

Feasibility and Design of a Livestock Management System

by

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EXECUTIVE SUMMARY

The European Union (EU) is one of the bigger importers of beef globally, ranking fifth in the top ten importing countries. To protect its constituents, the EU has implemented strict rules and regulations regarding the export of any food products to the EU. In order to achieve these requirements, the focus has shifted from the end-product to the upstream production process. Consequently animal traceability has become extremely important.

If a South African wishes to be eligible to export meat and meat products to the EU, the European Commission (EC) requires that South Africa (SA) must first be put on a “positive list of eligible countries”. However, for one’s country to be worthy of being on this list, the country must meet multiple criteria (which is discussed later on) as determined by the EC. Alas, SA has not yet been accredited and approved by the EC. Part of this document is dedicated to the clarification of the requirements which are to be met and to the actions countries may take to conform to these requirements.

The legislation and livestock management systems which some countries have implemented will be analyzed and discussed. The focal point will be the legislation passed, the technologies used and the rules and regulations the country conforms to. By doing this, one may gain a greater perspective of what SA may require from its own Livestock Management System (LMS).

Once the technologies are identified, they are analyzed and compared to one another in order to select the most appropriate instruments for use in SA.

Finally, a LMS is designed. In order to perform this task, certain tools and techniques are considered. These techniques enable determining the operational and functional requirements and their relation to one another in the context of a system.

Deliverables include a comprehensive LMS which will be easily and readily accessible and allow improvement/expansion of the security features against rustling. This project will lessen the compliance burden to farmers by focussing on the requirements to meet the EU’s rules and regulations.



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LIST OF DEFINITIONS, ACRONYMS AND ABBREVIATIONS

Abattoir	:	A building where animals are slaughtered
Bolus	:	Device which is permanently lodged in a ruminant animal's digestive track
Bovine	:	Of or relating to or belonging to the genus Bos (Cattle)
BSE	:	Bovine Spongiform Encephalitis. A fatal disease that affects the central nervous system
CDFD	:	Context Data Flow Diagram
Cloud	:	Internet connection to remote servers regarded as a space for processing and storage
EC	:	European Commission
EID	:	Electronic Identification
ERD	:	Entity Relationship Diagram
EU	:	European Union
FFBD	:	Functional Flow Block Diagram
FVO	:	Food and Veterinary Office
HACPP	:	Hazard Analysis and Critical Control Points
IDEFO	:	Integration Definition For Function Modelling
LMS	:	Livestock Management System
OIE	:	World Organization for Animal Health
Pen	:	An enclosure for confining livestock
Reader	:	A device for obtaining information from a transponder, typically a RFID Reader and RFID transponder.
RFID	:	Radio Frequency Identification
Rustling	:	The theft of cattle
SA	:	South Africa
Transponder	:	A device designed to receive a specific radio frequency request signal and to automatically transmit a reply of its ID number on a specific radio frequency.
UML	:	Unified Modelling Language
VBA	:	Visual Basic for Applications

CHAPTER 1 - INTRODUCTION

1.1. BACKGROUND

With SA's current economic state, more and more farmers are forced to seek that ever elusive "greener grass on the other side". The European Union (EU) presents just that with regard to beef.

The EU is one of the bigger importers of beef worldwide. The European Commission (EC), the acting competent authority, ascertains import rules and regulations for meat and meat products on behalf of its 25 Member States. Seeing that the EC is the sole negotiating partner for all non-EU countries in questions related to import conditions for meat and meat products, farmers and exporters must conform to the rules and regulations, as determined by the EC, if they wish to export their goods to the EU.



EUROPEAN COMMISSION

It is evident that the exporting of agricultural products has become a major industry, which many countries, exporters and farmers are eager to join. To be eligible for export to the EU, one must conform to various rules and regulations, be accredited and approved by the EC and be able to accurately manage all the relevant animals.

When considering the fact that most farmers have more than a few hundred (or even a few thousand) cattle, the task of accurately managing all of these animals becomes seemingly impractical, and even, impossible. The use of a LMS, which will be specifically designed to conform to the EU's rules and regulations, will simplify this massive task.

Each animal will be given an Electronic Identification device (EID). This device may be attached to the animal at an age as early as 5 days, and will be used to accurately identify the animal throughout its lifetime. This will do away with obsolete branding and tagging methods, whilst providing the farmer with greater security opportunities.

By being able to identify individual animals with great accuracy and efficiency, one will be able to more effectively manage that animal (or the entire herd) in all aspects. This will enable the average farmer to be eligible to export his meat and meat products to the EU.

It is clear that exporting to the EU will not be an easy task, but the rewards may be worthwhile.

1.2. PROBLEM STATEMENT

For SA be able to conform to the rules and regulations, as determined by the EC for the export of meat and meat products, it must be able to continually, and accurately, “manage” all cattle from their date of birth, up on to the day it is slaughtered or sold.

This means that accurate and complete record keeping is required for every single head of cattle. However, with data ranging from the type of medicines administered, the type of feed and body mass, this task becomes impossible when considering that a single farmer may have a few hundred/thousand cattle. The traditional method of using a pen and paper seemingly becomes obsolete.

1.3. PROJECT AIM

The aim of this project is to design, and if possible deliver, a livestock management system (LMS).

This system must conform to EU requirements (which includes management of the national authority and its establishments), replace obsolete (paper based) livestock management methods, be user friendly, easily accessible, utilize current technologies (such as RFID tags and cloud computing), and be automated to the maximum extent.

1.4. PROJECT SCOPE

The objective of this project is to provide SA, and the common cattle farmer, with a LMS so that SA may be eligible to export its meat and meat products to the EU. Thus this project will focus on:

- Animal Species –
 - The Bovine family group, in other words, Cattle
- Rules and Regulations –
 - South African rules and regulations on food safety and exporting, and
 - EU rules and regulations on food safety and importing
- Data –
 - Automated and/or streamlined capturing,
 - Cloud based systems, and
 - Ease of accessibility
- Control –
 - Conformance of the LMS’ database with the real world

This project in particular covers:

- Data management (which includes capturing, storage, manipulation and accessibility) of animals from the Bovine family group, which will enable SA and the common farmer to be eligible for exporting of meat and meat products to the EU by conforming to the rules and regulations as determined by the EU and SA food safety acts.
- Conformance between the data in the LMS’ database and the real world, which will determine the validity of the data.

1.5. DELIVERABLES

1.5.1. ELECTRONIC IDENTIFICATION

A comprehensive Electronic Identification (EID) system is designed and implemented. This requires that a passive transponder (an EID device without any battery power, but designed to receive a transmission of the energy required to automatically transmit a specific reply), which will have a unique ID number stored on it, be attached to or inserted into the animals.

The ID number on the transponder may be acquired by a reader (a device for transmitting the required energy and receiving information from a transponder). This ID number is then communicated to a computer for further use.

The use of an EID device ensures that the identification of animals is accurate and consistent. The implementation of such a method will enable the farmer to:

- Accurately identify individual animals,
- Monitor the number of animals in a specific area,
- Record diseases and veterinary treatment of an animal,
- Link regular body mass measured to a specific animal,
- Discourage rustling, and
- Effectively manage his cattle.

1.5.2. DATABASE

The LMS' database is designed so that it enables the user (the farmer) to accurately and effectively manage his cattle.

This database is:

- Designed using an Entity Relationship Diagram (ERD), and
- Built using MS Access.

The database has been tried and tested using MS Access, but if resources and time allows, the concept of using Cloud based systems may be explored. Using a Cloud will allow the user to access the LMS database from any computer, provided it has an internet connection. A Cloud will also allow abattoirs and authorities to access the LMS database, but without the right to change or delete any records.

The use of files exported from an EID reader's memory to a computer will be explored as a method for communication between an EID reader and the LMS Database. This will provide accurate data transfer between the reader and the database. If the use of files seems to be unsuccessful, the use of either VBA (Visual Basic for Applications) or Delphi will be explored.

1.5.3. SECURITY

By attaching a transponder to an animal, one gains the ability of accurately identifying such animals. Since certain of the devices (such as the Bolus) cannot be removed from the animal without slaughtering it, this provides one with the opportunity to reclaim one's property if it was stolen. In this case, if one was to be a victim of rustling, and the stolen animals were found, authorities may use handheld readers to accurately identify the rightful owner(s) of the animals. The LMS database may simply be consulted; specifically the ID numbers which were scanned by readers and, by doing so, the animals may be traced back to the rightful owner.

This principle may also be implemented at abattoirs. If one supplies cattle to an abattoir for slaughtering, the abattoir must first determine whether the supplier is the rightful owner of the cattle.

On the farm itself, readers may be placed at watering holes, pens or any other key locations. These readers will then record the activity around it for certain periods (say for a week) and store the ID numbers it scanned in its memory. The file may then be exported to a computer, allowing for the number of animals to be calculated. By doing this, one may determine whether an animal, or a few, are missing and when the incident occurred.

1.5.4. WEIGHING

By combining EID and weighing technologies, one develops a device that will be able to take an accurate measurement of an animal's body mass whilst it is standing on a scale, and automatically link this measured mass with the ID of the animal, which is acquired by the reader of the EID system.

The data (the ID linked to the body mass of the animal) will then be stored in the memory of the device. This may be stored in many different file formats (simple text files, MS Excel spreadsheets, etc.) which can be exported to a computer and then be imported into the database. The LMS will then automatically update the specific animals' entries in the database with the new body mass and the date on which it was recorded.



CHAPTER 2 - LITERATURE REVIEW

2.1. GLOBAL MARKET

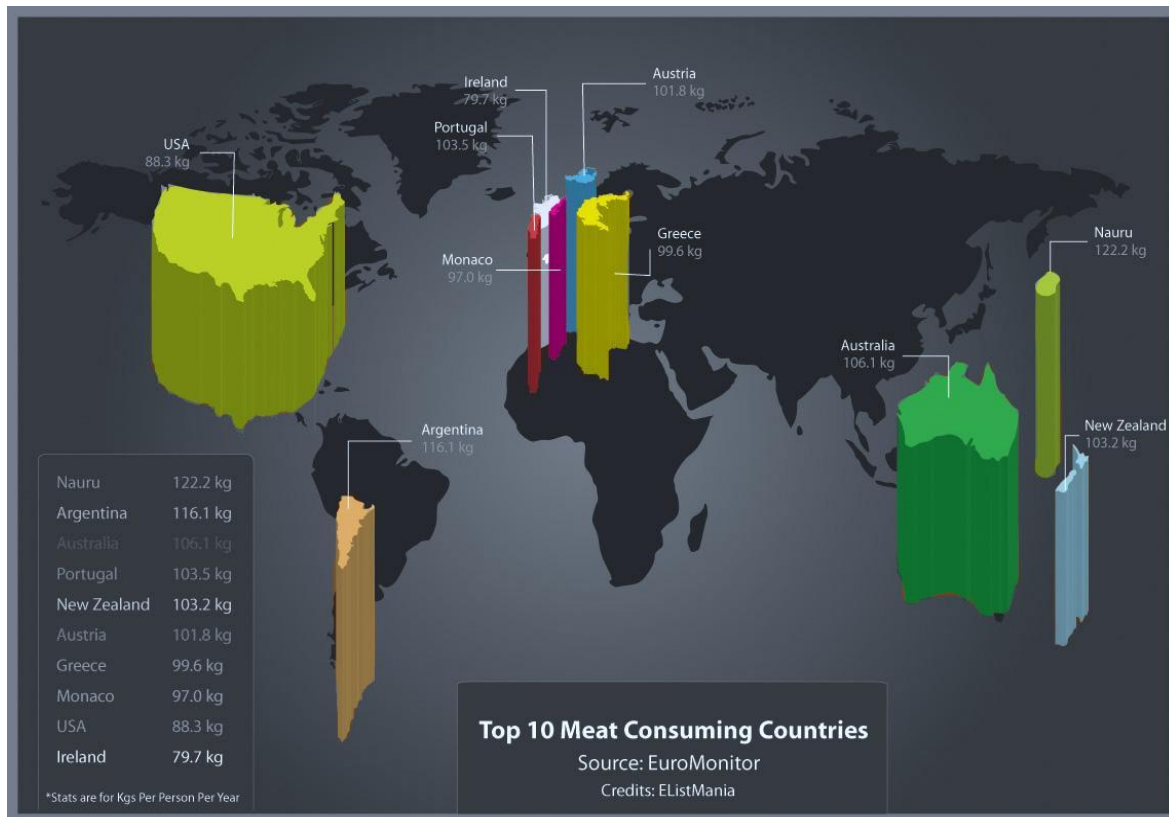


Figure 1: Top 10 meat consuming countries

In today's age, meat consumption is ever increasing. This is due to the increasing desire to consume meat as a protein in the more affluent communities such as the EU and the global availability of meat and meat products. *Figure 1* depicts the top ten meat consuming countries worldwide. One may observe that there is a cluster of meat consuming countries within in the EU. With the ever increase in consumption, demand also increases, and so does the total of imports. According to the United States Meat Export Federation (USMEF) Manager of Research and Analysis, factors leading to the projected decrease in meat consumption are likely include limited beef supplies, high consumer prices and market uncertainty. The United States Department of Agriculture (USDA) states that the top beef importers for 2017 will be (U.S. Meat Export Federation, 2012):

- *United States.* Growth to 1,748,000 tons, which is an increase of 277,000 tons, or 19% over 10 years.
- *Russia.* Imports will grow to 1,398,000 tons, an increase of 348,000 tons, or 33% over 10 years.
- *Japan.* Imports in 2017 will total 851,000 tons, an increase of 136,000 tons, or a 19 percent increase.
- *Mexico.* 765,000 tons to be imported in 2017, reflecting a 365,000 ton, or a 91 percent increase. A mild increase of 2 percent in 2008 is followed by a 15 percent increase in 2009 and then 5 percent to 7 percent annual growth over the remainder of the outlook period.
- *European Union.* EU imports are projected at 709,000 tons in 2017, with a decrease of 16,000 tons from the 2007 import estimate.
- *Egypt and Canada.* Each country is projected to import about 332,000 tons in 2017 with Egypt's imports growing from 250,000 tons and Canada's imports growing from 225,000 tons in 2007.

