- RFID reader upon exit to the dairy
- Drafting gates associated with RFID reader upon exit to dairy
- Multiple high pressure hoses throughout

5.1.6. Milking Times & Operators

Milking takes place twice daily on this farm – firstly, at 5am, and secondly at 3pm. Each milking session takes approximately two hours, and is conducted by two operators.

5.1.7. Cochrane Dairy Layout

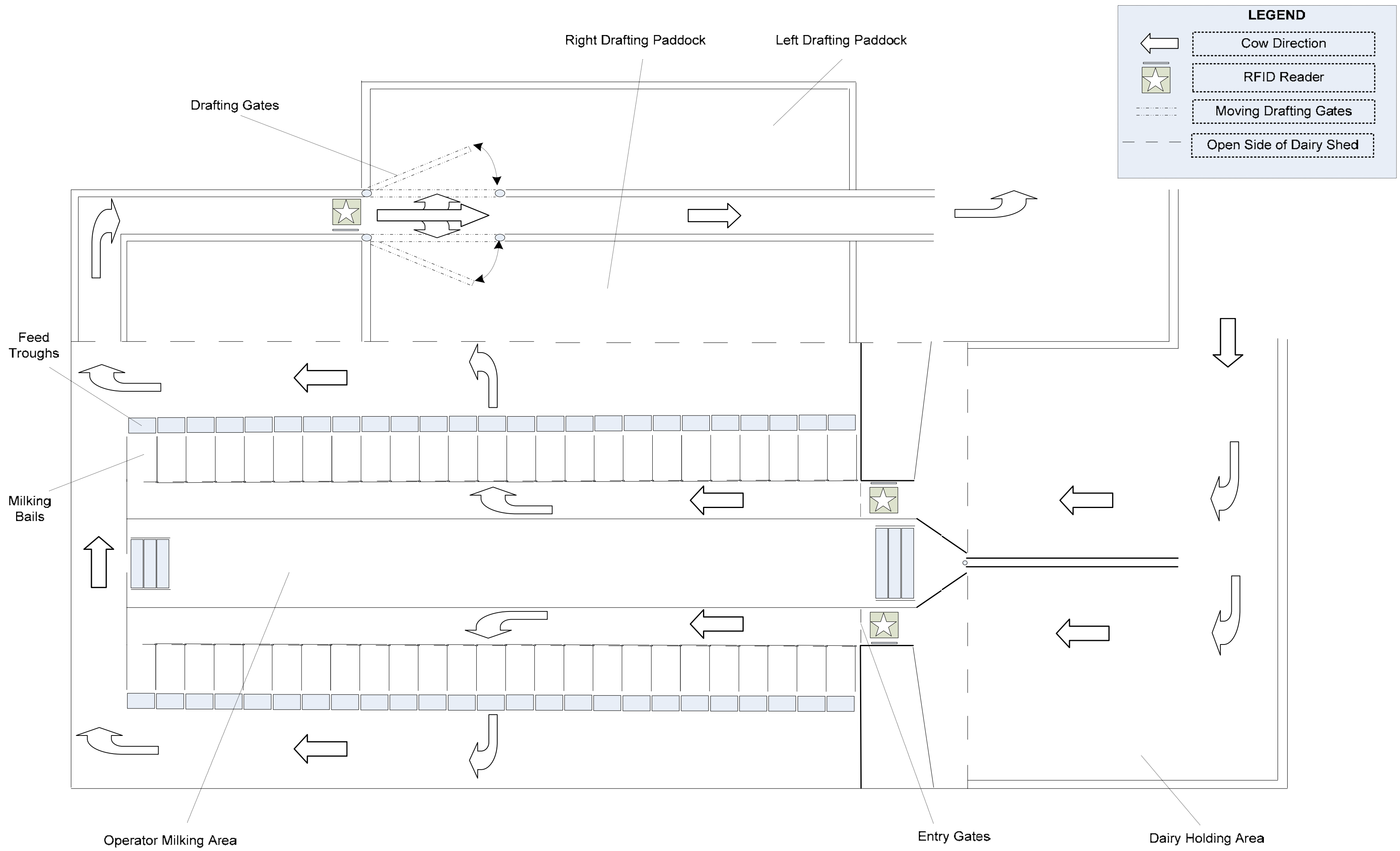

Diagram 5.1 Cochrane dairy layout

5.2. Milking Procedure

The milking procedure of the Cochrane dairy is one major area gaining benefits from the use of RFID. As previously noted in section 4.2 (case study A), it is also an integral component of dairy farm management in general, and thus provides an important area in which further benefits may be derived from RFID in the future. As such, a thorough understanding of this procedure is an essential element to understand both how RFID is currently being utilised, and as well as to provide a basis for future development of RFID on dairy farms.

5.2.1. Workflow Diagram of the Cochrane Milking Procedure

The following workflow diagram summarises the milking procedure undertaken on the Cochrane dairy. Detailed information regarding each of these steps is provided in the following section (section 5.2.2).

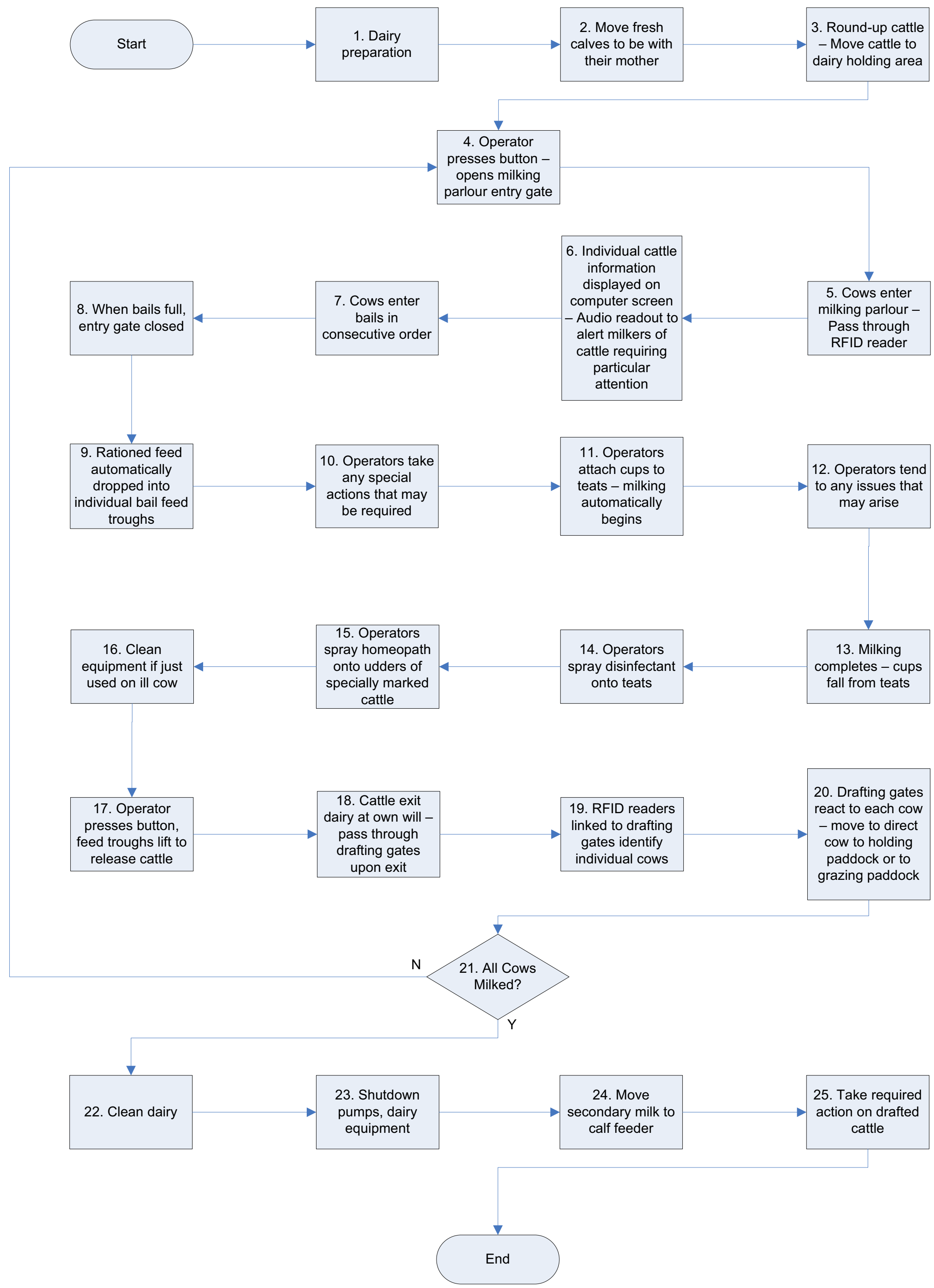

Diagram 5.2 Cochrane dairy milking procedure

5.2.2. Details of the Cochrane milking procedure

At the Cochrane dairy, the following steps are taken for each milking session:

5.2.2.1. Dairy Preparation

Prior to milking, one operator prepares the dairy for milking. This involves ensuring the equipment is clean and ready, and that the computer system is ready for operation. This may also involve entering data about cows into the computer system, or perhaps entering information pertaining to what cows are to be drafted for this milking session.

5.2.2.2. Move fresh calves to be with their mother.

Fresh calves (new born calves) require their mother's milk for the first few days of their lives. The Cochrane's facilitate this by moving the fresh cows into a pen with their natural mother. The calves can then suckle their mother for milk while the milking in the dairy is conducted (after milking the remainder of the herd, the mother cows are moved to the dairy and milked to extract the remaining milk).

5.2.2.3. Round-up cattle – Move cattle to dairy holding area.

Utilising a motorbike, one operator rides out to the paddock, groups the cattle and escorts them to the dairy holding area. While the cows are approaching the dairy, both operators spend time observing the herd for any signs of cows that may be on heat. This is primarily signified by other cows mounting the cow on heat from behind, and may also be indicated by the cows taking a special interest in the bull in a nearby paddock. If the operators determine a cow to be on heat, they will record her identification number (from the visual identification tag placed in her ear beside the RFID tag). If this cow is determined to be beyond their first 60 days of lactation, the operators will then record this cow number into the nearby computer and select it to be drafted when it exits the dairy (where the cow will then be artificially inseminated). As with the Strongs (as described in section 4.2.2.2), the Cochrane's wait until a cow is beyond 60 days of her lactation cycle before attempting to impregnate her. This allows for the cow to have two months away from milking ('dry') before calving again and entering a new lactation period.

After the cows reach the holding area, and the operators have recorded any cow identified as being on heat for drafting, both operators finalise the preparations for milking. The gate to the holding area is then closed by an operator (ensuring the cows to be milked are retained in the holding area), before re-entering the dairy, ready for milking to begin.

Exhibit 5.2 Cows in dairy holding area

5.2.2.4. Operator presses button – opens milking parlour entry gate

Operator presses button to open the milking parlour entry gate - gates open automatically.

5.2.2.5. Cows enter milking parlour – pass through RFID reader

Cows enter the milking parlour in single file, passing through a permanent RFID reader installed on the entry gates. This reader retrieves the identification number from the RFID tags attached to the ear of each cow. This unique identification number is then used to gather data pertaining to each cow from the central database.

Exhibit 5.3 Entry to milking parlour

5.2.2.6. Individual cattle information displayed on computer screen – audio readout to alert milkers of cattle requiring particular attention

As each cow passes through the RFID reader, their individual information is displayed on the two computer screens located in the dairy. These screens provide a selection of information pertaining to each cow. This information is drawn from the central herd management database, and the user is able to specify the specific fields of information to be displayed on the screen. The cows are listed in rows, with their characteristics displayed in the corresponding columns. Importantly, this display also provides the bail number that each cow will enter (the program is able to recognise which bail the cow will be entering, as cows must enter the bails in sequential order, as described in the next section - 5.2.2.7).

Cows with attributes requiring particular attention from the operators are highlighted with various colours on the computer screen. For example, slow milking cows are highlighted in red on the computer screen, cows that have freshly calved are highlighted in yellow etc. For these cows, an audio readout is also generated from the computer system, providing a verbal signal to aid in identifying cows requiring particular attention. This allows the operators to better plan their milking approach for a batch of cows, and aids to ensure they take the required actions. For example, the operators will begin to milk the slow milking cows before the others, thus aiding in efficiency for each batch of cows. For

freshly calved cows, and cows who have had a penicillin injection (and thus their milk must be withheld) the operator will also attach the milking cups to a separate holding drum. This effectively separates specific cow's milk from the main milk, allowing it to be thrown away after milking has completed.

Exhibit 5.4 LCD screen – displaying individual cow data

5.2.2.7. Cows enter bails in consecutive order

Cows enter their bails in sequential order (from one to twenty-five). The order in which they enter bails is enforced by having each bail blocked when the cows first enter. The only bail available for entry is the end bail (number 1). When a cow enters this bail, it will push forward a rotating bar. This will subsequently rotate and open the next bail (bail number 2).). Enforcing this sequencing process allows the computer to establish which bail number each cow will enter as they are read. This is also important to ensure that all bails are occupied, and provide easy entry to the bail for each cow.

5.2.2.8. When bails full, entry gate closed

By reading each cow's RFID tag as she enters the dairy, the computer system is able to determine when twenty-five cows have moved into the dairy. Thus, when a

side is full, the entry gate automatically closes. This prevents other cows from entering the milking parlour during milking.

5.2.2.9. Rationed feed automatically dropped into individual bail troughs

Approximately 40 seconds after the cows have passed through the reader (enough time for them to reach their bail), feed is automatically dispensed from feed holders above the bails. This feed is a mixture of approximately 80% wheat, and 20% pellets. These feed ingredients are stored in large silos beside the dairy, and are mixed into a designated ratio before being pumped through to the feed holders in the dairy. The amount of feed given to each cow varies according to her production and lactation cycle.

Roughly, a cow producing 50 litres or more per milking session (extremely high) will receive 12 kilograms of feed. Those producing approximately 30 litres will receive 8 kilograms, 20 litres will receive 6 kilograms, and finally, those producing 12 litres or less per milking will be provided 2 kilograms of feed during the milking session. Production amounts in between these boundaries will receive an amount of feed rationed to their exact production (e.g. a cow producing 15 litres will receive a calculated ration between 2 and 6 kilograms).

