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The importance of utilising electronic identification for total farm management in Australia

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Abstract

This paper aims to explore how Radio Frequency Identification (RFID) 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 aim. In line with this global trend, and to meet the requirements of key trading partners (such as the EU), Australia has implemented the National Livestock Identification System (NLIS) 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.

Keywords: radio-frequency identification, livestock, traceability, total farm management

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.

2 Background

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).

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).

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.

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).

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).

2.6 Focus benefit of RFID

An important benefit listed above 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.

3 Literature overview

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 and biometrics). A section of chapter seven, 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.

4 Benefits of using RFID for farm management

4.1 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.

4.2 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.

4.2.1 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.

4.2.2 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.

4.2.3 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.

5 Australia's traceability system

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.

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."

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.

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).

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.

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.

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.

5.4.3 Pricing and 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 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.

5.5 International recognition of the NLIS

RFID vendor Aleis International speak highly of Australia's NLIS, stating that "[t]he 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.

5.6 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).

5.7 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.

6 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).

6.1 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.

6.2 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.

6.3 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.

6.4 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.

6.5 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.

7 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.

8 Conclusion

Despite the fact that RFID technology has been in existence for many decades, 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.

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7

Using scenario planning in the evaluation of information security applications

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Abstract

This paper provides a broad overview of the scenario approach as it relates to the evaluation of location based services (LBS) technologies and their application. A scenario is a plausible vision of the future, based around a particular technology or application and developed via a scenario planning methodology. The main worth of the scenario planning approach is that it allows an application to be evaluated in terms of potential social impacts as well as technical merit and commercial viability. A sample scenario is presented within the paper to illustrate how the scenario planning methodology can be used. This scenario is analysed via deconstruction to draw out major issues presented regarding the use of LBS. The major contribution of this paper is a demonstration of the merits of scenarios in evaluating new technologies.

Keywords: scenarios, scenario planning, location-based services, evaluation methodology, social impacts