2.2. SOUTH AFRICA

When considering the above mentioned statistics, there will be a huge global demand for meat and meat products by 2017 which the current meat export industry may not be able to satisfy. This offers an opportunity for SA as it may strive to participate in the supply of this ever growing demand. By conforming to EU requirements, which are the strictest of any country worldwide, SA will be able to export its animal products across the globe.

Alas, at this stage SA cannot export meat and meat products (specifically that of red meat) to the EU, since it does not conform to their requirements (le Roux, 2012). This is a problem that cannot be overcome by commercial farmers on their own, but needs to be addressed in co-operation with the Department of Agriculture.

In order for SA to align our meat standards to the EU regulations and be able to make an informed decision on how to proceed, we must consider what other nations have done to achieve this (see the *Section 2.4 on Animal Identification Systems*). One may note that most nations follow EU rules, regulations and requirements (Fernández Caramés, 2010). Ultimately, SA will have to do the same.

2.3. THE EUROPEAN UNION

On 1 January 2006 (European Commission, 2006) the EU implemented certain legislation (see Appendix A) regarding their new food law, food safety and the hygiene of foodstuffs. This legislation, imposing a series of health and supervisory requirements, is designed to ensure that imported animals and products meet standards at least equivalent to those required for production in (and trade between) Member States.

For a country (hereafter also referred to as the third country) to be eligible for export of meat and meat products to the EU, it must abide by the EU's legislation, and conform to certain standards and requirements. In other words, the third country must first be accredited and approved by the EC in order to export their products of animal origin to the EU.

For an in depth discussion on the EU's legislation, see *Appendix A – Legislation*.

2.4. ANIMAL IDENTIFICATION SYSTEMS

2.4.1. Worldwide Initiative

2.4.1.1. Legislation

Many nations have developed legislative initiatives in response to growing demands of consumers and health experts. These initiatives usually involve the implementation of mechanisms for attaining accurate animal traceability and identification (Fernández Caramés, 2010).

Unfortunately, no international standard for animal identification exists - only that of individual countries. The following table illustrates the lack of international standardization. One may observe that the traceability and identification requirements vary greatly from one country to another. (Fernández Caramés, 2010).

Table 1: Cattle Identification Systems (M=Mandatory, V=Voluntary)

Region	Country	Sort of Program	Start Date	Identification				Movements Registry
				Premises	Individuals	Groups or Lots	RFID	
Europe	EU	M	1997	M	M	V	V	M
Oceania	Australia	M	2002	M	M	V	M	M
	New Zealand	V	1999	M/V	M/V	V	V	V
Africa	Namibia	M	1999	M	M	V	V	M
	Botswana	M	2001	V	M	-	M	M
Asia	Japan	M	2003	M	M	V	V	M
	South Korea	M	2004	M	M	V	V	M
South America	Brazil	V	2001	M/V	M/V	V	V	V
	Uruguay	M	2006	M	M	V	M	M
	Argentina	M	2007	M	M	V	V	M
	Chile	M	2004	M	M	-	V	M
North America	Paraguay	V	2004	V	V	V	V	V
	USA	V	2004	V	V	V	V	V
	Canada	M	2002	V	M	-	M	V
	Mexico	V	2003	V	V	V	V	V

It's evident, when looking at the start dates above, that SA lags several years behind other countries. According to de Koker (2012), SA's legislative state (regarding animal traceability and identification) won't change any time soon. For the near future, it seems that private companies would need to take the initiative. In other words, private companies would have to father SA's Livestock Management System.

2.4.1.2. Individual Systems

South Africa

Seeing that SA currently does not have an LMS that follows EU regulations – such a system must be designed. This system can borrow concepts and ideas from that of other countries to establish a LMS unique to SA.

In order for SA to be able to make an informed decision on how to proceed with its own LMS, we must first take into account the systems and legislations other nations have implemented, and what these have accomplished.

Botswana

In order to keep on trading with the EU, Botswana's government decided to implement an identification system which uses a central database to store information of all animals to be exported.

The system was launched in 2001 and is called LITS (Livestock Identification and Trace-back System). Animals are identified individually with RFID boluses and can be tracked throughout the whole production chain. Every bolus emits a code which is associated with relevant information about the animal (owner, type of identification tag used, skin color or the premise where the animal resides).

Namibia

In 1999, the Namibian government, through the Meat Board of Namibia, implemented a system called FANMS (Farm Assured Namibian Meat Scheme), which manages a database that stores information about the different producers and their brands, data about meat exports and imports, and thus enables maintaining cattle traceability.

Due to the importance of exports to the EU, the system follows EU regulations. Animals are tagged individually with ear tags that display printed bar codes associated with unique serial numbers. Every animal must be tagged with a FANMS approved tag before leaving the premises where it was born, and every producer has to fill out a registration document to indicate such movements. Each premise has to own records of all animals that enter/leave the premise and abattoirs must keep track of slaughters.

Brazil

The Brazilian animal identification system is known as SISBOV (Brazilian System of Identification and Origin Certification for Cattle and Buffaloes).

In 2006 the system was extended to the whole meat processing chain and since 2008 it is compulsory. It is based on the use of ear tags which are associated to individual certificates. These certificates are emitted by private government contracted companies and are required when the animals are moved from one location (farm or feedlot) to another.

Although SISBOV was designed to work at an individual level, the classification is generally performed in groups, except when the tagged animals are to be exported to Europe (in such case, the animals are identified individually following EU requirements).

European Union

The European Union (currently comprising Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta,

Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and United Kingdom) manages a large number of cattle, pigs and sheep.

In the past 30 years, the EU has been a victim of several severe disease outbreaks (Fernández Caramés, 2010): BSE (1986-1988), classic swine fever (1997 and 2000), FMD (2001) and avian influenza (2003-2006). These outbreaks caused economic losses of more than \$15 billion. Not wanting the past to be repeated, the EU became especially concerned with every aspect related to health control of their livestock. Thus the EC has created legislation to launch animal identification and traceability systems. The basic goals of these systems were to:

- Permit traceability and tracking of animals for veterinary controls,
- Permit meat traceability which would satisfy the requirements of the public health regulations,
- Tag, and assign a unique number to, each animal,
- Create a registry of all premises (farms, markets...),
- Use of livestock passports for movement management, and
- Create a national computerized database.

Japan

In order to stop the spread of possible disease outbreaks, Japan (in 2002) implemented numerous laws that regulate cattle identification and traceability.

The beef traceability law states that, since 1 December 2003, cattle must be identified individually “from birth to the plate”. The Japanese government manages the traceability system, requiring the tracking of food throughout the processing chain until it is sold to the consumer. Each animal must receive an identification number at birth in order for it to be associated with a register that stores information such as its date of the birth, its sex and the identification numbers of its parents. Animals are identified by means of two ear tags that display a 10-digit number and a bar code.

Accurate records for the control of animal movements between premises must be kept. Likewise, abattoirs must maintain a register of the slaughter: each animal's identification number, its origin and the date of slaughter.

This traceability system is aimed at increasing the consumer's trust. In fact, consumers are able to access information about the meat they've just bought through the internet, which in effect increases consumer confidence in the product.

Australia

Australia's animal identification system is called NLIS (National Livestock Identification System). The NLIS system is based on the use of different types of permanent identification tags:

- *Breeder tags*. They indicate an identification code related to the premise where the animal was born.
- *Post-breeder tags*. They are used in two cases:
 - When the animal wasn't born in the premise where its currently residing or,
 - When the animal has been previously moved to another premise, although it was born in the premise where it currently resides.
- *Ear tags for bolus identification*. They indicate whether the animal holds a tag in its digestive tract.

- *Sale yard post-breeder devices.* They are used when the animals arrive at a place to be sold but they don't have a tag yet.
- *District tags.* They are managed by inspectors and are dedicated to premises that could be in the database, but they haven't still been registered in the system.

And these temporary tags:

- *Transaction tags.* These are tags that can be placed in the ears or in the tail and, during a trip, they provide reference to the premise the animal originates from.
- *Sale yard tags.* They are used in the sale yard when the permanent tag of an animal doesn't work properly.
- *HGP free tags.* They are placed in an ear or in the tail with to indicate that the animal is free from substances that provoke alterations in hormone levels.

The NLIS was implemented in 1999 and is supervised by the MLA (Meat and Livestock Australia). Since 1 July 2005, its use is compulsory for all states and territories of Australia.

The cattle industry plays an important role in the country's economy. Since the lack of effective disease detection and tracking systems could lead to the ban or restriction of exports, the implementation of the NLIS system, which was created with the aim of maintaining traceability in order to control and limit the spread of diseases, was essential.

The NLIS system is based on the use of RFID tags: these can be placed in each ear of the animal or, one in an ear and the other in the rumen. Each RFID tag emits an identifier that allows associating the animal with the code (Property Identification Code (PIC code)) of the premise where it was born. Each territory owns a register that stores all the premises identified by a PIC code.

Canada

Bovine animal identification is managed by the CCIA (Canadian Cattle Identification Agency). This organization is led by the cattle industry and promotes the safe consumption of meat. The system is mandatory for all cattle and bison.

Identification is performed by using two tags: one is a visual plastic ear tag and the other is an RFID device. Both tags remain in the animal until slaughter or its exportation. Such tags are distributed through a network which stores the identifiers in a national database.

The use of RFID technology is mandatory since 1 September 2006. Presently, the CCIA is developing new applications that include premise and animal group identification and tracking.

USA

The US manages a system known as NAIS (National Animal Identification System). NAIS allows for performing generic identification, is voluntary and its main goals are to:

- Quickly respond to any kind of outbreak, allowing the industry and the different federal governments to take the proper measures.
- Allow the development of disease eradication programs.
- Protect American exports by following the requirements of the international markets.
- Protect the domestic market and thus increase consumer confidence.

The NAIS system is based on three foundations: the identification of the different premises, the identification of the animals and the tracking of such animals throughout the processing chain.

To do this, the system requires the following actions:

- Each premise is identified by a PIN (Premise Identification Number). The USDA expected to identify all the premises during 2009, but seeing that the system is voluntary, it is probable that this wasn't possible.
- Regarding animal identification, it can be carried out at on an individual level or at a group level. If the animals belong to the same species, they are treated during the processing chain as a group and therefore they can be identified with a group or lot number (GIN, Group/Lot Identification Number). However, if the animals are processed individually, identification must be also performed individually. The identification is performed using two tags: one is a visual plastic ear tag and the other is an RFID device.
- The third foundation of the system is animal tracking. For this purpose all the animal movements are stored in a database called ATD (Animal Tracking Database), which is managed by the industry and authorities of each state. This database can be accessed by health inspectors through the internet should an outbreak of disease be detected.

2.4.2. *Electronic Identification (EID)*

Electronic identification devices emit a unique identifier that is associated with the animal (Fernández Caramés, 2010). The unique identifier is acquired by a reader, which in the case of a passive transponder also transmits energy to the tag via its antenna to power up the RFID chip embedded in the tag. Once powered up, the RFID chip transmits its identifier using the same antenna. Such devices have been commonly used, in conjunction with a visual tag that complements the electronic device (in case it is damaged, is lost or when there is no RFID reader), for stock keeping over the past 20 years (Finkenzeller, 2010). Recently, the introduction of injectable tags and ruminal transponders (bolus) has greatly reduced the probability of losing an EID tag.

These devices may be used for unique identification, quality assurance, retracing the origin of animals, the control and eradication of epidemics, and for other applications such as automated feeding and the calculation of productivity. The required data transmission and coding procedures for animal identification are provided by the 1996 ISO standards 11784, 11785 and 14223.