Once a cow has passed their 150^{th} day of their 300 day lactation cycle, they are considered to have past their peak production abilities. As such, the feed provided is then gradually decreased to only 75% of the figures provided above. As a cow passes the 250^{th} day of lactation, they are considered to be well past their peak production capacity, and the feed is again gradually decreased to 50% of the above provided figures, so as to gradually wean the cow off this food supply. This 50% of the original stated amount is then maintained until the cow is dry and thus does not return to the dairy.

The data regarding how much milk each cow is producing is extracted from the central herd management database (this data is recorded by Dairy Express herd recording services) according to the cow's unique RFID identification number. This rationing of feed ensures that cows are provided the nutrients they require to

continue their milk production, while not overfeeding those cows who do not need it.

When a cow enters the dairy for the first milking of her new lactation cycle, the automatic feeder also starts this cow at a low amount of feed (approximately 1 kilogram). The amount of feed is then gradually increased over a 20 day period, up to a standard 8 kilograms of feed. This feed is then maintained until the cows production capacity is measured (through the use of Dairy Express herd recording), and her amount of feed is then determined by this figure. This gradual incrementing of feed is required so as to allow time for the cow to develop the required bacteria in their stomachs to handle the wheat and grain in the feed. If they are not gradually introduced to the feed in this way, a cow may be susceptible to fatal wheat or grain poisoning.

5.2.2.10. Operators take any special actions that may be required

As the cows enter their bails, operators are able to take any required action on cows. For example, if a cow has had a penicillin injection in the last few days, their milk must be disposed of, as it is not suitable for consumption by any animal. To achieve this, the hose connecting the milking cups to the main milk flow pipes are detached from the main milk pipes, and instead attached to a barrel. When milking is complete, the milk in this barrel is disposed of.

Other actions that may be required include attaching the milk pipes for specific cows to a secondary milk vat. This vat is used to store milk that the Cochrane's consider second grade milk, and is later used to feed the calves via the automatic calf milking machine (details of this automatic calf feeding machine are provided later in section 5.3). This second grade milk is still quality milk, and suitable for consumption, however it is considered of lower quality than that being produced by the rest of the herd. Therefore, to maximise the quality of the milk provided to the manufacturer (in this case Dairy Farmers), the Cochrane's separate the lower quality milk. Thus, this separation and use of secondary milk maximises the use of produced milk and provides enhanced benefits for the farmer.

5.2.2.11. Operators attach cups to teats – milking automatically begins

Operator presses lever to begin milking pulsation and suction within milking cups before attaching these cups to the teats of a cow. The milking cups provide pulsations that mimic a calf suckling, and thus extract milk from the cow through these gentle nature-inspired pulsations. For slow milking cows, the operator will often begin the milking process by hand, so as to get the milk flowing.

Exhibit 5.5 Milking cups attached and suckling milk from teats

How the operators attach the cups may vary depending on the current udder condition of the cow. For the majority of cows, the cups are simply attached to all four teats on the cow without any further action being required. However, some cows may have problems with a specific teat on their udder, may have had one teat dried off for a particular reason, or are currently being treated for a disease in a teat. To cater for such individual attributes, operators are required to take different actions to the standard milking procedure (such as not attaching a cup to a dried teat).

Cows requiring these varied actions are identified by coloured leg bands that are attached to the legs of cows using Velcro straps. The colour and placement of the leg band signifies the position of the problem teat on this cow, and how the milking operator should conduct milking for her. A green leg band on the cow indicates that there is a problem with the front teats, and the leg band is placed on

the left or right leg to signify which of the front teats have the problem (thus indicating left or right front teat). A red leg band is also used, which indicates that there is a problem with the rear teats, and the leg band is again placed on the left or right to signify which of the rear teats have the problem (thus indicating left or right rear teat). Having two leg bands of the same colour on the one leg of a cow indicates that one of her teats is bad, or has been dried off for a particular reason. It is up to the operators to recognise these leg bands and combinations, and to not apply milking cups to the teat identified as having the problem.

Cows that have had a penicillin injection are identified with a single leg band (utilising the colour and placement code previously described to identify the problem teat), as well as having blue spray paint on their back of their udder. Thus, the milk from this cow is to be separated from the main milk and disposed of (as described in section 5.2.2.10).

5.2.2.12. Operators tend to any issues that may arise

Occasionally unpredictable events will occur that will require the operator's attention. These events include cows kicking the milking cups off before they have finished milking, cups not retracting correctly when milking completed, slow milkers may require a check to ensure they have provided all of their milk (requiring a manual feel of the milk left in the teat).

Operators may also be monitoring certain cows that they believe may be coming down with an illness, or are recovering from an illness (such as mastitis). Thus, the operators may take extra steps to monitor the progress of this cow, such as ensuring this cow has given all of her milk, or check that cows milk line filter for signs of clogging.

This milk line filter is placed in the milk line between the milking cups and the main milk flow line that leads to the milk storage vat. As milking is being conducted, milk flows through this filter before it enters the main milk flow line, thus aiding to remove any impurities in the milk. Additionally, as this filter is associated with each individual milking bail, this filter is a good indicator of the milk quality being provided by the cow in that milking bail. If the milk is of poor

quality (a good sign of a cow being ill), the filter will catch quite a lot of impurities, thus appearing somewhat clogged. Keeping a watch of these filters (as they are surrounded by clear surface) aids operators to detect any illnesses in cows and also poor quality milk.

5.2.2.13. Milking completes – cups fall from teat

The milking cups automatically detect when the cow has finished giving milk. At this point, the cups will cease their suckling and suction, and subsequently fall from the cow's teats. As they fall from the teat a piece of cord linking the milking cups to the base of the milking controller unit will retract, thus raising the cups to a stationary position – keeping them off the floor and at a position ready for attachment on the next cow. This signals to the operators that the milking has completed for the cow that these were attached to.

As previously noted, operators may wish to ensure that slow milking cows have been fully milked. This involves manually feeling the udder to identify if any milk may be left. If there is, then the operator may manually pull the teats to extract remaining milk, or reattach the milking cups for a brief period.

5.2.2.14. Operators spray disinfectant onto teats.

As cows finish milking, operators spray an iodine-based disinfectant onto cow teats. This solution aids to kill bacteria present on the teat, and protect the teat against foreign bodies for a brief period while the teat returns to being fully closed after milking.

5.2.2.15. Operators spray homeopathy onto udders of specially marked cattle

While the process of spraying disinfectant onto teats is being conducted, homeopathy is also applied to the udders of those cows identified as requiring the treatment. This homeopathy treatment is a naturally developed solution that is utilised on cattle that the Cochrane's feel may be developing an illness (such as mastitis). The solution is applied to the udder of cows via a spray bottle that the operators carry on their belts. This treatment is first tried when the operators believe a cow may be falling ill, and the cow is monitored for any progress. If the homeopathy does not resolve the issue, drugs such as penicillin will then be

utilised. Cattle requiring this treatment are identified by a yellow tag attached to their tail.

Exhibit 5.6 Yellow tail tag to identify cow requiring homeopathy

5.2.2.16. Clean equipment if ill cow just used

If a cow with an illness has just been milked (cows with illnesses are identified by their leg straps, as noted in section 5.2.2.11), the operators clean the inside of the milking cups that were used on that cow. This is undertaken to prevent the possibility of spreading disease between cows via the milking cups. This cleaning is performed for all cows that have been treated with penicillin (or another drug), homeopathy, or who the operators feel may developing an illness. The milk line filters are also checked and cleaned after such cows, thus clearing any impurities that may have been caught here.

5.2.2.17. Operator presses button, feed troughs lift to release cattle

When all cows in the row have completed milking, all additional actions taken (such as spraying homeopathy), and disinfectant has been sprayed onto all cows teats, the operator is free to release the row of cows. This is achieved by pressing the designated release button.

Pressing this button triggers the feeding bails that are currently placed in front of the cows to automatically be brought backward and raised into the air. This enables the cows to move out of their bails in a forward direction, underneath the feed bails. Once they have moved far enough out of their bails (approximately a metre clear of the bails), the operator presses the lower button to bring the feeding bails back to the feeding position and ready to hold the next group of cows.

Exhibit 5.7 Bails raised, cows exiting milking parlour

5.2.2.18. Cattle exit dairy at own will – pass through drafting gates upon exit

Once they have moved beyond the bails, cows may exit the dairy at their own will. As the cows are not occupying the bails, the operators can immediately bring in the next group of cows for milking into that row, thus aiding to save time and effort for the operators.

As the cows exit the dairy, they again move single-file through a drafting gate. These gates are located outside of the physical dairy building, and thus cows have plenty of room to freely move and arrange themselves before moving back to single file to move through the drafting gates.

5.2.2.19. RFID readers linked to drafting gates identify individual cows

An RFID reader is placed slightly in front these drafting gates so as to determine the identity of each cow before they enter the gates. This reader attains the unique

identification number from each cow's RFID tag, and utilises this number to query the database and derive information relating to the direction in which the current cow should be directed.

5.2.2.20. Drafting gates react to individual cows – move to direct cow to holding paddock or back to grazing paddock

From the information gathered on each cow, the drafting gates will move to direct the cow to the desired area. By default, these gates point straight ahead, thus providing a thoroughfare for cows to continue to walk towards the grazing paddock. However, if a cow has been selected to be drafted out of the main group, then the drafting gates will move to direct a cow either to small holding paddocks on the left or right of the main thoroughfare.

When a cow that has been selected for drafting is recognised by the RFID reader, two flipper gates will rotate to block entry to the drafting gate for this cow. This gate prevents the selected cow from entering the drafting gate section until it has completely changed direction, and is ready to lead the selected cow directly to their designated paddock. Visual detection devices are utilised on the entry to the drafting gates to ensure that the cow that was read previous to the currently selected cow is clear of these gates before they close. The same devices are also utilised on the exit to the drafting gate to detect when the previous cow has completely left the drafting gate section. Once the previous cow has completely moved free of the drafting gates, flipper gates on the exit to the drafting gate will then also close, thus preventing other cows from returning. The drafting gates will then move either to the left or right (as specified in the information collected from the herd management software), directing the next cow to their designated paddock.

Once the drafting gates are in position, the entry flipper gates will retract, and allow the selected cow to proceed to their designated paddock. As she enters the drafting gate, and is detected to have moved past the entry flipper gates, the entry gates will then close again to prevent other cows from following her path. Again, when the drafting gate devices detect that the selected cow has moved completely free of the drafting gates, the gates will move back to their default position of

straight ahead. The flipper gates on both the entry and exit to the drafting gates will then open again, allowing cows to move through the drafting gate.

Cows may be selected for drafting for a variety of reasons. In general, any cows requiring additional treatment, such as veterinary treatment, artificial insemination etc., are drafted to the holding paddock to the right of the drafting gates (and main thoroughfare). High producing cows, or cows that the Cochrane's have selected to be show cows, are directed to a holding paddock to the left of the drafting gates, where they will have access to additional feed in the form of hay and silage.

5.2.2.21. Repeat process until all cows milked.

This completes the milking process for a batch of cows (one row of 25 cows). This process is then repeated for the remainder of the herd (approximately 300 cows), and is conducted on both sides of the milking parlour (enabling the dairy to cater for 50 cows at once). Each row of the dairy can be at a different stage of this process, thus aiding to maximise efficiency in milking – i.e. on one side of the dairy the operators may begin attaching milking cups to the cows, while the cows on the other side are moving in or out of their bails (where human intervention is not required).

5.2.2.22. Clean dairy

Once all cows in the herd have been milked and moved out of the dairy, the cleaning process then begins. This involves thoroughly washing out the dairy floor and milking area, flushing out the faeces catcher, and hosing down any other areas that may have been dirtied, including the outside of the milking cups.

Automatic cleaning of the milking equipment is then undertaken. To facilitate this, the milking operators place each set of milking cups onto their holding rack (four fixed prongs). A milking operator can then exit the milking parlour, and select on the central milking controlling computer to begin the cleaning cycle for the dairy equipment. This cleaning process involves pumping a range of chemicals (including alkaline and acid) throughout all pipes and milking equipment through which milk flows. This includes all milk lines and milking cups. When selecting to start this cleaning cycle, the milking operator can enter a range of parameters

for the cycle, including what chemicals to use, how long each chemical should be used, what temperature to run each chemical at etc., thus providing the ability to customise this cleaning process. The milking operators can then exit the dairy, and leave the cleaning process to manage itself (including completion, pumping all water and chemicals out of the milk lines and turning itself off).

5.2.2.23. Move secondary milk to calf feeder.

The milk that was pumped to the secondary vat (milk taken from cows considered to be giving secondary quality milk) is then transported from the dairy to the calf feeding area. This is easily transported to the calving area due to the vat being relatively small and mobile, as it is placed on wheels. This milk is then poured into the refrigerated vat that is linked to the calf feeding machine.

5.2.24. Take required action on drafted cattle

Once the dairy has been cleaned, the required action is then taken on the drafted cattle before releasing them to return to the grazing paddock with the rest of the herd. This may include artificial insemination, veterinary treatments etc.

5.3. Automatic Calf Feeder

The other key area in which RFID is utilised on the Cochrane farm is for the important process of calf feeding. To undertake this task, the Cochrane's have implemented an automatic calf feeder. This feeder utilises a calves RFID tag to gain their unique RFID identification number and regulate the amount of milk being provided to each calf on a daily basis.

5.3.1. Operation

The automatic calf feeder dispenses milk through an artificial teat, which the calves suckle to gain the milk. Calves access this teat by walking into an entry gate (barrier) that ensures only one calf has access to the teat at any one time. As they approach the teat through this walkway, an RFID reader built in to the walkway gains the identification number of the calf from the RFID tag in its right ear. This number is then used to retrieve data regarding the amount of milk this calf is allowed to drink over a 24-hour period, and how much of this they have consumed already. If they

have already drunk their full quota of milk over the past 24 hours, no milk will be supplied to the fake teat. This ensures that calves do not drink excessive amounts of milk. However, if they have not drunk their full quota, they will be provided with more milk until they reach this full quota. The calves can stop drinking at any time, and the computer will record data pertaining to the amount of milk taken during that session. Utilising this approach ensures that calves are provided with the required amount of milk to support their current age and growth.

5.3.2. Feeder Setup

The calf feeder at the Cochrane dairy provides two separate milking points for feeding, thus enabling two calves to be fed at once. These are placed at opposing sides of the feeder, ensuring there is plenty of space at both entry gates. The automatic feeder draws it’s milk from a refrigerated milk vat placed a few metres from the feeder. This vat is topped up with the secondary milk retained from every milking session, and serves as the primary source of milk for the calves. The automatic calf feeder also has the ability to deliver milk to calves from a powdered mixture base. This manner of providing milk will be automatically reverted to if the main milk vat is detected to have run dry. In such a case, the machine will begin mixing water with the milk powder to create liquid milk and continue feeding the calves.