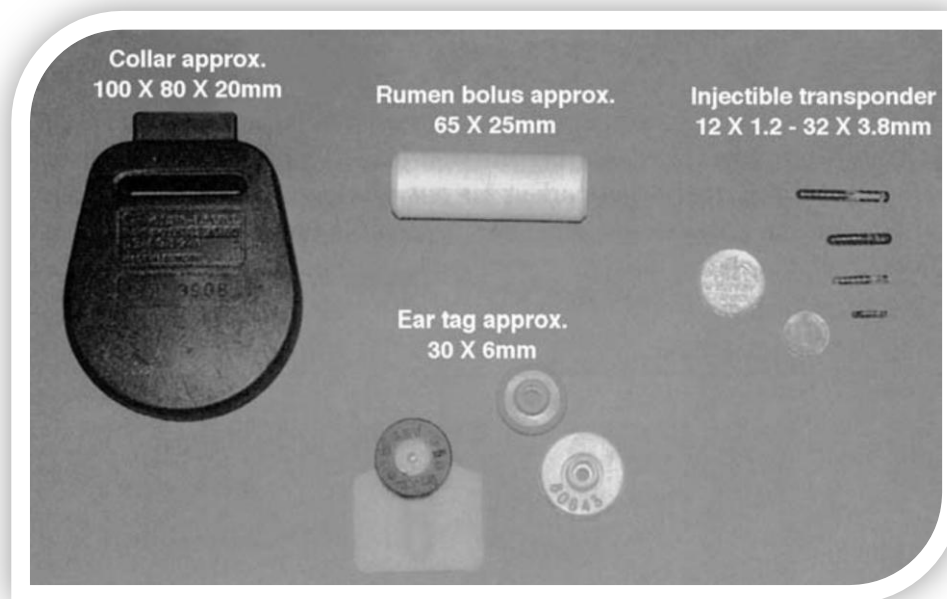


Figure 2: Size comparison of different variants of electronic animal identification transponders

There are four basic types of transponder that may be affixed to the animal: collar-, ear tag-, injectable- and bolus transponders (*Figure 2*). (Finkenzeller, 2010).

- *Collar transponders.* These are easily transferable from one animal to another. This allows for the application of this system inside a process. Other applications include that of automatic feeding (in a feeding stall) and measuring performance.
- *Ear tags.* Tags bearing an RFID transponder contend for better market position with the cheaper barcoded ear tags. The latter, however, may not be suitable for complete automation, seeing that barcoded ear tags must be scanned only centimeters away from a handheld reader in order to accurately identify the animal. On the other hand, RFID ear tags may be read at varying distances.
- *Injectable transponders.* Using a special tool, this transponder is injected under the animal's skin. Seeing that the transponder is affixed underneath the skin, it can only be removed by an operation. This makes the injectable transponder, to some extent, tamper proof.
- *Bolus transponders.* The Bolus is discussed later on in this section.

Figure 3 graphically illustrates each of the above mentioned transponder types respectively. (Finkenzeller, 2010).



Figure 3: The options for attaching the transponder to a cow

Since an injected transponder (a non-organic object) represents a foreign body in the animal’s tissues, problems in the positioning of the transponder may arise, therefore incurring difficulties when reading the transponder. In other words, an injected transponder can, throughout the animal’s lifetime, ‘wander’ around in the tissue, causing readability errors. To solve this problem, various injection sites have been investigated since 1989 (Finkenzeller, 2010). Subsequently, the injection under the *scutulum*, as recommended injection site, is currently favored over that of the right ear.

(Finkenzeller, 2010)

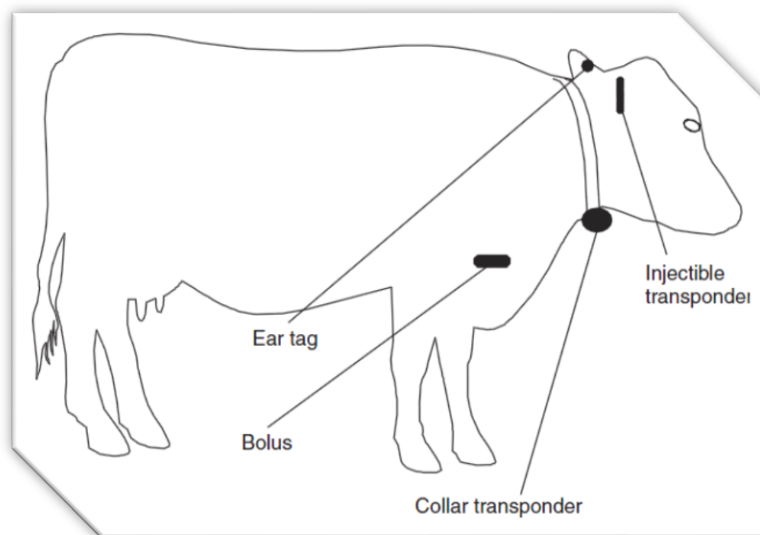
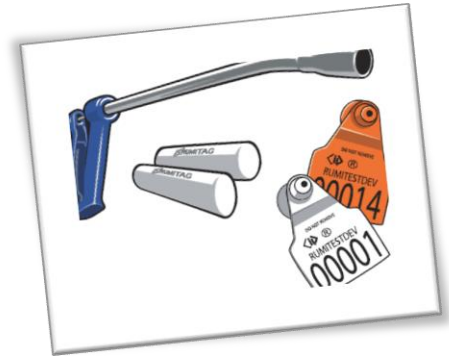


Figure 4: Injection of a transponder under the scutulum & Oral application of a bolus

The bolus transponder is affixed in a ceramic, acid-resistant, cylindrical housing. The bolus is inserted into the rumen via the gullet. Normally the bolus will remain in the stomach for the entire duration of the animal’s life. Advantages of the bolus include the simple insertion of the transponder into the animal’s body, the fact that its tamper proof, does not cause any injury to the animal and that removal in abattoirs is simplified.

It’s evident that the injected and bolus transponders are the only tamper proof identification systems available. A more elaborate comparison of shows that for:

- *Extensive stock keeping* (animals which are free range and only occasionally handled), which is most prevalent in Australia and South America, that the use of a bolus is particularly suited.
- *Intensive stock keeping* (animals which are kept under close and constant supervision and often handled), which is usually used in central Europe, both systems seem to be worthy.



The industry standard for the identification of animals is yet to be determined. Each type of RFID tag is still equal contenders.

2.4.2.1. Identification Code Structure

The identification code for animals, specified in ISO/IEC 11784, comprises a total of 64 bits (8 bytes). Table 2 shows the significance of the individual bits. The national identification code should be managed by the individual countries. Bits 27 to 64 may also be allocated to differentiate between different animal types, breeds, regions within the country, breeders, etc., but this is not specified in this standard (Finkenzeller, 2010).

Table 2: ID Codes for Animals

Identification codes for animals

Bit number	Information	Description
1	Animal (1)/non-animal application (0)	Specifies whether the transponder is used for animal identification or for other purposes
2–15	Reserved	Reserved for future applications
16	Data block (1) follows/no data block (0)	Specifies whether additional data will be transmitted after the identification code
17–26	Country code as per ISO/IEC 3166	Specifies the country of use (the code 999 describes a test transponder)
27–64	National identification code	Unique, country-specific registration number

Using the above explained standard, an animal identification code, of an animal originating from South Africa, may look something like the following example:

1 – xxxxxxxxxxxxxx – 0 – ZAF710xxxx – xx

At present, the remaining characters of “ZAF710xxxx” seems to be left to the discretion of each county's National Authority since it is not specified anywhere within any of the ISO standards. Furthermore, the remaining 37 characters are to be defined by the countries' National Authority. This means that when such an authority is established within SA, the format of this unique, country specific registration number must be determined.

2.4.2.2. Visual Tags versus Electronic Tags

The question whether conventional visual tags or RFID tags are better may be answered by assessing the advantages and disadvantages of each kind of tag (Fernández Caramés, 2010):

Advantages of RFID over visual tagging

- *Faster Readings.* A Line of sight is not required for an RFID reading, thus this eliminates part of the human participation in the procedure.
- *More accurate readings.* Visual ID labels may be transcribed incorrectly by a human operator, whilst RFID systems significantly reduce the probability of acquiring an incorrect identifier.
- *Market Related.* RFID tagging ensures that the demand (by importing countries) of traceability and health control across the different stages of production in that of the exporting country are met.
- *Standardization.* RFID tags that can be used for animal identification generally conform to ISO 11784 and/or ISO 11785 standards. This means that the tags (and readers) are compatible worldwide, whereas visual tags may be exclusive to a specific country or region.
- *Automation.* RFID technology allows the automation of multiple tasks that would ordinarily require human supervision if they were to be performed by using a visual tag based system.
- *Reduction of counterfeiting.* In comparison with a simple plastic label (visual tag), RFID identification numbers are unique and not re-writable, which makes it much harder to counterfeit or tamper with. Furthermore, the substitution of an RFID transponder is much more difficult than that of a visual tag.
- *Less risk of loss and deterioration.* Conventional visual tags must be fixed to a visible part of the animal (mainly the ears or tail), which increases the risk of being lost or damaged due to the animals normal interaction with the environment. Although RFID tags are also affixed externally to the animal, it may as well be inserted under the animal's skin or orally into its digestive tract, thus reducing the risk of loss or deterioration.

Disadvantages of RFID tags

- *Cost.* The unitary cost of a RFID transponder is far greater than that of basic plastic labels. However, this gap in costs has been reduced over the last few years due to cheaper manufacturing techniques.
- *Toxicity.* If an RFID tag isn't removed from the animal's carcass, it may enter the food chain. Presently this is quite unlikely due to the controls performed in abattoirs; however, human failures might still occur. Today though, thanks to the use of rumen boluses, the probability of missing an EID has decreased substantially.
- *Complex insertion.* Conventional ear tags only require simple insertion that may be performed by any able person with little to no skills, whilst bolus tags generally need to be inserted by trained people (mainly vets) in order to diminish the risk of infections.

Fernández Caramés (2010) demonstrated that the use of RFID tags far surpasses that of conventional visual tags. It should also be emphasized that the use of RFID and visual tagging are compatible: one may place a visual tag in the animal's one ear and a RFID tag in the other (or inside the reticulum). This ensures that if the EID fails, the animal may still be accurately identified.

CHAPTER 3 - TOOLS AND TECHNIQUES

3.1. FUNCTIONAL FLOW BLOCK DIAGRAM (FFBD)

Functional Analysis examines a system's functions (and sub-functions) that accomplish the system's objectives (Federal Aviation Administration, 2006). It describes *what* the system does, not *how* it does it. Every function required to meet the operational needs of a system is identified, defined, and organized into a functional architecture that is used to define system requirements. A functional architecture is a hierarchical depiction of functions and interfaces that forms a complete representation of the system from an operational and behavioral perspective. As the identified functions are decomposed into sub-functions, the process becomes more detailed. Functional decomposition reduces the systems complexity by allocating functionality and interfaces to more readily understood and managed sublevel functions. This process may be repeated until the system is completely decomposed into its simplest sub-functions, where each such sub-function is defined by a valid set of requirements. The functions and sub-functions are then laid out in a functional architecture in order to show their relationships and internal/external interfaces.

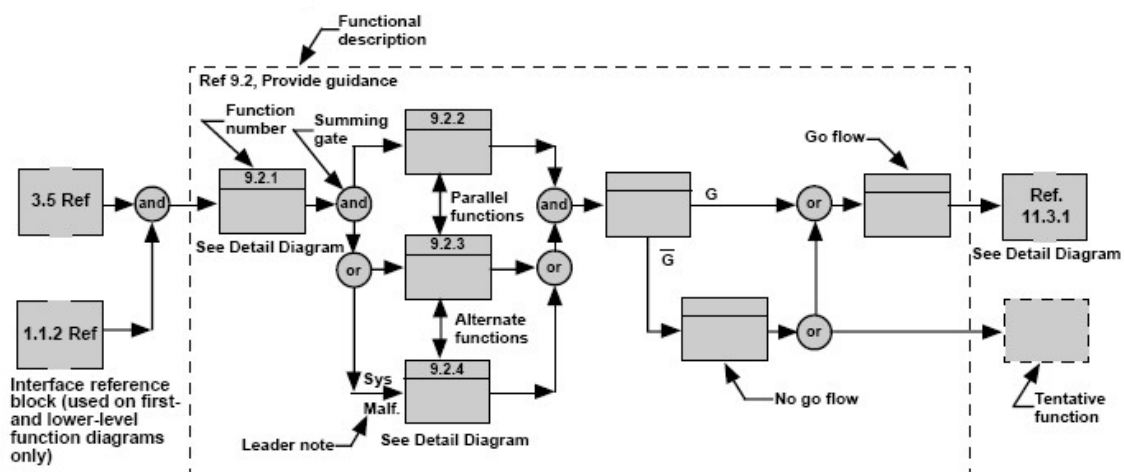


Figure 5: Example of an FFBD (Federal Aviation Administration, 2012)

The Functional Flow Block Diagram (FFBD) is a tiered, step-by-step, time-sequenced diagram of the system's operational flow. FFBDs effectively define processes for developing and producing systems, although they're usually used for defining the detailed stepwise functional and support sequences for systems. In the context of a system, the steps of operational flow may include combinations of facilities, personnel, procedures, software and hardware. In the FFBD method, the functions are arrayed in their legitimate order of performance. Each function's logical relationship is shown in respect to the performing and completion of other functions. Each function is depicted by a node labeled with its name, whilst arrows illustrate the order of execution (from left to right) of the functions. Successive or parallel execution of functions is represented by means of logic symbols.

Finally, by performing a functional analysis, the requirements for a LMS unique to SA may be determined. Subsequently, FFBD may be used to identify, define and decompose the required functions of the LMS.

3.2. INTEGRATION DEFINITION FOR FUNCTION MODELLING

IDEF0 is an engineering technique which may be used to perform and manage needs analysis, benefits analysis, requirements definition, functional analysis, systems design, maintenance, and baselines for continuous improvement (National Institute of Standards and Technology, 1993).

The IDEF0 model depicts how system functions interrelate and operate. When used systematically, IDEF0 supplies a systems engineering approach to:

1. Perform systems analysis and design, for systems compiled of various materials, machines, computers, information and people of the entire subject area, system or enterprise.
2. Produce reference documentation co-occurring with development to function as the basis for incorporating new systems or improving existing systems.
3. Communicate amongst users, analysts, managers and designers.
4. Allow for coalition team consensus to be attained by shared understanding.
5. Manage large and complex projects using qualitative measures of progress.
6. Provide reference architecture for resource management, information engineering and enterprise analysis.

IDEF0 is structured on the combination of graphics and text which are to be portrayed (in an organized and systematic manner) to specify requirements, gain understanding, provide logic for potential changes, support analysis, or support systems level design and integration activities. An IDEF0 model is a hierarchical series of diagrams which describes (in the context of a system) the functions and their interfaces. Three types of diagrams exist: glossary, text and graphic. A Graphic diagram determines functions and functional relationship, whilst a text and/or glossary diagram provides extra information in support of the graphic diagram.

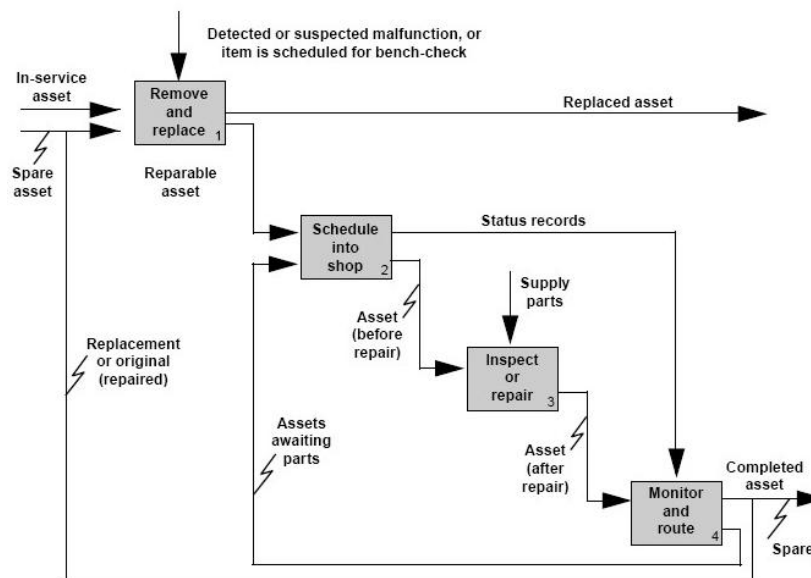


Figure 6: Example of an IDEF0 diagram

For new systems, like that of an LMS for SA, IDEF0 can be used to determine the requirements, define the functions, and then to design its execution.

3.3. ENTITY RELATIONSHIP DIAGRAM (ERD)

An Entity Relationship Diagram (ERD) is a graphical depiction of organizational system elements and the association among the elements. ERD can help define system boundaries. The elements that make up a system are referred to as entities. A relationship is the association that describes the interaction between entities.

ERD's are a major data modelling tool and will help organize the data in your project into entities and define the relationships between the entities. This process has proved to enable the analyst to produce a good database structure so that the data can be stored and retrieved in a most efficient manner.

3.3.1. Components

The elements that make up a system are referred to as entities. A relationship is the association that describes the interaction between entities. The components used in the creation of an ERD are (Bentley, 2007):

3.3.1.1. Entity

An Entity is a person, place or thing about which we want to collect and store multiple instances of data. It has a name, which is a noun, and attributes which describe the data we are interested in storing. It also has an identifier, which uniquely identifies one instance of an entity.

3.3.1.2. Relationship

The relationship illustrates an association between two entities. It has a name which is a verb. It also has cardinality and modality.

Cardinality & Modality

Cardinality and Modality are the indicators of the business rules around a relationship. Cardinality refers to the maximum number of times an instance in one entity can be associated with instances in the related entity. Modality refers to the minimum number of times an instance in one entity can be associated with an instance in the related entity.

Cardinality can be 1 or many and the symbol is placed on the outside ends of the relationship line, closest to the entity, Modality can be 1 or 0 and the symbol is placed on the inside, next to the cardinality symbol. For a cardinality of 1 a straight line is drawn. For a cardinality of many a foot with three toes is drawn. For a modality of 1 a straight line is drawn. For a modality of 0 a circle is drawn.

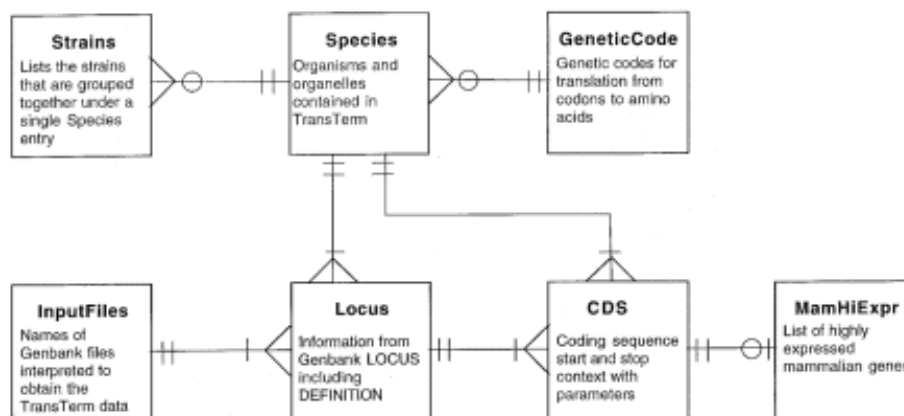


Figure 7: Example of an ERD

3.4. UNIFIED MODELLING LANGUAGE (UML)

Unified Modelling Language (UML) is a standardized general-purpose modelling language in the field of object-oriented software engineering. The standard is managed, and was created, by the Object Management Group (OMG). It was first added to the list of OMG adopted technologies in 1997, and has since become the industry standard for modelling software-intensive systems (Chonoles, 2003).

UML combines techniques from data modelling (entity relationship diagrams), business modelling (work flows), object modelling, and component modelling. It can be used with all processes, throughout the software development life cycle, and across different implementation technologies.

3.4.1. Modelling

It is important to distinguish between the UML model and the set of diagrams of a system. A diagram is a partial graphic representation of a system's model. The model also contains documentation that drives the model elements and diagrams (such as written use cases). UML diagrams represent two different views of a system model (Chonoles, 2003):

- **Static (or *structural*) view:** emphasizes the static structure of the system using objects, attributes, operations and relationships. The structural view includes class diagrams and composite structure diagrams.
- **Dynamic (or *behavioural*) view:** emphasizes the dynamic behaviour of the system by showing collaborations among objects and changes to the internal states of objects. This view includes sequence diagrams, activity diagrams and state diagrams.

3.4.2. Overview of Diagrams

UML 2.2 has 14 types of diagrams divided into two categories. Seven diagram types represent *structural* information, and the other seven represent general types of *behaviour*, including four that represent different aspects of *interactions*. These diagrams can be categorized hierarchically as shown in the following class diagram (Chonoles, 2003):

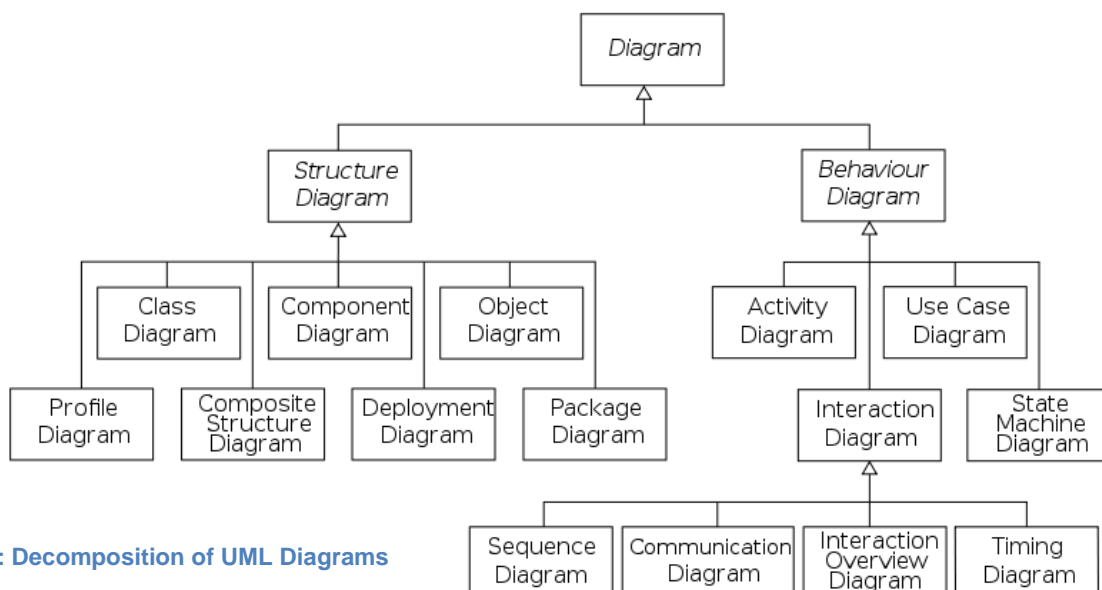


Figure 8: Decomposition of UML Diagrams

3.4.2.1. Structure Diagrams

Structure diagrams emphasize the things that must be present in the system being modelled. Since structure diagrams represent the structure, they are used extensively in documenting the software architecture of software systems. These diagrams are (Chonoles, 2003):

- Class diagram - describes the structure of a system by showing the system's classes, their attributes, and the relationships among the classes.
- Component diagram - describes how a software system is split up into components and shows the dependencies among these components.
- Composite structure diagram - describes the internal structure of a class and the collaborations that this structure makes possible.
- Deployment diagram - describes the hardware used in system implementations and the execution environments and artefacts deployed on the hardware.
- Object diagram - shows a complete or partial view of the structure of an example modelled system at a specific time.
- Package diagram - describes how a system is split up into logical groupings by showing the dependencies among these groupings.
- Profile diagram - operates at the metamodel level to show stereotypes as classes, and profiles as packages.

3.4.2.2. Behaviour Diagrams

Behaviour diagrams emphasize what must happen in the system being modelled. Since behaviour diagrams illustrate the behaviour of a system, they are used extensively to describe the functionality of software systems. These diagrams are (Chonoles, 2003):

- Activity diagram - describes the business and operational step-by-step workflows of components in a system. An activity diagram shows the overall flow of control.
- UML state machine diagram - describes the states and state transitions of the system.
- Use Case Diagram - describes the functionality provided by a system in terms of actors, their goals represented as use cases, and any dependencies among those use cases.

3.4.2.3. Interaction Diagrams

Interaction diagrams, a subset of behaviour diagrams, emphasize the flow of control and data among the things in the system being modelled (Chonoles, 2003):

- Communication diagram - shows the interactions between objects or parts in terms of sequenced messages. They represent a combination of information taken from Class, Sequence, and Use Case Diagrams describing both the static structure and dynamic behaviour of a system.
- Interaction overview diagram - provides an overview in which the nodes represent communication diagrams.
- Sequence diagram - shows how objects communicate with each other in terms of a sequence of messages. Also indicates the lifespans of objects relative to those messages.
- Timing diagrams - a specific type of interaction diagram where the focus is on timing constraints.

CHAPTER 4 - DESIGN

4.1. STAGES OF DEVELOPMENT

For the development of the LMS' Database, a set procedure was followed. This procedure (see *Figure 7*) entails requirement analysis, conceptual design, and construction, testing, and evaluation of the database.