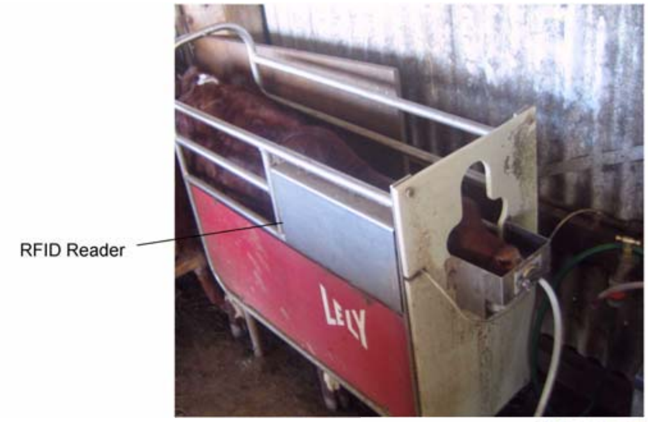

Exhibit 5.8 Calf Feeding Equipment – Top Left: Calf suckling milk from artificial teat; Top Right: Calf feeder unit; Bottom Centre: Refrigerated vat for holding milk to feed calves.

5.3.3. Milk Quotas

The preset limit for the amount of milk each calf is permitted to drink is dependent upon the age of the calf. When the calf is first introduced to the calf feeder (from around 4-7 days after birth – before which they feed from their mother), they are provided 4 litres a day. As they grow older, they are gradually allowed more, up to a maximum of 7 litres.

After approximately three months on the calf feeder, the calves will join the rest of the cows in the grazing paddocks, where they will not receive this supply of milk. This transition is aided by the calf feeder, by gradually weaning the calf from the provided milk before being released to the paddock. The amount of milk available to the calf is lowered from 7 litres to 6, then 5, 4 etc., all the way down to providing only 1 litre of milk per day. This weaning encourages the calves to eat more grass, and adapt to life without the automated feeding.

5.3.4. Viewing Consumption

The calf feeder allows the farmers to view the amount of milk that any specific calf is drinking through a simple screen attached to the machine. This feature is highly useful, and the operators frequently utilise this to check that calves are drinking most, if not all of their allocated amount of milk. This is especially useful when a calf is first introduced to the milking machine, as it provides the farmers with feedback to ensure that the new calf is adapting to this new feeding mechanism.

The milking machine also provides alerts to farmers if a calf has not taken any milk for an extended period, or if it is only consuming a small percentage of its total available amount. These characteristics could indicate a problem with a calf, such as illness, and thus requires investigation by the farmer. These alerts are posted to the display screen of the milking machine, which the farmers check at regular intervals.

5.3.5. Introducing a Calf to the Feeder

To introduce a new calf to the feeding machine, the operator simply sets the mode on the calf feeder to record new calf. They then swipe the RFID identification tag past the RFID reader in the feeder entry, and that calf is immediately registered. The calf can then begin suckling for milk, and the calf feeder will manage their allocated amount of milk over the next three months of the calf's life.

5.3.6. Other Feed Provided

Other feed provided to calves include a mixture of grain and pellets (the same mixture that is provided to cows in the dairy), and also hay (which calves sometimes just like to chew on). However, this feed is not dispensed or controlled by any device, but rather is simply placed around the calf paddock, allowing calves to eat this feed whenever they desire.

5.4. Herd Information Storage and Retrieval

5.4.1. Herd Management Software

As earlier noted in section 5.1.3, the Cochrane dairy utilises the Dairy 2000 software application to assist in their herd management operations. This software has been

designed to meet the requirements of the dairy industry, and provides the ability to store information pertaining to each individual cow in the Cochrane herd.
This includes the ability to store data on a range of characteristics for each cow, such as the date of artificial insemination, date calved (date a cow gave birth to a calf), treatments (such a penicillin), milking rates etc., as well as a range of data that may assist in facilitating herd management. As such, this software is able to provide an entire history of any particular cow. This data can be easily accessed and updated based on a cow's unique RFID tag number, or also by the cow's unique farm number as assigned by the Cochrane farm.

This software application is the underlying component of all of the RFID operations of the dairy. The data contained in this program is accessed by the RFID readers and utilised to facilitate the relevant automation operations, such as deciding on the amount of feed to be provided to a cow, which direction a cow is to be drafted etc. It also provides the interface to display individual cow data to the milking operators in the dairy during the milking process. It is important to note however, that this software application is not being utilised to operate the automatic calf feeder, as this machine utilises its own self-contained software for data storage and operation.

5.4.2. Manual Recording Processes

Complementing this software package, the Cochrane's also utilise 2 manual entry books as a form of running diary for their herd management operations – one for the purposes of recording cow information, and the second for recording paddock information. They fill in the cow diary with information pertaining to any actions taken on cows for that day. For example, penicillin injections, artificial inseminations etc. They manually write down the cow number, action taken and any other relevant information in this book. The paddock work diary is used to store information pertaining to any work completed on any of the farms paddocks. This may include seeding a paddock, spraying chemicals etc. These diaries are retained as manual form of recording, enabling the computer system and written diaries to complement one another.

Retaining this form of manual record keeping subsequently requires the farmers to record cow data twice - once in the diaries, and again to transfer this information into

the herd management software. This approach is required however, so as to enable the farmers to record information while they are in the field conducting the actions. Despite this double recording of cow information, it is felt that the benefits provided by storing data in the herd management software certainly make this additional step worthwhile. Additionally, having this information provided in two forms and in two locations (the computer system located at the dairy and also the portable diary) provides valuable backup sources for this information.

5.4.3. Dairy Express Herd Recording

Like the Strong dairy (case study A), the Cochrane dairy also utilise the services of Dairy Express herd recording to test the milk produced by each of their cows. The Cochrane's also download the results of this analysis, and are able to import this information directly into their herd management software. This allows for the information relating to each cow to be updated on a frequent monthly basis, thus aiding to provide up to date information to be utilised in RFID operations, and providing a common ground for analysis and comparisons to be made.

5.5. RFID Benefits

The Cochrane's believe that they are certainly gaining a good return on their RFID investment, both financially and in general convenience. The following are some of the areas in which benefits being are provided by the use of RFID on this dairy farm.

5.5.1. Automatic Feeding

One of the benefits of the RFID setup is that it makes individual feeding far easier. Having the computer calculate and deliver the appropriate amount of feed for each cow (depending on their production as measured during the last herd recording), makes the feeding process far easier for the operators, as it relieves them from managing this aspect of the milking process.

Providing this automated feeding also guarantees that cows are provided the required amount of feed to sustain the amount of milk they are currently producing. Subsequently, this ensures that the cows are given the best chance at good health, while leaving no room for human error in providing the varied amounts. This

approach also saves the farm significant money, as they do not have to provide large amount of feed for low producing cows, nor do they suffer from wasted feed through spilling. With feed accounting for a large proportion of dairy farm costs, it is certainly beneficial to ensure that this feed is being utilised to gain the best possible return.

The ability to automatically detect recently calved cows (those new to the dairy for this lactation cycle), and to gradually introduce them to the feed is also a valuable asset. This ensures the cows do not fall victim to wheat or grain poisoning, as may happen if they immediately are provided with a large amount of feed. Thus, this provides another avenue to aid in the ensuring the health of cows, which subsequently aids to encourage high milk production and continued good health for the farms most important assets.

5.5.2. Automatic Drafting

Another large benefit is obviously the ability to automatically separate cows that require particular attention from the rest of the herd. This is achieved through the use of the RFID reader linked with the automatic drafting gates. By entering the numbers of the cattle to be drafted into the herd management software, these cows will be automatically separated from the rest of the herd at the designated milking session. This saves the farmers from having to attempt to identify individual cows outside of the milking session, and also saves them from having to exit the milking parlour and retrieve a cow as she exits the milking parlour if they wish to gain her at that time. As such, this automatic drafting can be seen to provide a reduction in hassle for the farmers, while increasing the efficiency of the milking process.

The Cochrane’s also utilise this drafting ability to provide additional attention for their selected show cows. By drafting their show cows to a separate paddock after each milking session, the Cochrane’s are able to easily provide these cows with additional feed of hay and silage, thus aiding to supplement their existing diets that they share with the rest of the herd. While these cows are in the separate paddock, the Cochrane’s are also being able to monitor the condition of these cows, and take any further steps that may be required to keep them in the best possible health and show condition.

5.5.3. Automatic Calf Feeder

Automating the practice of calf feeding provides large benefits for the Cochrane's, primarily through the reduction of labour required to undertake this activity. Prior to the automated calf feeder, the Cochrane's undertook calf feeding in the same manner as many other dairy farms (including the Strongs) – by grouping calves into age groups, and manually providing milk to each group of calves via buckets at designated feeding times. While effective, this approach is quite time consuming for the farmers, and depending on the manner in which the calves are fed, it may be difficult to gauge exactly how much milk each calf is receiving.

Utilising the automatic calf feeder, this human labour requirement is reduced, as the calf feeder will automatically manage the task. This results in the only remaining labour required for calf feeding being a regular check of the machine to ensure it is working correctly, and for the farmers to view the amount of milk each calf is currently consuming (easily achieved via the associated information screen for the machine). Of course the calves will require human attention for a number of other activities, however this large labour requirement for feeding is now virtually eliminated. This provides additional valuable time to the farmers to undertake other activities on the farm. Alternatively, the Cochrane's have elected to increase the amount of calves being raised on the dairy, without having to increase the amount of labour provided.

The ability of the calf feeder to adjust the amount of milk being provided to each calf ensures that each calf receives the correct amount of milk required for their age on a daily basis. This aids to ensure that calves develop and grow healthily, while providing them with the ability to drink when they desire, rather than at a preset feeding time. As the calf feeder is capable of determining each calves age (and subsequently the amount of milk to provide) through their identification tag, the machine also removes the requirement to group calves into similar age groups. As such, this further removes the labour requirement and hassle for farmers. This also benefits the calves, as they are free to associate and learn from a larger and more diverse group of other calves.

5.5.4. Provision of information during the milking procedure

As noted in section 5.2.2.6, selected information relating to each individual cow, as well as the bail number that each cow is assigned to in each milking row is displayed on two screens located at either end of the milking parlour. The ability for the milking operators to be provided with this information as the cows enter the milking parlour is highly useful for the Cochranes. Primarily, this ability provides another mechanism for informing milking operators of any cows with particular characteristics that may subsequently require particular attention or additional steps to taken during the milking process (e.g. disposing of milk from cows that have had a recent penicillin injection). The associated audio readout of this information, as well as the colour-coded highlighting of this cow on the computer screens also aids to ensure that these characteristics are recognised by the operators and appropriate action taken.

This relay of information also enables the operators to better plan their milking procedure for each row of cows that enter. This is possible as milking operators may begin preparations for milking of cows requiring particular attention as soon as they enter the milking parlour – as opposed to only recognising that a cow requires additional actions to be taken when the operator arrives at this cow to place the milking cups on her. Additionally, the operators can also begin milking the slow milking cows first. Taking these actions aids to increase the efficiency of milking for each row of cows, subsequently aiding to reduce the total time taken for milking the herd.

5.6. RFID Cost – Benefit

The cost, as well as the effort and labour required to implement the current RFID setup on the Cochrane dairy certainly required a large investment of both time and money. The combined cost of both the hardware and software for the upgrade to RFID was estimated to be $60, 000. As to whether the Cochrane's believe this large investment has been justified, Tom Cochrane (2005) states,

> *"the advantages have outweighed the cost of it, long term. Like, if you're talking only over a year, there's no way you can justify that cost, but if you justify it over 20 years, it's paid for itself well and truly."*

Regarding the ongoing costs of RFID, the Cochrane's do not see these are being excessive either. The main ongoing cost for this implementation is for additional RFID tags. However, as these tags are now mandated by law in NSW (due to NSW NLIS regulations), the Cochrane's point out that there is now no option but to identify cows with RFID devices anyway. As such, this cost cannot be attributed solely to ongoing costs of this setup, but is a required cost by law. Rather, the application of these tags at the start of a cows life (rather than only as they exit the farm) and subsequent use of these tags to facilitate farm management operations is simply an optional way for the farm to gain benefits from this required cost.

5.7. Future RFID Implementations for this Farm

The Cochrane's have found great benefits from their use of RFID currently, and are interested in further advancing their RFID operations in the future. However, the only advancement that they are realistically considering is the implementation of milking meters for every milking bail. Implementing these milking meters will provide the ability to record the amount of milk each cow has provided at every milking session. This is in contrast to the current practice of only gaining these figures once a month through the use of the herd recording services of Dairy Express.

Attaining milk production figures for every cow from every milking session will provide vastly more information for the farmers to utilise in their farm management decisions. This ability may facilitate enhancements to a range of other activities also, such as enabling more up-to-date figures to be utilised for the calculation of feed requirements for each cow. Further, this frequent recording of information may also serve as a means to detect problems with cows. For example, a cow producing significantly less milk than her calculated average may be suffering from an illness, or other stress factor that is reducing her milk production abilities. Thus, the farmers can investigate this cow and resolve any issues, enabling the cow to return to health and her increased production capacity in much quicker time.

Chapter 6 – Towards Total Farm Management

6.1. The Current State

Chapters 5 and 6 have demonstrated the operation of a dairy farm without RFID, and also how RFID is currently being utilised at a relatively advanced level for farm management. From these case studies, it is possible to identify numerous common elements evident from both farms, and the assistance that RFID is currently providing to dairy farm management practices. This chapter will attempt to build upon the current RFID usage as identified in the case studies, proposing a framework for the use of RFID on dairy farms, while also proposing enhancements and ideas which could be considered as future additions to further add value to the utilisation of RFID in farm management.

6.2. Mandatory Components for RFID-Enabled Dairy Farms

The following section describes components that are believed to be mandatory for a dairy farm that wishes to utilise RFID to aid in farm management in any manner (whether advanced or basic). These components can be used on their own to provide a variety of advantages for the farmer, however also form the basis for the use of more advanced components, described later in section 6.3.