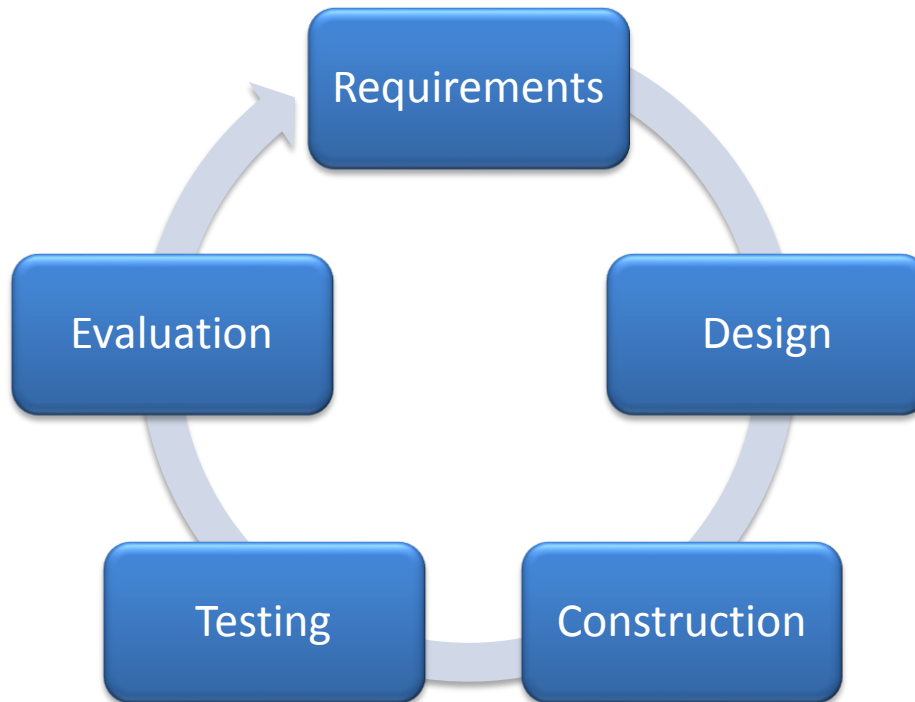


Figure 9: Stages of Development

Before continuing, it's important to note that since the scope of this project (refer to *Section 1.4*) has defined the borders as that of the animal side of the database, the focus has been on the animal side of the database regarding the above-mentioned stages. This means that no work will be performed regarding the management of facilities or the needs of a National Authority.

4.2. PRELIMINARY DESIGN

4.2.1. Requirement Analysis

For requirement analysis, it was decided that IDEF0 be used as the modelling notation. This decision was based purely on the capability of the toolkits available. The toolkit used to draw the IDEF0 diagram is *Edraw 6* (see www.edrawsoft.com for further details regarding this toolkit).

In order to understand the IDEF0 diagram, one must first note its modelling notation (see *Figure 9*). Each side of the function box has a standard meaning in terms of box/arrow relationships. The side of the box with which an arrow interfaces reflects the arrow's role. Arrows entering the left side of the box are inputs. Inputs are transformed or consumed by the function to produce outputs. Arrows entering the box on the top are controls. Controls specify the conditions required for the function to produce correct outputs. Arrows leaving a box on the right side are outputs. Outputs are the data or objects produced by the function. Arrows connected to the bottom side of the box represent mechanisms. Upward pointing arrows identify some of the means that support the execution of the function (National Institute of Standards and Technology, 1993).

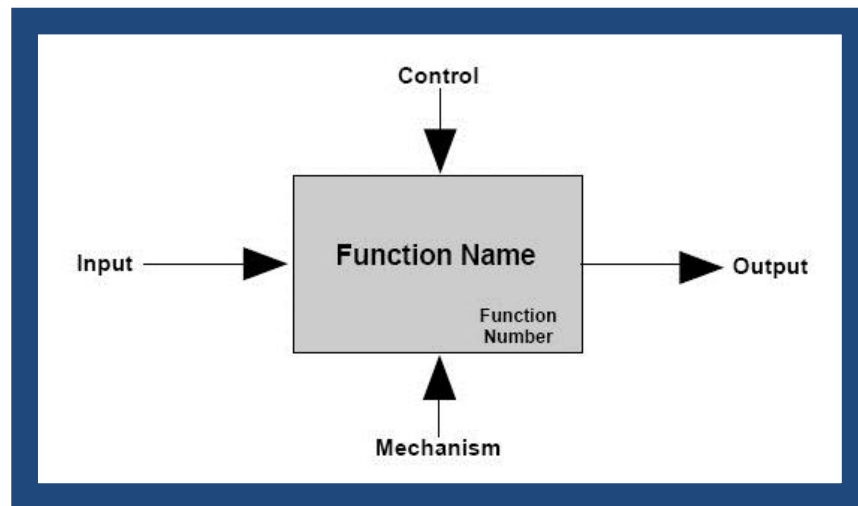


Figure 10: IDEF0 Arrow Positions and Roles

Regarding the IDEF0 diagram for the animal side of the LMS' database (*Figure 11*), the following must be noted:

1. *Node 0-A*, the Top level context diagram, illustrates –
 - a. The systems main function; which is to manage livestock,
 - b. The input and output has respectively been determined as Bovine Information and Traceability,
 - c. The controls are the Bovine's health status, EU Rules & Regulations and the integrity of information received,
 - d. The mechanisms identified are the farmer, the veterinarian and the officials.
2. The controls and mechanisms are repetitive throughout the diagram.

It's also important to note that two more IDEF0 diagrams may be created in parallel to that of *Figure 10*. These diagrams may be used to illustrate the functions of both *Managing Facilities* and *Managing the National Authority*. This is further discussed in *Section 4.4. Future Endeavours*.

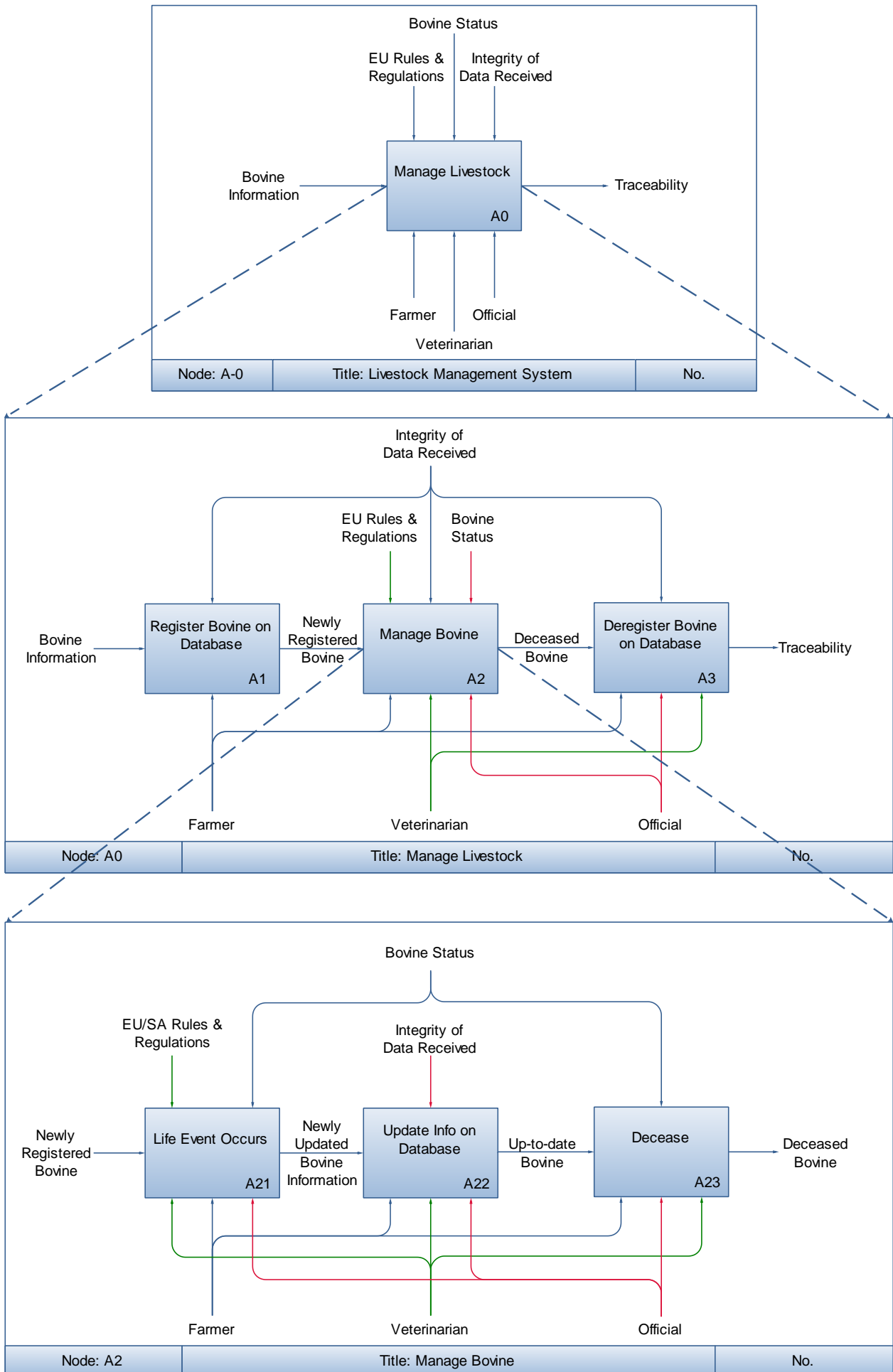


Figure 11: Requirement Analysis using IDEF0

As part of the requirement analysis, a use case diagram (Figure 12) was constructed to graphically depict the system as a collection of use cases, actors/users, and their relationships. This diagram helps in communicating, at a high level, the scope of the business events that must be processed by the system. However, a use case itself is not considered a functional requirement, but the story/scenario the use case tells, consists of one or more requirements.

The following actors and subsystems were identified:

- Actors – Farmer, Veterinarian and the Official, and
- Subsystems – Registration, Bovine, Bovine Trade, Weighing, Disease and Medicine.

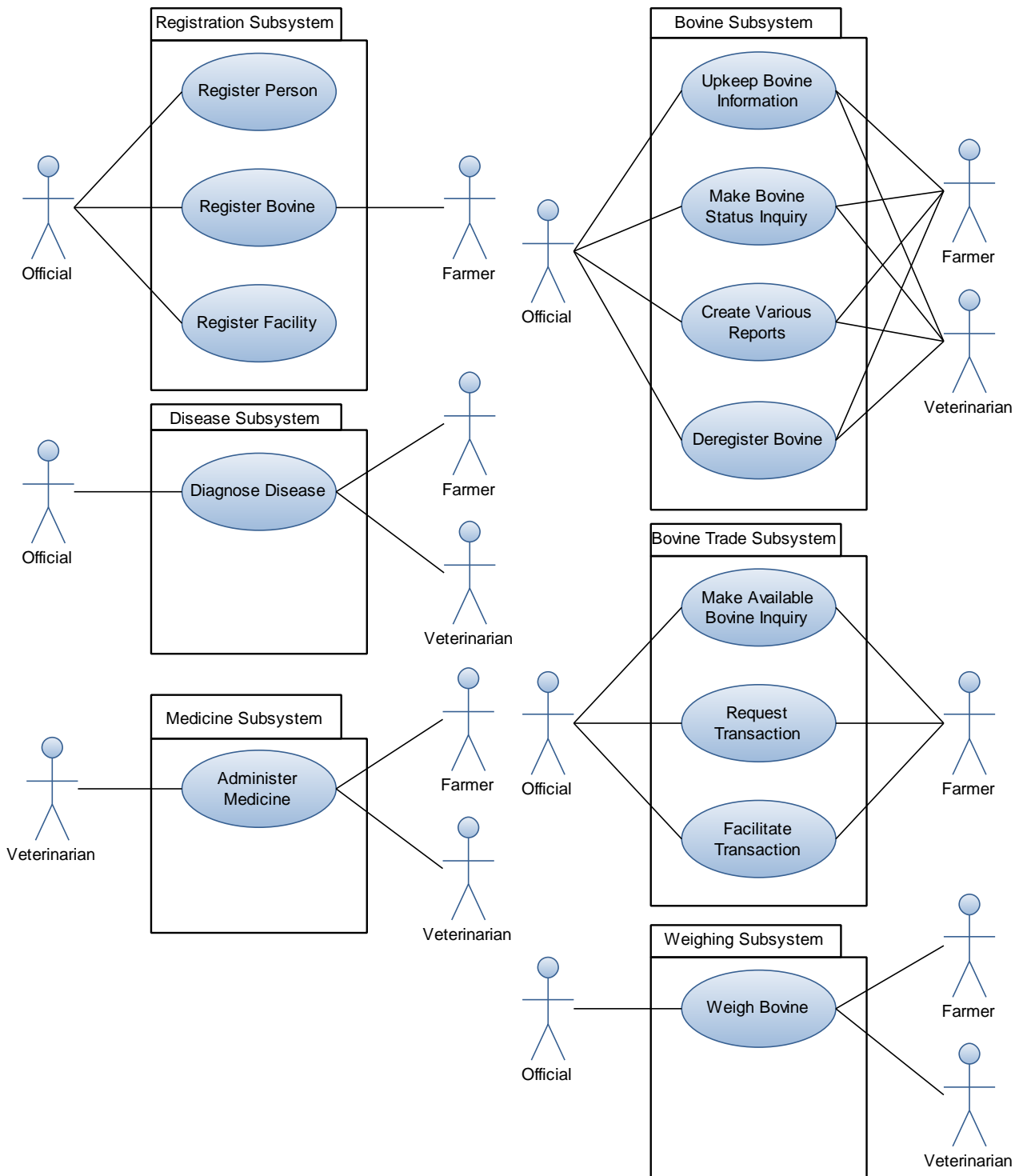


Figure 12: Use Case Diagram of the LMS' Animal Side of the Database

After the Use Case Diagram was created, a Context Data Flow Diagram (CDFD) was also created which depicts the system as a *black box* and illustrates its main interfaces with its environment. The CDFD contains only those data flows that represent the main objective and/or the most important input and outputs of the system. Less common data flows are deferred to the System Diagram which is to be drawn at a later stage (see *Section 4.4. Future Endeavours*).

The CDFD contains only one process: the LMS. External agents are drawn along the perimeter, and data flows define the interactions of the system with its boundaries.

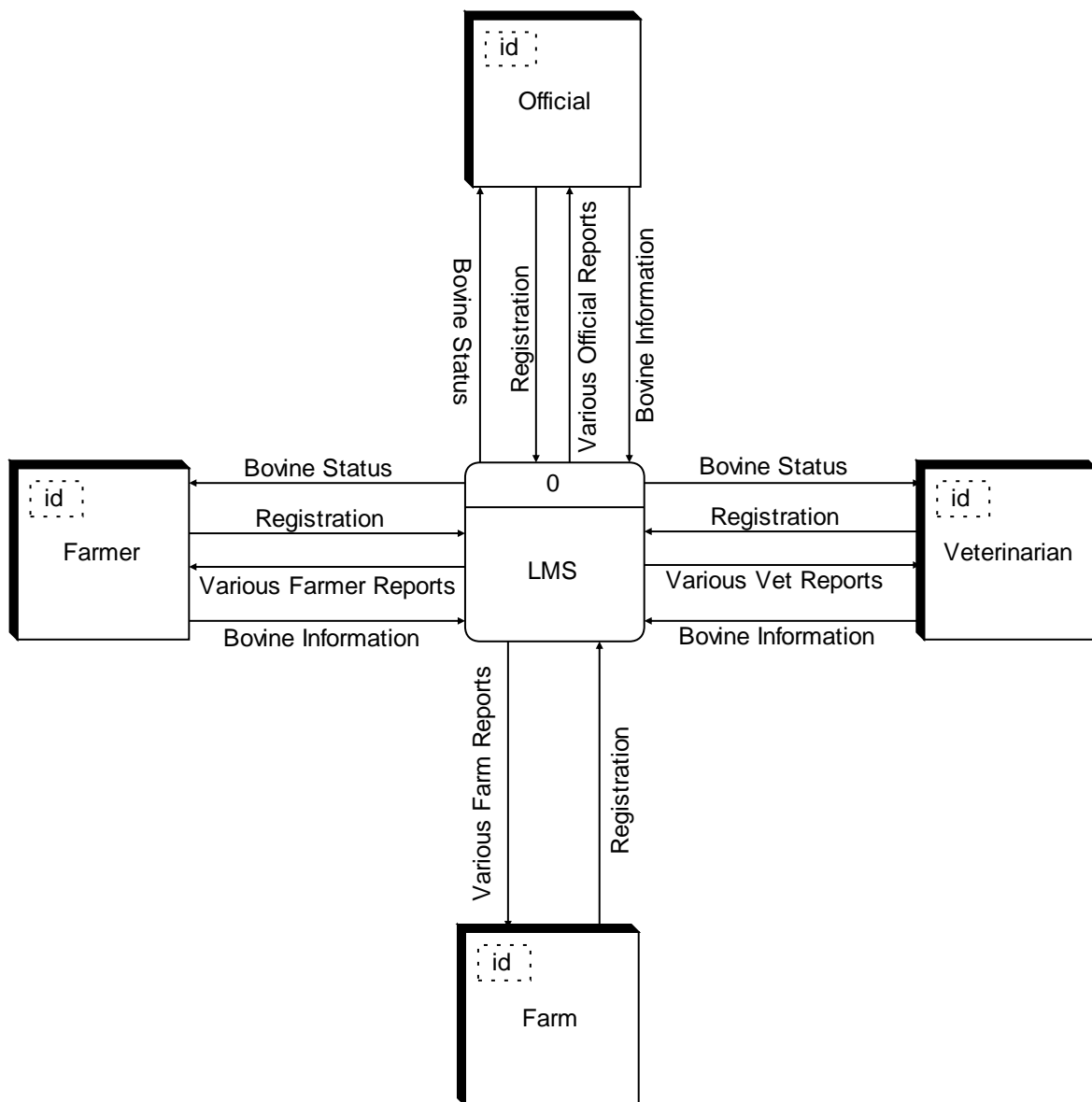


Figure 13: Context Data Flow Diagram of the LMS' Animal Side of the Database

As shown in this CDFD (*Figure 13*), the main purpose of this system is to register the external agents and the bovine they come in contact with, to effectively manage and upkeep the registered bovine's information to maintain traceability, and to report on multiple bovine statistics, including its health status.

4.2.2. ERD

After requirement analysis was performed, an ERD was created to depict the design of the LMS' animal side of the database (Figure 14).

Regarding the ERD, the following may be noted:

1. *Person* is a parent entity, with two child entities; *Farmer* and *Veterinarian*,
2. A *Farmer* may have 1 or more *Farms*,
3. A *Farm* may have –
 - a. 0 or more *Bovine*,
 - b. 0 or more *Bovine Events*,
4. A *Veterinarian* may have 0 or more *Medicines Administered*,
5. A *Bovine* may have –
 - a. 0 or 1 *Sire-* and/or 0 or 1 *Dam Bovine* (a recursive relationship),
 - b. 0 or more *Diseases Per Bovine* (which is an associative entity),
 - c. 0 or more *Medicines Administered Per Bovine* (which is also an associative entity),
 - d. 0 or more *Bovine Transactions*,
 - e. 0 or more *Weights*, and
 - f. 0 or one *Post Mortem*.

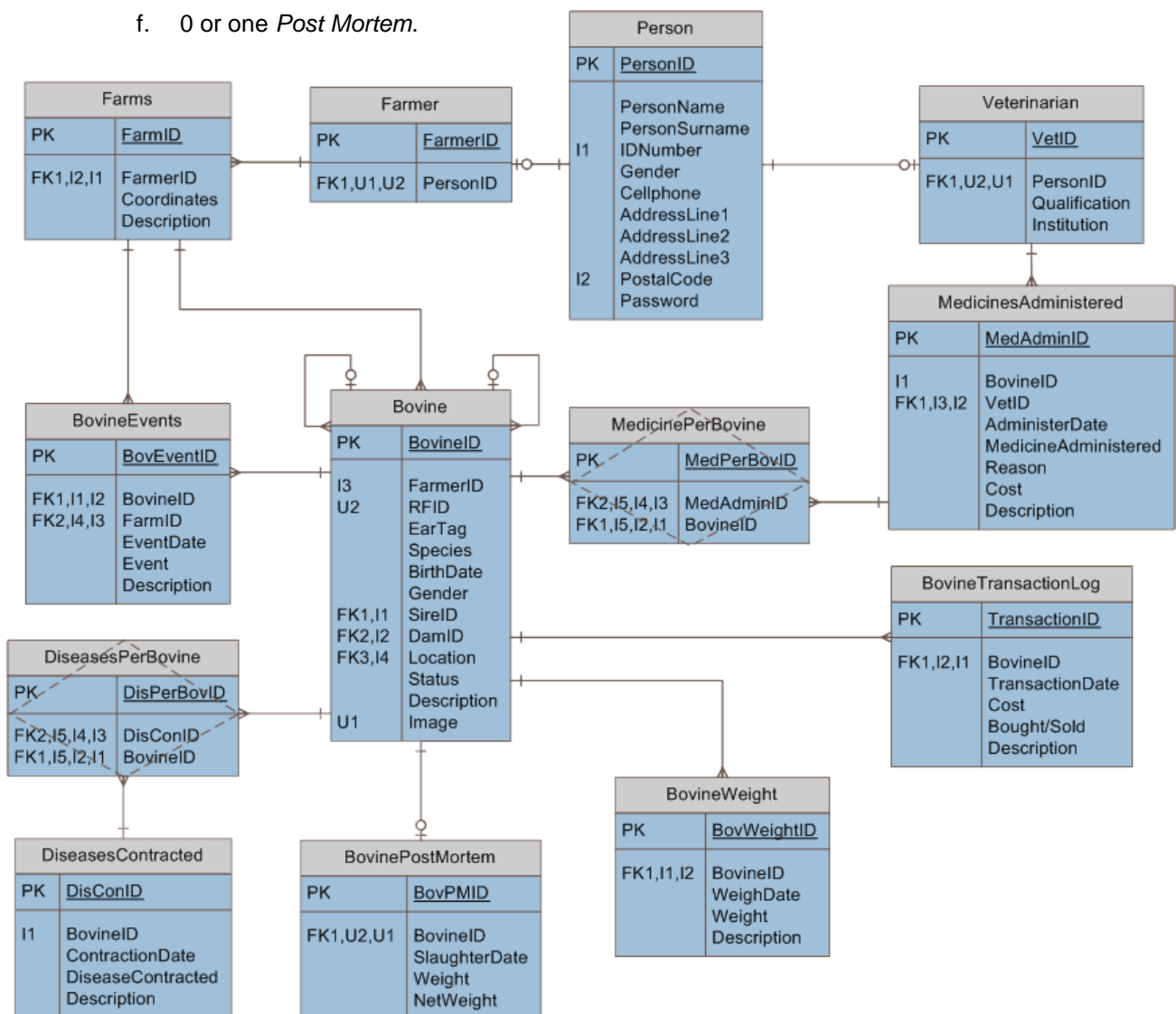


Figure 14: ERD of the LMS' Animal Side of the Database

4.2.3. Database Construction

After completing the design, the ERD was used to construct the LMS' animal side of the database in MS Access. *Figure 15* is a screenshot of the relationships between the tables of the database. In essence, it's a physical representation of the ERD (as shown in *Figure 14*).

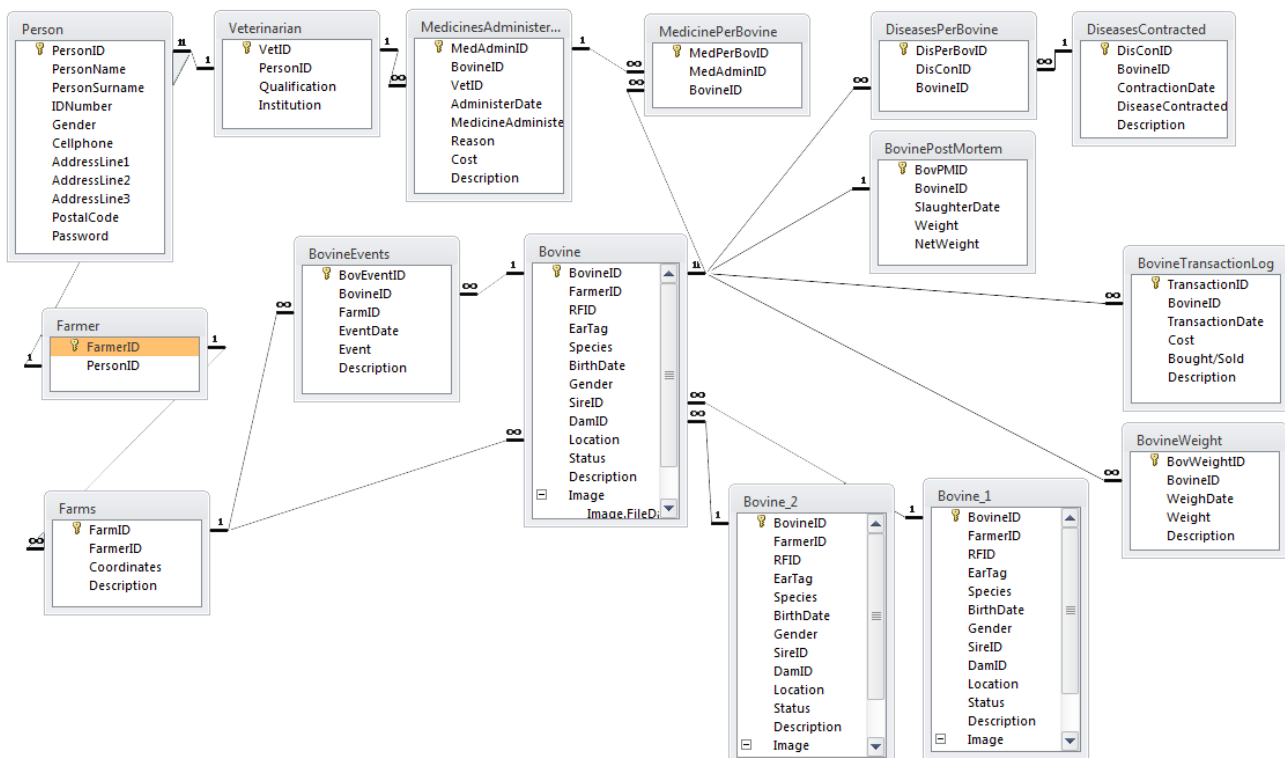


Figure 15: Screenshot of Table Relationships in MS Access

Following construction of the database tables, the following tasks were performed:

- Creation of Forms for user interaction with the database,
- Creation of Queries for –
 - user interaction with the database,
 - Evaluating the database, and
 - Enabling the creation of useful Reports.
- Creation of Reports for –
 - User interaction with the database,
 - Evaluating the database, and
 - Viewing bovine statistics.