6.2.1. RFID Tags/Boluses

RFID tags, boluses or microchips form the basis of any dairy farm RFID system. The choice of what RFID device a farm utilises is specifically a matter of personal preference for the farm owners. Each of these devices provide the same functionality, reliability and accuracy, and are intended to last for the life of the cow. Further to this, each device has their own advantages and disadvantages (such as tags being cheaper, boluses being irretrievable until the time of slaughter etc.), leaving the eventual choice of device to the individual farmer to select the device type that best suits their requirements and farm. It is important to note that for the remaining sections of this chapter, the word ‘tag’ is utilised generically, however microchips and boluses can be used to perform the same functions.

6.2.1.1. NLIS-Compliant RFID Tags/Boluses

There are a number of tags, boluses and microchips available from various vendors, however there are currently only three tags, and one bolus that have been approved for use with Australia's NLIS (Meat and Livestock Australia n.d.b, p. 18). As such, Australian farms that are required to participate in the NLIS by state law, or who wish to participate voluntarily (which is permitted), should adopt one of these NLIS recommended devices. This will ensure that they both provide themselves with RFID capability, and also comply with the relevant NLIS specifications (as required by law in some states). Microchips cannot currently be utilised by those participants in the NLIS, as none have been approved to date.

6.2.1.2. Timing of Attaching RFID devices

The chosen RFID device should be attached to the cow immediately after birth (or several days thereafter). This will ensure that all cows on a farm are tagged, and allow the RFID tags to be utilised for farm management practices immediately from birth. Even if RFID devices are not utilised until later stages of a cows life, attaching these devices at birth ensures that the tagging has been conducted for all cows, and removes the need for any special RFID attaching sessions at later dates (thus causing an unnecessary change in routine and possible stress for a cow). Both the Cochrane and the Strong farms have been shown to utilise this approach to attaching RFID devices, despite the Strongs currently not utilising RFID devices in their farm management operations at all.

6.2.2. Herd Management Software

The ability to digitally store herd information is certainly a valuable tool for all farms, and a necessity for those desiring to utilise RFID to aid in farm management. Herd management software provides farmers with this ability, providing mechanisms for them to store individual cow data into a database. Data can be entered into this software application manually via an easy to use, standardised interface, or alternatively (and predominantly for the purposes of this framework), data can be automatically entered through the use of other digital devices (such as milk meters, cow weight scales – discussed later in this chapter) linked to this database. Automating data entry through the use of other digital devices enables data to be

stored reliably and accurately, while reducing the labour requirements of the farmers by saving them from entering the data themselves.

Many capabilities of herd management software are virtually impossible to achieve utilising traditional paper-based techniques. For example, utilising such an application allows a farmer to easily view, analyse, manipulate and sort data, all in a matter of keystrokes. Such an activity would be extremely time consuming at the least, if not completely impossible for farmers to complete via traditional, paper-based techniques. Subsequently, farmers are able to easily and immediately view information on individual cattle, view an entire cows history (calving date, artificial insemination dates, treatments etc.), produce reports on individual cows, selected cows or the herd as a whole etc. All this can be conducted without physically looking at hand-written or previously printed documents. Additionally, the data, and results from any analysis/reports can then be viewed via a digital display (such as computer screen) or in hard copy documents (via printouts). Such information storage and manipulation capabilities provide farmers with an extremely valuable resource to aid them in their farm management activities and decisions.

6.2.2.1. Reference Point for RFID devices

Such herd management software also provides RFID devices with the information required to make a decision or conduct an action. The Cochrane dairy case study provided a valuable demonstration of how herd management software is utilised in this fashion. For example, the information stored regarding each cows last recorded volume of milk production and their stage of lactation provides the basis for the automated decision of how much feed to be provided to each cow during the milking session. A complete herd management system provides such devices with this ability to access detailed individual cow information, thus making it a central element to any dairy wishing to implement RFID to aid in farm management.

6.2.2.2. Herd Management Software and the NLIS

Australian dairy farmers may also receive additional benefits by utilising herd management software that provides the capability to communicate automatically with the NLIS central database. Utilising this approach, in the event of a farmer recording the receipt of cattle from another farm, or the movement of cattle from one of their

farms to another, the software can then prepare and send the required information update files to the NLIS central database via the Internet. This process would otherwise have to be undertaken by the farmer as an additional step to recording cow movements if not automated in such a way. Thus, purchasing herd management software with this in-built capability further aids to reduce labour, while also saving farmers who may not be highly experienced with computers and technology from having to learn how to send these NLIS updates themselves. Cattle software vendors such as HerdLink Currently provide software with this capability (HerdLink 2004).

6.2.3. Fixed RFID Reader

In order to derive any use and subsequent benefit from the practice of identifying every cow with RFID tags, a farm requires an RFID reader device. Subsequently, at every position in which a farmer wishes to utilise a cows RFID number on a regular basis, a fixed RFID reader should be utilised. These provide a reliable and robust source of identification, while also providing a greater range for reading RFID devices than portable RFID readers.

6.2.3.1. Deriving Benefits from Fixed RFID Readers

These fixed readers can be used in conjunction with other devices to enable a subsequent action or series of actions to be performed, or decisions to be automatically made (based on set data parameters). For example, fixed readers may be utilised for the purposes of identifying a cow as she enters the milking parlour, and subsequently recording the time and date of this read to the central herd management database (indicating the milking time for this cow). Likewise, fixed RFID readers may be utilised to record a cows milk production (in association with milk meters), to identify cows required for drafting gate operations etc. To facilitate such actions, a communication (network) link is required to the herd management software (networking will be discussed in greater details in section 6.2.4).

6.2.3.2. Minimum Fixed RFID Implementation

At the simplest level of RFID implementation, a fixed RFID reader should be placed upon entry to the dairy, and have a network link to the herd management software. This is the most fundamental placement of a fixed RFID reader on dairy farms, as lactating cows must pass through this reader at least twice a day on their way to be

milked. At a minimum, placing the RFID reader in this position allows data to be automatically recorded regarding the time and date that each cow enters the milking parlour, and should at least be arranged so as to display cow information (displayed via relevant interface of the herd management software) on a computer screen at the end of the dairy. Placing the reader in this position also provides the possibility for the reader to serve as the basis for a wide range of optional operations to be conducted within the dairy that require individual identification of cows (e.g. automatic feeding etc.). Even if no further RFID linked components are currently utilised in the dairy, placing the reader in such a location provides the possibility for these additional components to be implemented in the future.

6.2.4. Digital Device Network – Wireless/Wired

A form of digital network is required so as to enable the communication of devices between one another, with RFID readers and the central herd management software. There are essentially three methods of establishing such a network – wired, wireless or a hybrid of the two. Each has their own advantages and disadvantages, and the eventual selection of the implementation type will depend upon the characteristics and preferences of individual dairy farms.

6.2.4.1. Completely Wired Network

A completely wired network involves connecting all devices with network cable, with no ability to cater for wireless connections or wireless devices. Utilising this network, all devices will have a direct connection to the herd management database, thus providing access to the latest information, and providing the capability to immediately write information to this database. Such a network is best suited for farms where all devices requiring network communication abilities are permanently fixed in a location (e.g. milking controller unit, fixed RFID reader on entry to dairy etc.).

A wired network arrangement is likely to be cheaper than establishing a wireless network on the farm in terms of up-front costs. However, ongoing costs for this network may be higher due to maintenance that is likely to be required for the cables used to operate the network. Additionally, these cables may suffer reliability problems due to unforeseen circumstances, such as rodents eating away at exposed cables in or near the dairy, general wear and tear on the cables etc. If communication through a

cable in this network type is affected, it could cause a malfunction, or halt the operation of a device (such as a milk meter, or feeding control units), or even force the entire network to become inoperable (for example if a basic ring topology is used). In general however, if precautions are taken to protect these cables and they are laid out in correct fashion, such networks usually provide strong reliability. Naturally, completely wired networks also pose limitations on the portability of devices, as they must be connected via cables for communication.

6.2.4.2. Wireless Network

Ideally, farmers will be utilising wireless networks in future arrangements. This will enable an array of devices, whether fixed or portable, to be linked directly to real-time data in the herd management database. Such devices include the mainstream computer network devices, such as PDAs (Personal Digital Assistants), laptops, desktop personal computers and printers, however will also provide the vital links to dairy farm devices, such as RFID readers, milking controller units, feed management units, drafting gates, and a vast array of other devices that could be configured to operate under computer control, or require access to herd information for operation.

Providing this direct link from these devices to the herd management database enables all devices to refer to the latest herd information for their operation. Likewise, a wireless network also provides these devices with the ability to record changes, updates or new information immediately to the herd management database (as with a completely wired network). Additionally, new devices are also quite easy to introduce to a wireless network, as no cable extensions are required to be linked to them. However, to facilitate a wireless network, all the devices selected to be utilised on this network must be capable of wireless network connections.

6.2.4.3. Hybrid Network

Alternatively to a completely wired or wireless network, a hybrid of the two can be formed. This involves some components of the network utilising direct wired connections to the herd management software and server application, while other devices are provided with portable abilities, however do not have a direct link to the herd management database or to any other device on the network at these times. This may be the preferred option where there are devices that are intended to be

permanently placed in a position, while other devices require portability, however do not need immediate read and write access to the herd management database. Such devices may include PDAs, laptops etc. Utilising the hybrid approach, these portable devices can be connected to the network and subsequently the central herd management database at regular intervals (e.g. daily), where they can download the latest information from the central herd management database. The farmer can then remove these devices from the network (a simple case of unplugging the network cable), and take this device with them out into the field, where they can use this device to view, record updates or modify existing data. However, any changes made will only be reflected in their local portable version of the database at the time of recording. The farmer must then return to base, and attach the device to the central network again to upload the data they recorded while in the field onto the wired central herd management database (synchronizing data between the two).

A hybrid network obviously provides the advantage of being able to utilise both portable and fixed devices. This provides farms with greater possibilities for use of devices and their information. In terms of disadvantages, a hybrid network will require the additional step of synchronising data between portable devices and the central database, thus meaning that the data that is accessed from this database via the wired network may not be current. This may occur as an update may not have been performed on the central database from the portable devices when the data for a particular cow is accessed from the central herd management database.

6.2.4.4. The Final Decision & Future Prediction

Essentially, the decision of wireless, wired or hybrid networks must be completed at each individual farm, based on the requirements and a cost-benefit analysis for each situation. It is believed that as wireless technologies advance in the future, providing greater capability and functionality while reducing costs, that wireless network arrangements will become the predominant network type. Either way however, providing a robust, quality network is a central component to enabling the use of RFID devices for farm management practices. The network established by the Cochrane's to link their RFID readers to their dairy software (and herd management software), feed dispensers and drafting gates provide a strong example of the use and value that such networks can provide. While this network is currently completely

wired, it could also be easily adaptable to support mobile devices (such as PDAs) in a hybrid arrangement, to enable an even greater range of abilities in the future.

6.3. Optional Components for RFID-Enabled Dairy Farms

Implementation of the mandatory components will provide farms with the equipment they require to conduct basic RFID operations. If desired, these components can be utilised as the foundation for a much larger RFID operation, designed to provide additional value for farm management practices. This can be achieved through the use of any, or all of the following optional components - the selection of which should be made so as to meet the requirements and aims of individual dairy farms.

6.3.1. Portable RFID Reader

Having an RFID reader that is portable provides farmers with the ability to read the RFID number of individual cattle, regardless of the cow's location on the farm. This may enable simple actions to be taken, such as identification of cows in the field, or possibly enable a range of actions to be taken, depending on the abilities of the portable RFID reader.

6.3.1.1. Basic Portable RFID Reader

At a basic level, portable readers are capable of reading the RFID tag of a cow, and displaying the cows RFID number on a small digital screen in-built into the portable reader, and possibly providing an audible reading of the identification number e.g. the Allflex Compact Reader (Allflex Australia, n.d.b). Such an ability will allow farmers to guarantee the identity of the cow they are dealing with, pick a cow out from a group without having to know the distinguishing visual features of the cow, be able to identify a cow if an alternative form of identification has fallen off the cow etc.

6.3.1.2. Advanced Portable RFID Reader

At a more advanced level, a portable RFID reader could be attached to a personal digital assistant (PDA – also known as hand-held computer, palmtop) device. Prior to use, the PDA can be loaded with herd management software, and the data stored on the farms central herd management software application can be copied to this PDA – effectively providing a mobile copy of the herd information. Utilising this

arrangement, the farmer can then scan a cows RFID tag with the portable RFID scanner, and the identity and information pertaining to that cow can be provided on the screen of the PDA. The farmer can then use the PDA similar to how they would utilise their host desktop computer, being able to browse the cows information, and should also be allowed to record and update cow information on-site. For example, a farmer could give a cow a penicillin injection – to record this, they simply scan the RFID tag of the treated cow, then use their PDA to record the details of that injection.

6.3.1.3. Updating Records in the Central Herd Management Database

Such data recording and updates may be immediately reflected in the central herd management software if the portable device has a direct network link to it (e.g. wireless network). Alternatively, if a direct link to the software is not possible, the updated information could be retained in the portable device, and uploaded to the herd management database at a later time when the device can gain a direct link to the network (i.e. transfer via network cable). Either way, the farmer will be receiving the benefits of being able to easily and rapidly retrieve and view data in the field, while also enabling simple, accurate and timely data recording. Such an arrangement would also remove the duplication of effort that is currently required on both the Strong and Cochrane farms for recording information to their herd management applications - as farmers would not be required to manually record this data in the field before entering it again into the herd management software at a later time. Considering the benefits and enhanced capabilities for farm management operations that such an advanced portable RFID reader would provide, the adoption of such a device is highly recommended.

6.3.2. Weight Scales on Entry to Dairy

The weight of cows is another significant factor that can be used to determine the overall health of a cow, detect any possible problems that may arise, and aid to identify if there are any nutritional changes that may be required to a cows diet. Placing a weight scale on the entrance to the dairy will ensure that each cow is weighed at a regular interval, and would not require any changes to a cows routine to gain this weight data. This weight scale can be associated with a permanent RFID reader, thus enabling each cow to be identified before standing on the scales, and their resulting weight to be recorded in the herd management database. This data can then

later be viewed and analysed by the farmer, or alternatively, an advanced arrangement could involve software that is able to recognise and alert farmers of anomalies or concerning variances in weights for each cow. For example, a cow may lose weight when she is not provided (or is not eating) enough food to satisfy her energy requirements to continue producing high quantities of milk (thus she utilises the fat reserves on her body to maintain this production rate). However, a loss of body weight may also occur if a cow falls sick, feed intake is restricted etc. (Ontario Ministry of Agriculture, Food and Rural Affairs 1996). Whatever the reason, it is important that farmers are informed of such changes, and thus allowed to investigate and take any required action.