Construction was finally completed by the end of September, at which point testing commenced. See *Appendix B* for further information regarding the MS Access database.

4.2.4. Testing

For testing, a valid test-plan was developed. This required listing the database-specific requirements. High level requirements must be broken down in smaller testable requirements.

Test scenarios for each requirement must be created:

1. In order to check the logical database design, it must be determined whether or not each entity in the application (e.g. actors) is represented in the database. However, an application entity may be represented in one or more tables of the database. The database should contain only those tables that are required to represent the application entities - no more.
2. In order to check database constraints, invalid test data sets will be developed and then attempted to insert/update them in the database. An example of an invalid data set is an invalid ID number, or an invalid RFID number.
3. In order to check the database security, tests that mimic unauthorized access will be performed. For example, one may log in to the database as a user with restricted access (as a specific farmer) and check if it is possible to view/modify/delete restricted database objects, or view and/or update restricted data. Also, any confidential data in the database e.g. passwords or ID numbers must be either encrypted or obfuscated (masked).
4. In order to test data integrity, one will design valid test data sets for each application entity. Insert/update a valid test data set (for example, a bovine) and check that the data has been stored in the correct table(s) and in the correct columns. Furthermore, the test data set should be inserted only once and there should not be any other change in the other data.
5. Since the system and test design requires creating SQL queries, one must keep them as simple as possible in order to prevent defects. It is a good idea for someone other than the author to review the queries. Also, one must dynamically test each query. One way to test a query is to modify it so that it just shows the result set and does not perform the actual operation e.g. insert, delete. Another way to test a query is to run it for a couple of iterations and verify the results.

Notes are created throughout the testing process. These notes will support the re-evaluation of the database design. If it is determined that the database has inadequately met its requirements, the project will re-enter the requirement analysis stage – seeing that it's a cyclic process (see *Section 4.1.*).

4.2.5. Evaluation

During the testing of the LMS in MS Access, some errors quickly arose whilst creating queries and reports. The cause of these problems was the associative entities which were created in order to eliminate many-to-many relationships.

These associative entities performed their task so well, that in effect it complicated the creation of queries and reports unnecessarily. The only solution was to remove these entities, re-think and re-design the relationships so that the remaining entities would still have a valid association with one another.

After these design changes were implemented, the creation of queries and reports were completed without any further errors or problems arising.

Furthermore, it was verified that a solution such as this in MS Access would not meet the system's requirements. This was confirmed by, but not limited to, MS Access' inability to accurately graph a Bovine's growth i.t.o. body mass. See *Appendix B* for further information regarding MS Access' limitations.

After verifying that the LMS' design is sufficient to meet its requirements, the ERD (as illustrated in *Figure 16*) was translated into an UML Class Diagram (*Figure 17* below).

This UML depicts the same structure of the ERD, but only in a different modelling notation – one which is object-orientated and of greater value for developing a web-based platform. The UML was created in an open source software package called StarUML (see <http://staruml.sourceforge.net/en/> for further information).

Regarding the UML Class Diagram, the following may be noted:

1. *Person, Bovine, etc.* are all classes –
 - a. Containing multiple attributes with their respective data types,
 - b. Containing respective *Getter & Setter* behaviours:
 - i. *Getter* behaviours read information in a class,
 - ii. *Setter* behaviours write information in a class,
 - c. *Farmer* and *Veterinarian* are generalizations of *Person*:
 - i. *Generalizations* extend their parent class,
 - ii. It creates an 'is-a' association with the parent,
 - d. *Farmer* and *Farms*, for example, forms an aggregation –
 - i. *Aggregations* creates a 'has-a' association with another class (a *Farmer* 'has-a' *Farm*),
 - ii. It also has a *cardinality* (see *Section 3.3.1.2.*) of 1-to-many,

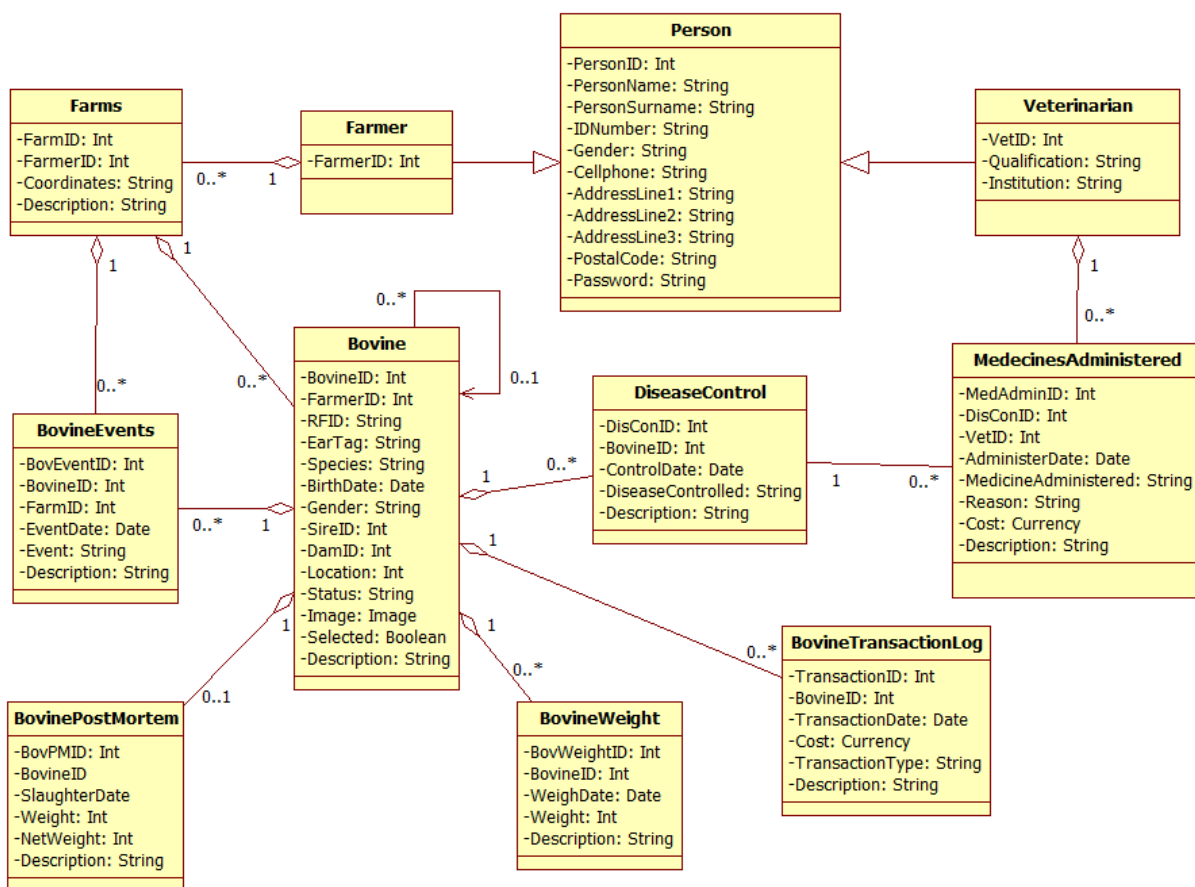


Figure 17: Final UML of the LMS' Animal Side of the Database

4.4. FUTURE ENDEAVOURS

This project has proven the feasibility of an LMS for use in SA. The contribution the LMS will bring to all its stakeholders is becoming ever more impressive. It is clear that such a system will greatly benefit SA's farmers, its farming industry, its economy and the consumers' health and safety.

It is evident that the LMS is a goal worth pursuing.

4.4.1. Short-term

The LMS' design has been tried and tested, and at present it has been deemed sufficient to meet its requirements. Its design has been translated from an ERD (as illustrated in *Figure 16*) into an UML Class Diagram (*Figure 17*), and, in the near future, the LMS will be developed using the proper tools. This entails the following tasks:

- Evaluating the different programming languages available –

- Back end languages include –
 - Java, and
 - PHP.

Both of these software languages may be used free of charge. This is due to the fact that both are licensed under the GNU General Public License. Furthermore, both of these languages integrate seamlessly with HTML and Object Orientated. A great example of a company which makes extensive use of Java is Google.

- Front end languages are limited to –
 - HTML, which is the main mark-up language for displaying web pages and other information in a web browser.

This spectrum is limited due to the decision which was made to make the LMS web based. Seeing that it is to be web based, and that one accesses the web through a web browser, and that a web browser's purpose is to read HTML documents and compose them into visible or audible web pages, it is only logical to develop using this language.

- Employment of a programmer –

A programmer, who is able to program using the above mentioned languages, must be employed to develop the LMS.

- Development of the LMS –

The LMS will initially be developed as a local package - this means that it will only be functional offline. This will simplify the testing of the LMS. Furthermore, communication between an RFID reader and the LMS will need to be established. This communication will need to be direct, in other words, not through an external file which must then be imported into the LMS.

- Implementation of the LMS –

The LMS will then be implemented on an Nguni farm in the Limpopo province. This will be seen as the LMS' trial and testing phase. The use of RFID technologies will also be implemented. The acquisition of these technologies is already underway – RFID readers have already been purchased.

4.4.2. Long-term

After the implementation of the LMS, as stated above in *Section 4.4.1*, private organisations/companies will be approached to enter into a partnership with. A partnership is needed to take initiative in designing a comprehensive LMS for SA. This will include, but is not limited to the following tasks:

- Design of the LMS -
 - The LMS must be expanded to include the management of the National Authority, as well as all approved facilities –
 - Requirement analysis will need to be performed, and
 - Design of the LMS using UML.
- Development of the LMS –
 - The LMS must be expanded to feature the above mentioned functionality,
 - A Domain Name must be registered, and
 - The LMS must be hosted on the newly registered domain.
- Drafting of preliminary residue monitoring programmes -
 - Arrangements with local (or foreign) laboratories must be made, and
 - The laboratories used in official control must conform to international standards.
- Determining of suitable processing establishments -
 - Establishments must conform to the standards as prescribed by the EU, and
 - Establishments must make use of an HACCP based control system.
- Establishing of a National Authority -
 - A National Authority dedicated to the implementation, management and control of the LMS must be created, and
 - The authority must be granted legal authority by means of government legislation –
 - SA government must draft and pass legislation granting the competent authority the authorization it requires.
- EC approval and accreditation -
 - Finally, after the above mentioned tasks have been completed, an application for approval must be submitted to the EU.

After the above tasks have been performed and the LMS has been approved by the EC, SA may start the nationwide implementation of the LMS and eventually, SA may export its meat and meat products to the EU.

APPENDIX A: LEGISLATION

1. COUNTRY ACCREDITATION REQUIREMENTS

1.1. Animal Health Situation

According to the EC (2006), the third country must be a member of the World Organization for Animal Health (OIE). This means that the third country must have certain systems in place for the rapid detection, confirmation and reporting of all OIE listed diseases. Also, the notification of the EC of any and all outbreaks of serious diseases, within 24 hours of confirmation, or any change in the vaccination policy concerning such diseases, will have to be guaranteed. To allow for the detection and confirmation (of listed diseases) to take place, the third country must either have its own laboratory facilities, or have formal arrangements in place with worthy laboratories in other countries. As of 1 January 2010, laboratories involved in official controls must be recognized in terms of international standards.

The type of animal or product concerned determines (to some extent) how the animal disease situation will affect whether approval can be considered, or what conditions are linked to the approval. For example: imports of live domestic ungulate animals are not authorized from countries which vaccinate against foot and mouth disease (FMD), or where the disease may be present. Whilst, for fully treated products, this would be of no concern, seeing that the contributing pathogen is eliminated by appropriate treatments or by other risk mitigating factors.

Animal disease control systems, of which the operation and results must be recorded and demonstrable, must be in place (European Commission, 2006). These would have to include, for example, animal identification, the registration of holdings and movement controls (a.k.a. traceability) so that conformance to the EU requirements can be confirmed.