6.3.2.1 Proposed Advanced Application

It is proposed that advanced software be developed to work in conjunction with these weight scales. Such advanced software could analyse the cows current stage of the lactation cycle, age and the amount of feed she is currently receiving and possibly provide a suggested reason for any concerning weight variances detected. For example, a cow may require more feed. These suggestions could then be provided to the farmer at the end of each milking session, allowing them to then inspect the cow and agree or disagree with the recommendation, depending on their own analysis of the cow and her situation.

6.3.2.2. Source of Feedback

Further, this weight gauging ability may also be used as a source of feedback for the farmer, to see how changes to a cows environmental factors impact their weight – subsequently aiding farmers to tailor their farm management practices to suit their own herd and farm characteristics (beyond the 'standard' approaches).

6.3.3. Automated Feed-Dropping Control Units (Feed Bins)

Feed bins that have the ability to automatically drop a designated amount of feed into the feed trough of each individual cow have been demonstrated to be highly effective in dairy farms. Both case studies have been shown to use this technology, and consider it an integral component of their herd management activities. However, the Cochrane dairy derive greater use from their feed bins, by actually combining the operation of their feed bins with the RFID tags of their cows and the herd

management software. This subsequently enables automated feed calculation and delivery in the dairy.

6.3.3.1. Review of benefits

Automated feed units provide a variety of benefits to farms, including reduced labour, cost savings, removal of possibility for human error, and of course the ability to automatically calculate and provide the required amount of feed for cows to sustain or increase their milk production (these benefits are provided in greater detail in section 5.5.1). Considering such strong benefits, it is believed that these automated feed bins, operating in conjunction with RFID tags and herd management software will certainly play an important role in RFID enabled dairy farms in the future.

6.3.3.2. Enhancing Capabilities

Beyond their current abilities, it is believed that future development of these automated feed bins could provide enhanced benefits for the farmers. Firstly, the use of milk meters to record the amount of milk produced by each cow at every milking session will also enable greater possibilities for extending the capabilities of feed bins. Utilising such an approach will enable feed amounts to be derived upon the most recent data of cow milk production, thus enabling feed amounts to adapt to meet the changing requirements of each cow.

Utilising milk meters will also allow an average milk production value to be derived and utilised in calculating the amount of feed to provide for each cow. This average may be taken from the production of the cow during their entire current lactation cycle, or perhaps derived from a selected amount of previous milking sessions (e.g. the average milk provided over the past 10 milking sessions). This ability to refer to an entire cows production history may also enable herd management software to recognise certain patterns in the production of each cow. Subsequently, feed may be adjusted to meet these patterns (e.g. every 10 days there is a rise in the production of a certain cow, thus provide it more feed than meets its average on this day). Recognising patterns in milk production, and providing up-to-date production records to serve as the basis for feed amount calculation aids to ensure each cow is provided with the required amount of feed to sustain their current milk production, and also to

encourage this production rate to increase – a vital element to maximising milk production from a herd.

Additionally, it is proposed that not only will feed bins be utilised to vary the ingredients of this feed. These feed bins could mix additional additives to each individual cows basic feed to boost specific elements that the cow has been recorded as requiring. For example, increased fibre, protein etc. The requirements for what additives to be supplied for individual cows should be entered by the farmer (possibly based on veterinary results, milk analysis etc.), and the automatic feed bins can then execute this requirement, mixing in the required additive for a specified amount of milking sessions. This subsequently further aids farmers in managing their farm, providing them with assistance to ensure the development and good health of their cows, while aiding to ensure high milk production of a high quality and volume.

6.3.4. Feed Troughs with Measuring Capability

The ability to provide a specific amount of feed to each cow to meet their requirements (as noted in section 6.3.3) is certainly one of the most valuable abilities for a dairy farm. However, this ability can be undermined if there is no way of telling if a cow is actually eating all of their allocated feed. From the floor of the milking parlour in which the milking operators stand, it is difficult, if not impossible to view if there is any feed left in the feed bails when each batch of cows leaves. As such, a cow may not be eating all (if any) of their allocated feed, however the farmer and the herd management software will not be aware of this unless there is a form of checking done when every cow leaves their bails. Utilising weight scales to measure the amount of feed left in each feed trough provides this important feedback ability for the farmer and software to measure any feed left in the feed troughs.

6.3.4.1. Proposed Operation

This can be achieved by placing weight scales underneath the feed trough of each bail, and having feed troughs with bases that open (base flaps drop down), allowing any feed remaining in these troughs after each cow has left to be dropped below to the scales. This leftover feed can then be weighed, and the resulting weight recorded in the herd management software, thus providing information on the amount of feed

provided, amount leftover, and subsequently the gross amount of feed induced by each cow.

It is proposed that this measurement process be triggered by the milking operators taking the required action to signify the end of milking. This may be the press of a button (as at the Cochranes), pull of a rod (as at the Strongs) or other means. So as to save the milking operators from then having to clear the feed from the scales before the next batch of cows enter the milking parlour, it is proposed that containers be used on the top of the scales with the ability to store a large amount of feed. Thus, when the operator takes the required action to open the milking parlour for the next batch of cows (press of a button/pull of a rod etc.), the scales will then re-calibrate themselves to consider their current weight as the starting point ('zero') for the next calculation. Subsequently, when the next batch of cows complete milking, the feed can be dropped into the container atop of the scales again, and the scales perform the required calculation to provide a weight reading for the amount of feed left in each independent bail (current reading minus the reading taken at the end of previous milking session).

6.3.4.2. Additional Benefits

Utilising this approach will not only allow farmers to ensure that their cows are eating their required amount of feed, but will also aid to detect any cows that may be having a problem, such as illness. It is proposed that the software that stores this eating data be able to identify any cows with concerning feed intake rates, and subsequently alert farmers to this issue. For example, if a cow is eating less than 70% of their allotted feed, there may be a need for the farmer to examine this cow and investigate possible reasons why this may be happening. Such low eating could be an early warning sign of sickness, and thus this approach would allow the farmer to separate this cow from the herd and take any required action to being her back to good health. Additionally, a reduced feed intake is also a characteristic of a cow on heat, and thus this may provide further information to support other signs of a cow being on heat (DeLaval 2005b).

6.3.5. Milk Meters

In a business where milk is the primary product, it is important to know how much milk each cow is producing, and likewise, to have a source of feedback to establish

what factors enable your cows to produce the maximum amount of milk. Milk meters provide this valuable ability, measuring the amount of milk each cow provides at every milking session.

6.3.5.1. Operation

Milk meters are placed in the milk flow line leading from each set of milking cups to the main milk flow line (leading to the vat). From here, the meter can gauge the amount of milk flowing through the pipes from each cow. To be useful, this information should be automatically recorded in the herd management database, and associated with the cow currently registered by the software as being present in that particular bail number. Other pieces of information, such as the time at which the reading took place, the cows bail number, and duration of milking can also be derived from milk meters, and should be stored in the database. These pieces of information serve as solid records of each cow's milking session, and may provide grounds to various analysis activities for the farmer.

6.3.5.2. Current Practices for Gauging Milk Production Volumes and Negative Aspects of This

Both the Strong and Cochrane dairies currently utilise the services of Dairy Express herd recording to provide information relating to the production volume of each individual cow. This service also provides information relating to the fat and protein components, somatic cell counts, and other information as requested. While this is all certainly valuable information, the infrequency at which this sampling occurs (monthly) reduces the scope of applications that this information can be used for. For example, this data does not provide a reliable basis on which to conduct day-to-day herd management operations. A great deal of cow characteristics can change over the course of a month, and utilising such distributed testing, farm operations will not be able to adapt to meet the changing characteristics and subsequent requirements of cows. Additionally, as this information is not collected regularly, it does not provide enough data to enable a direct analysis of how varying certain aspects of a cows environment may impact their milk production (whether positively or negatively).

Similarly, utilising data collected only on one day of the month could provide misleading results. For example, a cow may have an unusually bad milking day on the

day of herd recording - providing poor quality milk and a low volume of it. Subsequently, she will receive a bad report on her milk, and also have her feed adjusted to suit a low production cow for the rest of the month. However, she may normally be producing a much greater quantity of milk, and at higher quality than what was sampled on the day. Consequently, treating her as a low production cow would reduce her ability to maintain or increase her true milk output, and could result in decreased health.

Despite these negative aspects for the use of this information in farm management operations, the results of Dairy Express analysis remain a valuable asset for dairy farms. The information provided by these analyses other than production volume (fat content, protein etc.) provide valuable feedback on the quality of herd milk for the farmer, and are also information products that individual farms are unlikely to be able to practically gain through their own on farm testing facilities. Additionally, Dairy Express provides the ability for the individual results to be accumulated for the various categories of this analysis (thus providing total herd information), and compared to other dairies in the farms particular region, state or indeed the whole of Australia. This provides a great ability to benchmark the performance of your herd in multiple aspects, something that would be much more difficult by any other means. As such, it is not proposed that the implementation of milk meters replace the use of herd recording services, but rather they should be used to supplement this process - providing information relating to milk production volumes that can be more effectively utilised for farm management activities, and unveil a wider range of possible applications for such data.

6.3.5.3. Desire for Milk Meter Utilisation

Both the Cochrane and the Strong dairies stated their desire to implement milk meters in the future, indicating the presence of a firm desire within the dairy industry to adopt these devices. It is believed that the implementation of these devices could become an integral component of dairy farming in the future, and certainly plays an important role in this proposed framework.

6.3.5.4. Cycle of Information

As previously alluded to, a great benefit that milk meters provide is the ability for farmers to achieve a complete cycle of information. Currently, farmers are able to control and measure many aspects of a cows environment and lifestyle. For example, they are able to control the amount of feed provided to each cow, the ingredients and ratio of mixture for feed in the dairy (e.g. grain and wheat mixture), what paddock the cows are placed into (subsequently the type of grass present, fertilizer or other products used in maintaining this paddock etc.), when cows are milked, when they are fed and a variety of other factors. However, without milk meters, farmers are unable to accurately gauge how varying certain elements in a cows environment may affect their milk production.

Armed with the information collection ability provided by milk meters, farmers are able to experiment with varying elements of certain cows environments in an attempt to identify the ideal conditions for achieving maximum production with their particular herd. Every farm property is different, and every herd of cows may be considered different. Thus, while many dairy management practices are common between farms, it is important for farmers to fine tune their herd and farm management practices to suit their specific herd and farm, so as to attempt to gain the greatest possible milk production and quality from their cows.

Such experimentation can be achieved by taking a selection of cows, and modifying any of a wide array of elements that make up their environment. These elements should be varied only one at a time (so as to be able to identify what the characteristic is that caused any changes that may be realised), and the milk production of the selected group monitored for any growth or decline. Examples of varying elements may include varying the milking times for the selected group, the quality of feed provided, the amount of feed provided, paddocks placed in (and the grass/characteristics of their paddock compared to others), whether they are given hay or not, additional feeding sessions etc. The results of varying these factors should be analysed, and any positive aspects implemented with the remainder of the herd. To date, it is believed that such testing and data analysis is an aspect of farm management that has largely been under utilised.

6.3.5.5. Illness Detection

Utilising milk meters will also aid to identify any problems that may arise in the herd (such as illness). For example, if a cow provides a significantly lower amount of milk than their usual output, the system will be able to identify this disparity and alert the operators to check this cow when milking has completed. In this way, any illnesses or problems occurring with cows can be identified quickly and easily, subsequently enabling rapid treatment. The quicker that such issues are identified and treated, the sooner the cow can return to her normal milking and health, and thus minimise the loss of production for the dairy on the whole.

6.3.5.6. Audit Potential

A further benefit of such a device is the ability to provide audit functionality for the amount of milk produced. Currently, the only record of the amount of milk provided to the manufacturer is via a report provided by the manufacturer after they have collected a vat of milk from the dairy farm. Utilising milk meters, the farm is able to verify that the amount of milk stated by the manufacturer as having been received is in alignment with the total amount recorded by the milk meters. This will of course aid to ensure that farmers are being paid for the correct volume of milk, while also acting as a mechanism to identify if there may be a leak in the milk transportation pipes in the dairy. As milk is the primary product produced by dairies, this audit capability is an important aspect to ensuring farms are receiving the right income, and also minimising possible shrinkage (through leaking pipes etc.).

6.3.6. Milking Controller Unit

Milking controller units are essential pieces of equipment for all modern dairy operations. This is the device that controls the suction and suckling motion of the milking cups attached to the teats of each cow. This unit can function effectively without the use of RFID technology (as demonstrated in the Strong dairy case study), however it is recommended that RFID technology, combined with herd management software be incorporated in all future implementations of milking controller units. Combining these technologies will provide a range of enhanced options and capabilities for the operation of the milking controller unit.

6.3.6.1. Automatic Selection of Milking Style

Utilising this combination of components, it is proposed that future implementations may be able to gain and interpret a cows complete milking history. Subsequently, the units will then be able to establish for themselves the required manner for milking the cow that has been assigned to their bail. Some of the possible milking styles were outlined in the Strong dairy case study (case study A), including rapid milking, normal escalation milking etc. - however the abilities of each milking controller unit vary between products and vendors. As such, the software would need to have the ability to work with a range of milking controller units, or may be provided by a vendor to work in conjunction with their milking controller units. This ability to automatically select the milking style would remove the need for the operator to do this, thus reducing the demands on operators, while also reducing the possibility for human error in selecting milking styles. In order for the operator to know what milking style has been selected by the device, a form of visual feedback should be provided to the operator (such as various light sequences on the milking controller unit etc.).

6.3.6.2. Display Devices at Point of Milking

At a more advanced level, it is proposed that display devices be incorporated into the milking controller units, providing a mechanism to display a range of information to the dairy operator relating to the cow currently located in the milking bail. This could include any information stored in the herd management database, however it is felt that the essential information would include whether penicillin has been injected, if milk is required to be withheld for any reason, if a cow has a bad teat (thus this teat is not to be milked), if the cow is a slow milker, if the milk should be used for second grade milk (if farm utilises such a category of milk) and if the cow has freshly calved. This specific information is critical in determining if and how a cow should be milked differently.

The Cochrane dairy demonstrated that such information can be made available on screens at either end of the dairy, and audible readouts also provided for such information to provide a further alert to operators of a cow requiring additional attention during the milking process. While this setup is quite useful, the information

regarding each cow is still not directly available to be viewed at each individual milking station, as would ideally occur.

Rather, both the Cochrane and Strong dairies utilise other visual identification mechanisms to recognise particular attributes of individual cows at the point of milking (and also to simply identify cows with particular attributes for general herd management). These identification mechanisms include coloured tail tags, coloured ankle tags, paint on cow udders etc. The meaning, and number of these identification markings however, differ between the case studies. It is further believed that this sort of variance in identification devices will exist between all dairy farms. Whilst quite effective, these mechanisms are not foolproof. The requirement for milking operators to notice these identifiers, and subsequently take appropriate action (such as disposing of milk unsuitable for production) leaves room for human error in milking. Additionally, these identifiers may inadvertently fall from the cow while in the paddock, be covered by mud during milking sessions or suffer fading (thus being less eye-catching) etc., subsequently making it difficult or impossible for operators to recognise these markings.

If these identifiers are not recognised during milking, the farmer may face quite serious consequences. For example, such occurrences could lead to a cow being milked in an incorrect fashion, such as attempting to milk a teat that has been dried off. Even greater consequences will be realised if milk that should be disposed of (such as that extracted from a cow who has had a recent penicillin injection), accidentally flows through to the main milk vat. This will result in the bad milk contaminating an entire vat of milk. This will subsequently cost the farmer the intended revenue for the entire vat of milk, as it must then all be disposed of. Furthermore, if the farmer does not realise that contaminated milk has entered their vat and allow the dairy manufacturer to collect the milk (placing it into their large collection tanker with milk from other farms), the dairy manufacturer will end up detecting this contamination when testing the collection tanker of milk at their own depot. Subsequently, the farmer responsible will then be identified by the manufacturer via testing of individual farm samples taken at the time of pickup. The farmer may then face a fine, or be forced to reimburse the manufacturer for the value of the entire collection tanker of milk that must now be disposed of. As such, it is

evident that failure to notice visual identification markers on cows, for whatever reason, can be costly for a dairy, both financially and in terms of their reputation.

6.3.6.3. Proposed Enhancement – Data Interpretation Display, Interaction and Feedback

For this reason, it is proposed that the milking controller unit, combined with display devices (a form of computer screen) at each milking bail be utilised to aid the milking operator in identifying important requirements for each cows milking. This can be achieved by utilising RFID readers on the entry to the dairy, combined with bail blockers (or other mechanism that ensures cows enter the milking bails in consecutive order), and the ability for the herd management software to assign a cow (and its related data) to a milking bail as they pass through the RFID reader. The milking controller unit can then be linked with the herd management database, thus providing it with the ability to receive and interpret individual cow data for the milk assigned to it's corresponding bail number. This received data can then be displayed to the milking operator via the related bail information display device. It is important to note that such a system should be used to complement the existing visual identification methods on each cow, rather than replace them – thus providing dual identification capabilities for important cow characteristics.

At the most advanced (and expensive) level, this display device would be a small (and very well shielded) computer screen, displaying each cow's information in an easy to view interface. Information that may affect the milking procedure would be highlighted, and if the information is critical to milking (such as if the milk is to be withheld), the milking controller unit will not allow milking to proceed until it receives a signal to continue from the milking operator. This would act as a check that the milking operator is aware of any special actions that may be required for particular cows, has taken the required action (such as plugging the milk flow lines into a barrel for disposal), and is now ready to begin milking this cow. This 'continue' signal could be achieved by placing a small keypad beside each screen (even a single button to provide recognition of information), however, ideally an entire keyboard could be provided at each milking bail (with a bendable plastic mould covering the keys). Having a keyboard would enable a range of feedback to be provided by the milking operator, and also allow for data to be entered into the database regarding each cow.

This may include information such as whether any drugs were administered during milking (such as synthetic oxytocin), any problems that arose during milking, additional comments etc.

Additionally, a 'watch' button could also be provided as an input device. This button would be pressed by an operator if they notice something about a cow during milking that they would like to investigate after milking. The software will then remind farmers to investigate this cow at the end of milking, and if drafting gates are being utilised at the dairy, then pressing this button will immediately select this cow for drafting as it exits the dairy – thus providing easy access to this cow after milking.

Using this approach will provide a reliable means for transferring milking information to the operators, and aid to ensure that required actions are always taken – thus reducing the risk of discomfort for cows, and financial implications for the farmer of incorrect milking. This also enables rapid and immediate data entry into the herd management database, thus saving the farmer from having to enter this data at a later time.

6.3.6.4. Lower Priced Alternative

Utilising computer screens at every milking bail for conveying information to milking operators would be quite costly in large dairies, thus, a similar, but less expensive approach may be adopted. A less expensive version of the above information intensive milking controller system can be established utilising a panel of lights to transmit information from each milking controller unit. Each light on the panel could be labelled, and illuminated to display any pertinent information for the milking of the cow. For example, four lights could be placed so as to represent the four teats on a cows udder, and each light would subsequently illuminate to represent a teat that is not to be milked (thus complementing the use of ankle tags as is the practice on the Cochrane farm). Other lights may be set to represent certain information by default, or customised to represent any information that the farmer desires.

Despite not having a computer screen, this system could still provide the automated data interpretation features of the advanced milk controller unit. As previously noted, this will allow the unit to act as a final information check point, ensuring that milking

cannot begin for cows requiring particular treatment until the milking operator provides a recognition signal to the system. Again, a button could be used to gain this feedback from the operator. The main drawback of this lower cost arrangement is that it is unlikely to allow direct entry of information to the herd management database.

6.3.6.5. Personnel Benefits

An additional benefit of either of the bail information display device arrangements is that such a system may provide greater flexibility for farmers in employing milking operators. Utilising either of the previously described systems, milking operators do not need to be extensively trained in what visual identifiers to look for at each farm, as each cows information is clearly provided to them at each bail via a chosen display device. Further, the system can aid to ensure operators have recognised any particular characteristics that would require a varied milking procedure, as it will prevent the milking cups from working until the operator provides the required signal to continue (e.g. pressing 'continue' button) at the specific bail. These abilities therefore reduce the risk of contamination for the farms milk and aid to ensure cows do not suffer any undue stress during the milking process if a new milking operator is being utilised at the dairy. This may provide farmers with the ability to hire outsiders or contracted milking operators to fill in for regular milking operators in unforeseen circumstances, or to allow the regular farmers to take a holiday.

6.3.6.6. Existing Technology

Milking control unit vendors such as DeLaval currently provide milking controller units with similar capabilities to this. The DeLaval 'MPC' provides information to the milking operator through a series of labelled lights and a small display screen with scrolling text. A keypad is also provided to enable information to be directly updated and entered into the herd management database (DeLaval provide a herd management system entitled 'ALPRO'), and a variety of information can be viewed on the screen of the unit (DeLaval 2005a). As such, it is believed that at least part of the proposed milking controller unit arrangement is achievable currently, and the technology involved in these units is likely to further advance in the future.

6.3.7. Automatic Drafting Gates

The use of drafting gates has been demonstrated at the Cochrane dairy, and has been shown to provide large savings of both time and labour for the farmers in extracting individual cows from the main herd. These cows may be extracted for a wide variety of reasons, including the need for veterinary treatment, artificial insemination etc. Additionally, this automatic drafting ability enables farmers to provide additional attention to selected cows on a regular basis (such as by drafting show cows into a paddock with additional feed). The most useful location for these drafting gates is believed to be on the exit to the dairy, as this is where all lactating cows must pass at least twice a day. Operating in conjunction with herd management software, these gates would be a valuable asset to almost any dairy farm.

6.3.8. Temperature monitoring within RFID

It is evident from the articles of Higgins (2003) and Hostetter (2003) (articles described in section 2.7), that it is possible to incorporate temperature sensing abilities into RFID microchips currently – the application of which may soon be extended to the livestock industry. Such a device will provide the temperature of the cow along with the cows unique identification number every time the tag is read by an RFID reader.

6.3.8.1. The Value of Temperature Monitoring

The temperature of a cow is certainly a valuable attribute for a farmer to utilise in managing their herd. Importantly, fluctuations in the body temperature of a cow can indicate that the cow may be falling ill. Thus, reading this temperature will allow a more rapid response to aid in detection and subsequent treatment of any illnesses that a cow may have attracted. It will also enable the farmer to take action to minimise the spread of the illness by being able to rapidly isolate the cow for observation and treatment. Of course, the quicker an illness can be detected and treated, the less time a cow will spend affected by this illness and hence minimise probable reduction in milk production. As such, rapid treatment of cow illness is in the best interests of a farm financially, as well as to aid to keep the cows in good health.

A rise in temperature may also indicate that a certain cow is entering heat. It is important to know when this occurs, as this presents the farmer with a window of

opportunity to artificially inseminate the cow (if they are intending to impregnate the cow). This temperature sensing ability may aid to supplement the current visual manual mechanisms of detecting heat utilised on farms such as the Cochrane's, and also supplement or replace the use of Karmars, as utilised on the Strong farm (the use of Karmars is described in section 4.2.2.2).

There may also be other reasons for temperature fluctuations among cows, however whatever the reason, it is important that anomalies in temperatures be identified and investigated as soon as possible. As such, when temperature fluctuations are recognised by the system, functionality could be incorporated to allow the system to alert the farmer of such fluctuations via means such as a beeper device that the farmer may carry, sending a text message to their mobile phone, or by similar rapid alert device.

6.3.8.2. Using the temperature sensing device

At a basic level, a temperature sensing RFID device could be read by fixed RFID readers at the entry to the dairy. Such an arrangement would ensure that each cow has their temperature read at a regular interval at least twice a day, thus providing valuable information to the farmer. At a more advanced level, it is proposed that RFID readers also be placed at other high congregation areas throughout the farm. For example, placing a high powered RFID reader near a water trough in a paddock, hay feeders or similar areas that are frequented by cows. Under this approach, more temperature readings can be gained between milkings, thus providing an enhanced ability to detect temperature variations, and also to view patterns of temperature change among the cows (e.g. middle of the day they may be warmer than at sunrise). The obvious flaw in this system however, is that the temperature readings are not gained at the same time for the herd (thus making them somewhat incomparable), and it cannot be guaranteed that each cow will be read at any more frequent intervals than at the entrance to the dairy.

6.3.8.3. Ideal Use

Ultimately, if readers could be utilised to read a multitude of low-powered RFID devices over a large distance, then such readers could be placed in each paddock to interrogate the entire herd's RFID devices at pre-determined intervals. This would

provide a far greater picture of temperature fluctuations and patterns among individual cows in the herd.

6.3.8.4. Other Biological Sensing RFID Potential Combinations

As noted by Higgins (2003) and Hostetter (2003), there could be other applications with RFID and the monitoring of cow biological signs, however it is believed that these may be quite some time away, and their exact uses are not known as yet. As such, details of such devices have not been included in this framework. On the other hand, RFID temperature sensing is a currently available technology, and its use in the livestock industry is currently being investigated.

6.3.9. GPS Tracking

The precise details of GPS (Global Positioning System) operation are outside the scope of this research, however it is believed that a device may be developed in future that provides a combination of GPS and RFID technology, subsequently providing enhanced farm management capabilities. Thus, the application of GPS within this context will be discussed.

In brief, GPS is a technology that is used to track objects via satellites. There are a range of software and hardware products that can be used to facilitate GPS tracking, and depending on the quality of the GPS products used, these systems are believed to be able to track the movement of objects to within several metres. Even greater accuracy may be achieved through the use of Differential GPS – an implementation method requiring both a local fixed GPS receiver, acting as a relay for other mobile GPS devices (Federal Aviation Administration n.d.; Corvallis Microtechnology 2000; WiseGeek 2005). It is proposed that GPS technology be included in RFID tags in the future, thus providing the ability to track cattle movements, and locate individual cows with a single program. This will provide a range of abilities and benefits for farmers.

6.3.9.1. Utilisation for Location Identification & Tracking

One of the primary benefits of utilising GPS with RFID tags is the ability to gain the exact location of where a cow is currently located on the farm. This saves the farmer from having to lookup records of where the cow is currently located, or having to visit

the paddocks and try to visually identify the cow they are looking for. Obviously, with a small herd size, this is not a particularly prominent issue (as farmers will be able to know cow locations from their own knowledge of the herd and cow movements), however as herd size increases, GPS location ability becomes increasingly valuable. This ability is further enhanced as the farmer may be able to use a PDA or other mobile device to display a map of their farm and pinpoint the cows location within this farm layout. Utilising this approach, farmers can be guided to the exact location of any cow they desire.

6.3.9.2. Utilisation for Boundary Crossing Detection

Further to the primary use of tracking of cattle, a more advanced GPS-RFID setup could provide software that enables farm boundaries to be plotted and associated with the GPS devices. Using this arrangement, the software could detect if a cow (or cows) move beyond these plotted boundaries (i.e. escaping from a paddock). When such an occurrence is detected, the software can inform the farmers of this by displaying an alert message to all available display devices (computer monitors, PDAs etc.), and send a further message to designated people via mobile phone text messages, paging devices etc., so as to attempt to raise immediate notification. This will aid to ensure that if cows do escape their paddocks, that rapid action can be taken to precisely locate them, and bring them back to their paddock - thus hopefully reducing the chances of an injury being sustained by the cows while outside their paddocks (such as being hit by a car, eating poison baits, encountering other predatory animals or humans etc.), or the dairy simply losing their cows.

Once the cow has been retrieved and returned to their paddock, farmers can then also use their GPS software to trace back the path the cow took to escape from their paddock, and subsequently take any action they feel may be necessary to prevent the incident from occurring again (e.g. patching a fence, implementing electric fences). Any loss of lactating cows will have an immediate impact upon the milk production of the herd, and thus has direct financial implications for dairy farmers. Similarly, if any injuries are sustained to a cow this may impact their milk production also (permanently or temporarily). As such, it is in farmer’s best interests to minimise the risk of such incidents, which a GPS system utilising plotted boundaries can facilitate.

Similarly, the combination of GPS with RFID will aid to prevent and detect any theft of cows. While this is not a particularly serious problem in Australia, it remains a volatile possibility. If a farm is utilising GPS-RFID devices to tracking their cows, in combination with software that recognises farm boundaries, it will be quite apparent to a farmer if their stock is being stolen, as there will be a large and rapid exodus of cows from their property boundaries. Not only will GPS capability aid to detect such an act, but it can then be used to trace the cows if the thieves manage to successfully remove them from a property. Additionally, proof of identification and ownership of each cow can be provided via the RFID capability of such devices.

6.3.9.3. Further Abilities Enabled

Furthermore, software could be designed to detect individual cow movement that may be considered out of the ordinary. This may include if a cow does not move as much as it is expected (based upon the previous history of the cow), or likewise, if it is moving significantly more than expected or usual. If a cow is moving significantly less than usual, this could be a strong sign of illness, and certainly something worthy of a farmer's investigation. Additionally, this tracking may also be used as a mechanism for detecting when cows are in heat. When a cow is in heat, it is stated that their activity (movement) will increase by up to eight times the normal rate (DeLaval 2005b). Thus, if a cows movement is detected to be abnormally high, this may be a strong sign that she is in heat, and thus notification of this should be provided to the farmer. Further, this can be used as another form of feedback for the farmer, if they wish to test how certain environmental changes impact the cows – they may feel healthier and happier, and subsequently move more, or they may move less, thus indicating a negative impact. Having software enabled with such detection abilities will enable improved farm management capabilities for farmers.

6.3.10. Automatic Calf Feeding Machine

Through the demonstration of the use of an automatic calf feeder on the Cochrane dairy farm, it is evident that strong benefits can be gained from the use of this device. Primarily, this includes a dramatic reduction of labour, ensuring that calves are fed the most appropriate amount of milk for their age to encourage and support their growth, and to provide management information for the farmers. These benefits can save farmers both time and money, while also acting as an investment in their cows

futures. As such, it is believed that while this is not a necessary requirement for operating an RFID-enabled dairy farm, the benefits of utilising this device make it highly recommended, especially for large herds, or simply farms with many calves.

6.3.10.1. Potential Developments

While significant benefits are being realised currently, it is believed that additional benefits may be possible through further development of this device. A possible enhancement to the current implementation of this device on the Cochrane dairy is to enable this device to communicate with and store data in the central herd management software. Currently, this device uses it's own in-built software to manage its own operation, and while effective, it would be more useful if this data could also interact with the herd management software.

Such an arrangement would make accessing data simpler for farmers, as they would be provided with a single point of reference for all cow information. This would further aid farmers who may not be proficient with technology and computers, as they would only need to learn to use the one software package to conduct their farm management operations and view individual cow/calf data. Additionally, storing calf feeding information in the central herd management database would allow feeding information to be recorded almost immediately from birth. This new category of information provides greater possibilities for data analysis, aiding to provide farmers with another aspect of feedback for their various strategies. This may also provide farmers with a greater understanding of their herd, and aid them to identify particular characteristics that impact/benefit their cows throughout their life. For example, this may provide farmers with an ability to relate how the feeding rates of calves impacts upon their eventual development and milk production – thus enabling farmers to fine tune calf feeding practices to suit the characteristics of their particular herd.

Chapter 7 – Conclusion

7.1. Principle Conclusions

There are a number of conclusions that can be drawn from this research. The first is that RFID is currently being utilised and development of RFID hardware and software is continuing. Secondly, size does matter, both regarding herd size and the corresponding benefits of using RFID and in terms of economies of scale for the technology. Thirdly, RFID expands management capability through the information and automation capabilities, and finally it is concluded that legal requirements around the world have become a driving force behind the adoption of RFID on dairy farms.

7.1.1. Currently Used and Continuing Development

It has been seen that RFID is being utilised currently on dairy farms, both in Australia and around the world. While there is currently a large disparity in the scale of use from farm to farm, the level of interest in this technology and its applications is providing a solid base for future development of this technology within the dairy industry. Both hardware and software continues to be designed and enhanced to specifically cater for the needs of the dairy industry and its adoption of RFID technology.

7.1.2. Size Matters

The size of a farm's herd will be a large factor in determining the value of the benefits realised through utilising RFID. On farms with relatively small herds, farmers are likely to have intimate knowledge of the herd through their own interactions with the animals, and additionally, farm labour is unlikely to be in constant demand. Thus, the abilities of RFID to provide information storage, manipulation and easy retrieval, or dairy automation possibilities are unlikely to add significant value, and thus may be perceived as an unnecessary cost. On the other hand, with large herds, whereby farm labour is virtually on constant demand, and an intimate knowledge of each cow in the herd is difficult or impossible to achieve, RFID technology provides the ability for dramatic benefits to be realised. Thus, it is concluded that generally, the benefits provided by RFID are directly proportional to the size of the herd.

Similarly, the rate of RFID uptake will be a determining factor in the cost of the technology in the future, as it is believed that economies of scale will be realised for this technology. i.e. The greater the market and purchases of RFID devices, the lower the cost will be in the future. Additionally, it is expected that the market for RFID devices for dairy farms will expand, subsequently increasing competition between vendors, which will further drive prices down for this technology.

7.1.3. Expanding Management Capability

The use of RFID certainly provides the ability to enhance farm management practices. This technology provides the farmer with the ability to gain a far greater depth and accuracy of information on their individual cows and overall herd, thus enabling them to make more informed decisions. Furthermore, this wealth of information can be stored, manipulated, and viewed with unprecedented speed, accuracy and ease, undoubtedly providing the potential for massive benefits in the manner in which farm management is conducted.

Furthermore, RFID technology provides the capability to automate certain farm management practices. This includes the likes of automatic feed dispensing units, automatic calf feeding, automatic drafting etc. – all of which can dramatically save labour requirements, provide more reliable and accurate operations, and enables farmers to spend more time managing the vast array of other activities involved in operating a dairy farm. Additionally, these automation practices may aid the development, health and overall milk production of cows, thus providing further benefits for the farmer.

7.1.4. Legal Requirements a Driving Force of RFID Within Dairy

Despite being a quite mature technology, until recently RFID has had only limited application within the dairy industry. However, external forces, such as worldwide regulations attempting to provide whole of life traceability for livestock have been a catalyst for a dramatic growth in the interest, abilities and use of RFID technology within the dairy industry. It is only a matter of time before RFID becomes mandatory nationwide within the dairy industry in Australia (and likely many other countries) – subsequently, this is encouraging even those farmers who may be more

technologically conservative to investigate and embrace the opportunities presented by this technology.

7.2. Major Implications

7.2.1. Maximising Productivity

The use of RFID will assist farmers to maximise their productivity – an important aim in the modern competitive dairy industry. It is expected that the new farm management practices enabled by RFID will allow farmers to increase the volume and possibly the quality of milk output from their herd. This may be achieved through improved practices to monitor the health of their herd – thus minimising illness and subsequent low production of cows, speeding up the milking process – thus enabling the cows to return to the paddocks quicker, optimising feed to suit each cow production and stage of lactation cycle etc. The use of RFID for automation will also aid to minimise labour inputs, thus allowing each farmer to cater for more cows, or enabling farmers to have more time to spend on other activities – either way, maximising results from their input.

7.2.2. RFID Adoption to Continue

Considering the potential benefits offered by the implementation of RFID on dairy farms, combined with the global push for RFID to be utilised for livestock tracking, it is believed that the development and adoption of RFID technology on dairy farms will continue for quite some time. This adoption rate may even grow as the benefits of such implementation become more widely recognised, and correspondingly the costs of the technology lower with expected economies of scale. This adoption may continue to the point where the use of RFID becomes a mandatory aspect to survive in the future dairy market.

7.2.3. Increase in Farmer IT Literacy

As a consequence of the RFID adoption within the dairy industry, it is likely that farmers will become more involved with IT (Information Technology) generally. Traditionally, farmers have had little use for computers, however with the introduction of the NLIS, the potential benefits of NLIS etc., it is likely that

computers will become a central part of farm management. Subsequently, this is expected to raise the level of IT literacy amongst the industry.

7.2.4. Third Party Opportunities

The current and predicted continued uptake of RFID technology on dairy farms provides a large opportunity for the involvement of third parties. This may include existing vendors diversifying into this industry, or new enterprises opening and developing products to specifically suit the industry, consultants opening up to provide advice on dairy layouts, how and what devices to implement, third-party distributors and intermediaries etc. Considering that many traditional farmers may not have a great deal of technological experience or are comfortable with radical changes, such third party involvement may be considered more of a requirement than an opportunity. In Australia's case, the state or national government may wish to commit more resources to provide support and information on the technology and its possible uses for the dairy industry, especially considering the mandatory regulation of NLIS current in some states, and soon to spread nationwide.

Additionally, it may be possible for labour agencies to provide temporary milking operators for a brief or extended term to aid in operating a dairy farm. On farms with advanced RFID automation systems in the future, there may be little need for operators to have extensive knowledge of a farm or herd to conduct milking, as the machines will prevent them milking cow incorrectly, provide them with each cows information etc. Being able to hire such personnel could provide a temporary employee in the case of unexpected absence of a milking operator, or may enable the usual operators to take time away from the farm (holidays, family occasions etc.).

7.3. Research Scope

7.3.1. To Whom Do These Findings Apply?

The findings of this study primarily apply to dairy farmers, however other groups such as government agencies, dairy corporations, consultants, hardware and software vendors, anyone interested in the applications of RFID and the development of the dairy industry may find relevance in the findings of this study.

7.4. Recommendations

7.4.1. Further Research

A vast array of research could be undertaken to extend this work. At the time of completion there has been little academic research conducted on this particular topic, and as such, it is believed that there are a myriad of possible avenues for further research. This may include detailed research into a particular technology that has been described, technical research into what may be required to implement a suggested device, cost-benefit studies of implementing specific technologies, case studies on how utilising a particular technology has impacted the milk production volume of a farms cows, labour saving estimates for the automation of certain components etc.

This research has attempted to bring together a vast array of devices from two fields of study that have traditionally been widely separated (dairy farming and information technology), so as to provide a solid overview of the operations of a dairy farm and how RFID may be utilised to aid in total farm management within this industry. Specialist studies from either of these parties would aid to further develop the findings of this research.

7.4.2. Adoption & Implementation of the Findings

After completing this research, it is believed that RFID technology provides dairy farmers with a vast array of possible enhancements for existing farm management practices, as well as opportunities for adopting entirely new ones. Subsequently, it is recommended that farmers implement this technology, so as not simply to comply with legislative requirements, but with the aim to derive significant benefits for themselves and continue to enhance their total farm management capabilities.

A cautionary note to this research is that farmers should not simply change their current farm management practices on the basis that RFID appears the new popular technology. Rather, it is important they weigh up the requirements and aims for their farm alongside the costs and benefits of their own possible RFID implementation. The framework proposed in chapter 6 provides flexibility for farmers to select the components and benefits to meet their own individual aims and requirements - not all of the additional components described in chapter 6 may be desirable for some dairy

farms, while others may wish to implement all of them. Careful consideration should be provided to such a decision before committing to a large investment of RFID operations.

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Appendix A – Transcript of Interview with Lynne Strong

Interviewer - Adam Trevarthen
Participant - Lynne Strong

Interviewer: What industries does your farm serve? For example, dairy only, dairy and meat etc.

Participant: Dairy

Interviewer: Could you please provide a brief outline of the work processes involved in the milking operations of this dairy farm. For example, how/when you round up the cattle, what do they do when they reach the milking sheds etc.

Participant: The bulk of the milking herd is "Strip grazed" in the paddock on the farm containing the most suitable stage of pasture for milk production
The cows are rounded up three times daily by quad bike and travel back to the 14 aside double up herringbone dairy which is centrally located on the farm
The fresh cows (cows who have calved in the last 7 days) and cows with any health problems are located in a paddock adjacent to the dairy and are milked last

Interviewer: What information do you record during this process, and how do you collect it currently?

Participant: Once a month we herd record individual cows
The resultant prints provide information on Somatic cell count
Litres/cow/day
Fat & protein components /cow/day
As well as a number of other pieces of data e.g. pregnancy testing facilities are available

On a daily basis this information is provided for the herd as a whole by the processor from a bulk vat sample taken daily by the tanker driver. The tanker driver then delivers this to the laboratory at the processing plant
This data can be accessed within 24 hours over the internet

Interviewer: Could you please provide a brief outline of the everyday farm operations undertaken. For example, maintaining vaccine records, feeding livestock etc).

Participant: Accurate data is kept for all farm operations as per detailed by the HCAAP and NSW Food Authority (I have a booklet for you which outlines this thoroughly)

Interviewer: What information do you record during these processes, and how do you collect it currently?

Participant: As above / computer records and manual record

Interviewer: How would you consider your knowledge of IT - (Poor, below average, Average, above average, excellent)?

Participant: 2 out of three full time staff have above average to excellent IT knowledge (software specific) The third staff member has poor knowledge of IT

Interviewer: Do you know much about the technology of Radio Frequency Identification (RFID)?

Participant: Yes

At this point, the following description of RFID is provided:
What is RFID?
RFID is defined as "… a system that transmits the identity (in the form of a unique serial number) of an object or person wirelessly, using radio waves" (RFID Journal 2005a).

This technology is commonly implemented using a system of reusable and programmable RFID tags (also known as transponders) and readers (also known as interrogators). These tags can be attached/built-in to virtually any good/object and provide a storage capacity of up to 2 kilobytes of data (RFID Journal 2005a). This allows more than just a unique identifier to be stored on the tag, but may also allow additional information pertinent to the object to be stored (such as expiration date, manufacture date, owner information etc.). The receiver can be a mounted or hand-held computer-controlled device, and when a tag is brought within the reading range of a receiver, the receiver captures the data stored on the tag and forwards this to the host computer (Ames 1990, p. 1:5; RFID Journal 2005a; Williams 2004).

The following example system is then provided:
Systems have been developed to automatically feed cattle, depending upon their lactation cycle, automatically weigh them as they enter the dairy, separate the cattle into different yards, and many more.

Interviewer: Are you aware of such applications (as described above)?

Participant: Yes

Interviewer: Could you describe the ways in which you currently utilise RFID (both for milking, and farm management).

Participant: Not at all

Interviewer: (If not specified above) – Do you utilise an RFID reader at all, and for what purpose? The NSW regulations state that readers are not mandatory.

Participant: No

Interviewer: Do you utilise a software application to work with your RFID, or for any other purposes on your farm? If so, how does these applications function (if not specified earlier in Q1 or Q3).

Participant: No

Interviewer: What benefits do you believe your use of RFID provides to you?

Participant: RFID offers us the opportunity to combine all our software packages and manual farm managements systems into a single system

Interviewer: Do you believe there are any disadvantages that have arisen due to your use of RFID?

Participant: Yes their will be some challenges we will have to surmount

Interviewer: Do you feel you are gaining a good enough return on your RFID investment?

Participant: We will ensure we do

Interviewer: Are you considering extending the use of RFID for farm management operations on your farm in the future (such as feed enhancement, gate control etc)?

Participant: Yes

Interviewer: Do you find the cost of RFID to be excessive?

Participant: Compared to how the white collar sector would have addressed this challenge/opportunity Yes

Interviewer: Do you have any concerns regarding the use of RFID in general?

Participant: Accuracy of data collection. Software packages Red tape in early stages – to much focus on regulation rather than outcomes

Interviewer: Is there an application where you feel RFID would be useful on your farm, or for dairy farms in general, that you haven't as yet heard of?

Participant: Not at this stage – too early to say will need to have a greater understanding and more time spent with system ("clinical experience") at the present its all theoretical

Interviewer: Have you considered the use of RFID for monitoring the temperature of animals? Would you adopt such an invention?

Participant: It could do a hell of a lot more than just measure temperature – my god when was temperature the be all and end all of health monitoring

Appendix B – Transcript of Interview with Tom Cochrane

Interviewer - Adam Trevarthen
Participant - Tom Cochrane

Interviewer: What industries does your farm serve? For example, dairy only, dairy and meat etc.

Participant: Main industry is dairy. Obviously do sell beef from cold cows out of the dairy. Also dropping a bit into rearing steers until they're 2 or 3 years old, also excess bull calves.

Interviewer: Could you please provide a brief outline of the work processes involved in the milking operations of this dairy farm. For example, how/when you round up the cattle, what do they do when they reach the milking sheds etc.

Participant: Standard day includes waking up at 5, 2 people heading to the dairy, 1 person going to get the cows on the motorbike, the other one setting up the dairy. Once the cows are back at the dairy, about half-past 5 and they start milking, and finish around about 7 or quarter-past. After that, someone goes and puts the cows in the paddock, the other person cleans up a bit. The other person comes back and cleans up and feeds calves, and does odd jobs around. After that we go and have breakfast, and after breakfast if we haven't got enough grass we'll go and feed the cows with a supplement like corn silage or grass silage, just depending on what we've got available, or hay. Apart from that, we're just doing odd jobs around the farm - fencing, water pipes, fixing anything you can find, machinery, anything. Or working machinery, slashing, making hay, or doing anything like that. Back at 3 o'clock two people go into the dairy and do the same thing milking, finishing about 5. Walking away from the dairy about half past after you've finish all of the small little tasks.

Interviewer: What information do you record during this process, and how do you collect it currently?

Participant: On a standard milking there's not a lot recorded apart from if any cows are on heat, we need to record that, and artificially inseminate them. And the other things is just a visual check if any cows have got mastitis, using the mastitis detectors, and if we find a new case we'll have to either treat it, or just currently watch it and see how bad she gets or see if she gets better. There's also homeopathy sprayed on for cows with mastitis

Interviewer: For the mastitis checking, is that checking the filters?

Participant: yeah, checking those little filters mainly, another thing is just visually checking the cattle, and if one part of the udder looks very inflamed, like very large and hard, it's a very good indication that you're going to have a problem that afternoon or the next milking, so just a visual check.

Interviewer: Could you please provide a brief outline of the everyday farm operations undertaken. For example, maintaining vaccine records, feeding livestock etc).

Participant: From when the calf is about, from day one, you're just looking at the calf, seeing if it's ok, as in health wise. Giving it antibiotics if it's sick. At about 2 months of age, a calf gets it's first 5-in-1 vaccine, and it gets it's booster shot about a month later, on a rough basis. Once a year, every cow in the heard gets a 7-in-1 vaccine.

Interviewer: and they're vaccinations for certain diseases are they?

Participant: Yeah, like black leg and others.

Feeding livestock, well the dairy cows it's pretty constant sorta thing, as long as you've got enough feed for them, but the dry stock, on this farm they just follow up the milking

stock to eat out what they haven't eaten. On other farms we just move them round on a bi-weekly basis – so twice a week.

Interviewer: With things like vaccine records, do you record them in any way currently?

Participant: When we're vaccinating calves, at their 2 months of age, we have a system where an ear mark is taken out of their on their first one, and on the second one, a bigger mark is taken out of their ear. So we know if an individual calf has been vaccinated and it's booster shot. So, for instance there's a couple cows in our herd that were never given that second vaccination when they were young, because we've noticed that they've only got the first ear mark out of their ear. And we see that a little bit, it just means we're not on top of things enough, too many other things to do. But when it comes to annual vaccination within the herd, it's get in and do every cow, we don't sorta write anything down as such, we just get in and do everything. They're also recorded in the diary when we've actually completed it.

Interviewer: Do you keep much records about anything on the farm, or just records about specific cattle?

Participant: There's records on AI'ing, that is our main records. Penicillin given to any cow has got to be written down for HASAP accreditation. If you give a cow any antibiotics it's got to be written down in a certain form, you write it down and then you write down when she can be currently sold or milked again.

Interviewer: That's sorta like what was recorded on the computer system the other day?

Participant: Yeah, the computer's making that a lot easier, you can just type it in once, you don't have to do it again, and it can remind you for the next however many days not to sell her, or not to drink her milk.

Interviewer: What information do you record during these processes, and how do you collect it currently?

Participant: Yeah, every dairy has a manual diary they write in, or if they don't have one, they should – is just a daily, day book. Which is, anything that gets done on that day, you just write it down, in regards to penicillin or… yeah mainly penicillin. We've just got a normal school diary that we write all our AI's and all our penicillin in that little book, any cows that calved.
We've got 2 diaries, one for cows, and one for paddock work. Any work that gets done on a paddock – if we seed a paddock it gets written in this book, or spraying, anything like that.

Interviewer: How would you consider your knowledge of IT - (Poor, below average, Average, above average, excellent)?

Participant: Average.

Interviewer: Do you know much about the technology of Radio Frequency Identification (RFID)?

Participant: Myself being an electrician, I know a little bit about it, we briefly went into it. I can't speak for my brother's or my father. I suppose I'm a little bit ahead of them, but not much. At a general statement, I'd imagine it's the same sorta thing as what they use in shopping centres, when you steal a piece of clothing with a tag on it. I imagine it's very similar to that.

At this point, the following description of RFID is provided:
What is RFID?
RFID is defined as "… a system that transmits the identity (in the form of a unique serial number) of an object or person wirelessly, using radio waves" (RFID Journal 2005a). This technology is commonly implemented using a system of reusable and programmable

RFID tags (also known as transponders) and readers (also known as interrogators). These tags can be attached/built-in to virtually any good/object and provide a storage capacity of up to 2 kilobytes of data (RFID Journal 2005a). This allows more than just a unique identifier to be stored on the tag, but may also allow additional information pertinent to the object to be stored (such as expiration date, manufacture date, owner information etc.). The receiver can be a mounted or hand-held computer-controlled device, and when a tag is brought within the reading range of a receiver, the receiver captures the data stored on the tag and forwards this to the host computer (Ames 1990, p. 1:5; RFID Journal 2005a; Williams 2004).

The following example system is then provided:
Systems have been developed to automatically feed cattle, depending upon their lactation cycle, automatically weigh them as they enter the dairy, separate the cattle into different yards, and many more.

Interviewer: Are you aware of such applications (as described above)?

Participant: Yes.

Interviewer: Could you describe the ways in which you currently utilise RFID (both for milking, and farm management).

Participant: We’ve got a tag in every animal on the farm, including calves. From or day four of a calves life it gets a tag. It’s fed from then on for three months of its life on an automatic calf feeder, so when a calf comes in, it’s allowed a certain amount of milk. And if, say 4 hours later it comes in, it will give it a bit more, and so forth during the day until it’s allowed so much for that one day. As it gets older it gets more milk, until it gets weaned at about three months.

Later on in life, when the cows hit milking stage at 2, 2 and a half years of age, they run through the dairy with automatic feeding, starting them at low feed, and building them up

to a higher amount of feed, about 8 kilos of grain a day, depending on how much milk they produce, they go higher or lower to that for the next 300 days of their lactation.

Interviewer: So when they go in there they start off pretty low with their feeding?

Participant: Yeah about one kilo. Or about 2 kilos a day, and over about 20 days it builds them up to 8.

Interviewer: That's just getting them used to it?

Participant: Yeah, getting them used to the grain mainly, the wheat… so as to build up the required bugs in their stomach to handle the feed. Yeah, we've had neighbours who have killed cattle through wheat poisoning, grain poisoning. So, if you give them a big hit at once…

The only other thing is the automatic drafting.

Interviewer: Yeah they're guided to different paddocks depending on what you have to do with them?

Participant: Yeah the different yards

Interviewer: So if you had to give them veterinary treatment…?

Participant: Yeah, veterinary treatment, of artificial insemination, it puts them into the one yard. And if it's a show cow, and we want to give her a bit better treatment we put her into the other yard, with hay and stuff there.

Interviewer: And things like cows that have freshly calved, when they walk in the tag reader will identify them and the computer lets you know.

Participant: Yep, it will identify them and let us know that they have freshly calved… Yeah, as long as you calve the cow in the computer, but nine time out of ten that happens, so it's fine.

Interviewer: So the computer picks up again, freshly calved ones, slow milking ones it identifies, and also ones that have been treated with umm…

Participant: Yeah Penicillin.

Interviewer: Is there anything else it picks up as well?

Participant: obviously it will tell you if the cows are on a permanent draft, like if she's on that permanent draft for the show cow list. Along with that, you've got to initiate the process of that, so for it to tell you that the cow is fresh you've got to calve the cow, for it to tell you that she's got penicillin in her, you've got to tell the computer to start with. But you only have to do it once, so from then on, it will tell you for the remaining days. And if she's slow, you just write in this is a slow cow, and from then on, she's always gunna be a slow cow, that's her life, she will be slow. So you're employees know to deal with her first… which is good.

Interviewer: Do you utilise an RFID reader at all, and for what purpose? The NSW regulations state that readers are not mandatory.

Participant: Apart from in the dairy, no we don't use them for any other reason, and the calf feeder.

Interviewer: Do you utilise a software application to work with your RFID, or for any other purposes on your farm? If so, how do these applications function (if not specified earlier in Q1 or Q3).

Participant: Well, we went through that a little bit before, but the software is called Dairy 2000, built in Victoria only for dairy farms. As mentioned, it has all those functions in regards to drafting and feeding, and AI and those sort of functions. It has a lot of functions we don't use, because it's way above what we need.

Interviewer: And that was built by OnFarm Electronics was it?

Participant: Yeah, OnFarm Electronics

Interviewer: What benefits do you believe your use of RFID provides to you?

Participant: Mainly convenience, for feeding, making it so much easier to individual feed, and drafting, making it easier to draft a cow without racing out and going to get her. It's happening automatically nearly. That's the biggest advantage. Makes milking a lot smoother.

Interviewer: The automatic feeder, does it provide the cows that are milking better with more feed, so it just produces more milk.

Participant: It's the same as I suppose any program, as long as you program it in there to start with, it will happen automatically from them on. We herd record, so we measure every cows milk once a month, and then it goes on that, if she's done 38 litres on that herd record she'll get fed for 38 litres for the following month until we herd record again.

Interviewer: So is the idea to feed them more to get more milk out of them.

Participant: Yeah, to the general statement. As they get further in to their lactation they're going to slow off in their milk anyway. That's just a natural thing. So we've built into ours that over the 300 days of lactation that it will slowly bring them down after 150 days it'll slowly bring them down anyway.

Interviewer: Do you believe there are any disadvantages that have arisen due to your use of RFID?

Participant: The only disadvantage I suppose is getting old dogs to learn new tricks. Learning how to use the basics of the computer. That, I suppose, for any employer is a bit of a hassle sometimes.

The cost of it, the advantages have outweighed the cost of it, long term. Like, if you're talking only over a year, there's no way you can justify that cost, but if you justify it over 20 years, it's paid for itself well and truly. In regard to saving of feed, saving of headaches, in regard to running around out the dairy trying to catch a cow, just simple things.

Interviewer: Do you feel you are gaining a good enough return on your RFID investment?

Participant: Yes.

Interviewer: Are you considering extending the use of RFID for farm management operations on your farm in the future (such as feed enhancement, gate control etc)?

Participant: Well, we've got that already. The only other little things we'd probably go on are the milk meters, electronic milk meters. It's the only thing, well, not the only thing, but, it's one thing I've thought about which might happen within 10 years. You need the individual identification for that, so…

Interviewer: *Do you find the cost of RFID to be excessive?*

Participant: Well, the initial cost was a big hit. I suppose, at the end of the day it would have been close to $60, maybe $65, 000 to put the software and hardware into the dairy. For individual cows it's not expensive, for dairy farmers, because at the moment, well,

for any sort of farming I suppose it's not expensive, because you need to put the tag in the cow's ear now anyway now to sell it, by law, you need to put it in there. So, it's not excessive. $4 per animal, roughly, is not an excessive amount. It is when you start doing thousands of them, but, it's not excessive really.

Interviewer: Do you have any concerns regarding the use of RFID in general?

Participant: No, not really. I suppose the only thing when we installing was to keep it away from any other electrical items, because interference was happening and we weren't getting good read range.

Interviewer: Is there an application where you feel RFID would be useful on your farm, or for dairy farms in general, that you haven't as yet heard of?

Participant: Not that I can think of. On another farm, like in sheep farms it would probably be very handy for drafting, mainly on age. If you wanted to get your animals pregnant at a certain age for sheep, and you had them running through a race and it drafted them on age that would be handy. That's the only thing I can think of. Nothing extra on top, for dairies.

Interviewer: Have you considered the use of RFID for monitoring the temperature of animals? Would you adopt such an invention?

Participant: Yes, yes we have. They've thought about it in the U.S., and they've tried to implement it in the U.S. The temperature of a cow is obviously related to if they are in heat - in season to mate – so, if their temperate goes up, they're likely to be in heat. If they do more walking of a day, they're likely to be on heat. If they do less walking they're likely to be sick. Things like that, it's a big help for everyday things. If they made a device that could detect heat, and walking… that was simple, and could run in with the same system that we're running now, well we would have it in two seconds sorta thing, it would make it a lot easier.

Interviewer: I've heard, currently they've been trialling things with sheep and pigs as well, actually putting in a rumen bolus

Participant: yeah a rumen bolus

Interviewer: Yeah, in that kind of a field they've been working on those, and identifying temperatures and that. So, if a temperature was too high for a cow, that could signify they're on heat, or also it could signify that they're sick as well?

Participant: If the temperature of a cow, yeah, if she is high, that could… but yeah, if it's high temperature, there's something different happening there, so you've gotta check it out.