Contingency plans for the control and/or eradication of outbreaks of certain OIE listed diseases should be in place and operational. The type of animals/products for which approval is sought will determine the nature and extent of these plans.

Without compromising the safety of the import, flexibility is shown wherever possible. The following example regarding the outbreak of a highly infectious animal disease (like FMD) explains this principle - whilst imports under unsafe conditions cannot be accepted, but may still be feasible, the principle of regionalization is applied. Regionalization implies that imports of animal-origin can be allowed from those defined regions of countries, which satisfy the requirements, whilst suspending imports from other regions which do not. In other words: if an outbreak of an animal disease, restrictions are applied to the affected regions, whilst free movement of animals and products outside these affected regions may still be allowed. This means that only animals/products from unaffected areas may be thought fit for export. The EU is confident that regionalization is the best approach to maintain tolerable disease control with minimum restrictions to trade.

Furthermore, as it is allowed to move animals from their country of birth to a third country (given that it's listed) with a view of subsequent movement to the EU, the possibility of importing certain live animals from non-authorized countries arises. The minimum residency period in the authorized third country is six months. It may also be noted that St. Pierre and Miquelon is a listed third country in which the situation is ideal for this kind of import. Also, a quarantine station (where certain types of animals can remain under the satisfactory control of the official veterinary services within the facilities) which effectively decreases the residency period to as little as two months is available.

1.2. Residues, Contaminants and Additives Controls

The EU (European Commission, 2012) has detailed legislation in place to control and monitor the use of a wide variety of veterinary drugs (and other substances) for all classes of animals/products intended for human consumption. The third country must have legal control over prohibited substances (regarding the animals/products intended for export).

All third countries must have a monitoring program, which meets the requirements in respect of the animals/products concerned, in place for these substances. This program must be submitted to the EC for evaluation and ultimately approval.

Subsequently, the results of each year's program, together with an updated program for the coming year, must be submitted to the EC on an annual basis (European Commission, 2006).

It may be acceptable that the monitoring program be limited to specific areas and individual holdings. However, such a separated export-oriented system would require that effective tracing, control, registration and identification procedures, and that a transparent, reliable, monitoring system be implemented. This system, and its procedures, would be subject to special evaluation, which will form part of the approval process.

1.3. Processing Establishments

The standards of individual establishments proposed for approval must be at least equivalent to the requirements of EU legislation, which are the same as those for establishments in Member States.

Before an establishment is put forward to the EC for approval, the national authority should be confident that the standards of are met. Should this not to be the case at any subsequent on-the-spot review, it will reflect poorly on the evaluation of the authority's ability to deliver EU standards.

Particular attention must be paid to the installation and operation of permanent procedures of the establishment based on the Hazard Analysis and Critical Control Points (HACCP) principles, microbiological controls and an effective official control system, including documented records of control actions and their outcome. As of 1 January 2006, the implementation of a HACCP based control system is mandatory in all food production, processing and distribution establishments.

To avoid fraud and any conflict of interests, officials in processing establishments must be able to act independently of operators, which mean that there must be supervisory systems over these officials at regional and central levels.

As a general rule, processing establishments must conform to EU standards during an EU production run, and may conform to other standards at other times for their own national markets, but such products must be kept separate from products destined for the EU.

1.4. National Authority

It's necessary that the national authority (also referred to as the "competent authority") is able to deliver the level of veterinary controls required. Any shortfall would mean that an existing approval might be repealed, or that an approval may not be considered. As part of the approval process, a detailed questionnaire, relating to the sector for which approval is sought, is sent to the national authority. The following, amongst the various issues raised, are of particular importance in assessing the authority's performance:

1. *Management structure.* Satisfactory communication links between local, regional and central official services must be established. The central authorities, who are accountable for standards, must be able to exert control over the other services.
2. *Independence.* Official services must be autonomous, and be able to perform their duties without unwarranted restrictions. Officials must enjoy a status, which ensures their independence from commercial concerns, but not be dependent upon them for their livelihood.
3. *Resources.* All official services (including laboratories and border controls) must have ample resources; financial, personnel and equipment to allow them perform their control functions.
4. *Personnel.* All staff must enjoy an independent status within the official services. If external staff is used, they must be assured the same level of independence and accountability as full-time officials.
5. *Recruitment and training.* The national authority must be able to show that vacancies are promptly filled, and that operations of official services are not damaged by shortages of qualified personnel. A training program, so that staff can perform their duties properly, should be in place, and properly recorded.
6. *Legal/enforcement powers.* These powers must be enshrined in national legislation and allow these services to carry out their control functions in an effective manner.
7. *Prioritization and documentation of controls.* Official services should have written systems in place to prioritize their control activities and reflect the risks that may be posed by the different stages of the production chain. The planning, performance and outcome of these controls at local, regional and central levels should be noted so that conformance to EU standards may be illustrated. Also, internal audit systems should be established in order to monitor the operation of these controls.
8. *Laboratory services.* There should be a properly resourced laboratory network which includes a central reference laboratory, enjoys an independent status, and covers the entire country. However, it is acceptable to use laboratory facilities in other countries, given these can be shown to offer an equivalent level of service. The duties of the laboratory network, including reporting procedures, should non-compliant results be detected, should be clearly established.
9. *Import controls.* The import policy of the third country will be evaluated to ensure that the health status of the country is not jeopardized. Effective import controls must be in place at all points of entry to the third country to help safeguard the health status of the country. Also, these points must be properly resourced, staffed, and granted the necessary authorization to take control and enforce action. In particular, the reception, handling, storage and onward transmission of animals/products intended for dispatch to the EU, or for use in the production of EU-status products, must meet EU requirements and avoid risk of cross-contamination by non-eligible animals/products.
10. *Animal health controls.* An effective system, for the detection and notification of animal diseases (as listed by the OIE) relevant to the animals/products for export, must be established. This should include, but is not limited to, farm registration, surveillance measures, movement controls and animal identification, so that the eligibility of animals used in the manufacture of EU status products can be demonstrated (a.k.a. traceability). It may also be required that a disease monitoring, control and/or

eradication program be in place. The prompt notification of the confirmation of detected diseases must also be demonstrated.

11. *Food safety controls*. National legislation, and the control action thereof, addressing the particulars of zoonosis (animal diseases that can be transmitted to humans), should be provided. Procedures for the co-ordination of animal and public health authorities should be in place. Systems should be established to record the actions taken, and their outcome, for when zoonotic pathogens are identified. Traceability must be assured throughout the whole production process of food of animal origin.

2. COUNTRY APPROVAL PROCEDURE

The following sequence (European Commission, 2009) is normally followed (although it may vary according to the type of animal/product concerned):

1. The competent authority (of the country seeking approval) presents a formal request for approval to the EC services. This should include the following information:
 - a. The type of animal/product for which approval is sought,
 - b. The expected volume of trade and targeted Member States;
 - c. The class of animals (e.g. slaughter, fattening, breeding) involved;
 - d. An description of minimum treatment which may be applied to the products;
 - e. The total and type of establishments considered to meet EU requirements
 - The national authorities must also confirm that all of the proposed establishments satisfy EU requirements. In other words, the authorities must assure that the relevant hygiene and public health requirements are met, whilst referencing appropriate EU legislation. The hygiene legislation specifies requirements on the structure of establishments, equipment and operational processes for slaughter, cutting, storage and handling of meat. These provisions are aimed at preventing any contamination of the product during processing.
2. The EC then recognizes the request, and sends the relevant pre-mission questionnaire.
 - This pre-mission questionnaire may be viewed at EC (2009) pg. 33-50.
3. The completed questionnaire, with the proposed residues monitoring program attached, must be submitted by the national authority for approval. Copies of the national legislation relevant to the animals/products in question must also be attached (to speed up the processing of dossiers, English or French translations may be provided).
 - A monitoring system must be in place to verify compliance with EU requirements on residues of veterinary medicines, pesticides and contaminants.
4. The national authorities and the EC resolve outstanding issues by bilateral contacts.
5. If the information provided is satisfactory for the EC, an on-the-spot review is organized by the Food and Veterinary Office (FVO).
 - An inspection by the EC's FVO is essential to affirm compliancy to the above requirements. Confidence between the EC and the competent authority of the exporting country is established by means of such an inspection mission.
6. A copy of the FVO's report is sent to the national authorities, the relevant EC services, the European Parliament and the Member States following completion of its inspection.
7. If the mission's outcome is satisfactory, and all unresolved matters have been settled, the EC prepares draft legislation to:

- a. Append the list of third countries from which imports of the animal/product are approved,
 - b. If necessary, compose animal health certification based on the country or part of the country's health situation to accompany imports, (numerous models of health certificates are already included in Union legislation),
 - c. Approve the residues monitoring program, and
 - d. Set up an initial list of approved establishments.
- However, it must be mentioned that:
- the approval of residue programs,
 - the adding a country on a list for animal health purposes,
 - the requirements for public health purposes, and
 - the listing of the approved establishments,

Are performed by multiple EC services under various legal acts. The inclusion in one of them is not a condition for the inclusion on another. In other words, the inclusion on the residue list does not affect the possible inclusion on the animal health list. This means that the third country can launch its applications for approvals as it sees fit. However, it is recommended to start with the animal health listing, since this may be the most difficult to comply with, and that it may be costly to build a abattoir, only to discover that the export of meat cannot be authorized due to animal health reasons.

8. After a favorable opinion on the Food Chain and Animal Health has been received, the proposed legislative texts are adopted by the EC, and published in the Official Journal.
9. If the effectuation date is not specified in legislation, effectively it will be the date of official notice of the text by the EC to Member States.

3. IMPORT REQUIREMENTS

After the third country is approved by the EC, it may export its products of animal origin to the EU, but, for these products to be permitted to enter the EU, the following requirements and obligations, as determined by the rules and regulations stated in legislation (Appendix A), must be met by the various bodies involved (European Commission, 2006):

3.1. Food Hygiene Requirements

Obligations of food business operators in third countries

The relevant requirements with regard to the hygiene of food of animal origin are contained in:

- Articles 3 to 6 of Regulation (EC) No 852/2004, which means that the following rules need to be respected by food business operators in third countries:
 - A general obligation on the operator to monitor the food safety of products and processes under his responsibility (Article 3),
 - General hygiene provisions for primary production (Article 4.1 of, and Part A of Annex I to, Regulation (EC) No 852/2004),
 - Detailed requirements after primary production (Article 4.2 of and Annex II to Regulation (EC) No 852/2004),
 - For certain products, microbiological requirements (Article 4.3 of Regulation (EC) No 852/2004) and Commission Regulation (EC) No 2073/2005),
 - Procedures based on the HACCP principles (Article 5 of Regulation (EC) No 852/2004) ,
 - Registration of establishments (Article 6 of Regulation (EC) No 852/2004). The approval of establishments is in principle necessary only for foods of animal origin.
- The requirements appropriate for the products that are exported are contained in Regulation (EC) No 853/2004.

Obligations of competent authorities in third countries

EU food law requires that, for products of animal origin, the competent authority of the third country extends guarantees as to the conformity or equivalence with EU requirements. The competent authorities in the third country shall ensure that:

- Their control services comply with the operational criteria laid down in EC law, in particular in Regulation (EC) No 882/2004,
- The establishments that are authorized to export to the EU comply and continue to comply with the EC requirements and that the list of such establishments is kept up-to-date and communicated to the Commission (Article 12, paragraph 2 of Regulation (EC) No 854/2004),
- The certification requirements are satisfied. Detailed rules with regard to certification are laid down in Council Directive 96/93/EC on the certification of animals and animal products. Further details are laid down in Annex VI to Regulation (EC) No 854/2004 (e.g. that the certificate must be issued before the consignment to which it relates leaves the control of the competent authority or the third country of dispatch).

Obligations of importers (Article 6 of Regulation (EC) No 853/2004)

Food business operators importing products of animal origin must ensure that the products:

- Come from a third country or a part of a third country that appears on a EC list,
- Where applicable, come from an establishment that appears on a list,
- Where applicable, carry a health or identification mark,
- Where applicable, are accompanied by a certificate issued by the representative of the competent authority of the third country,
- Are made available for control in a border inspection post,
- Comply with the animal health requirements of Directive 2002/99/EC,
- Operations carried out under their control that take place after importation is carried out in accordance with the appropriate requirements of Regulation (EC) No 853/2004.

3.2. Animal Health Requirements

Food of animal origin from third countries must comply with requirements that prevent the introduction of animal diseases into the EU. These requirements, derived from Directive 2002/99/EC, lays down the animal health rules governing the production, processing, distribution and introduction of products of animal origin for human consumption.

3.3. Other Health Requirements

Under EU food law, a number of requirements may apply in complement or in addition to food hygiene. These include requirements concerning:

- Contaminants, residues, additives and radioactivity,
- The use of substances having a hormonal effect, and
- Materials and articles in contact with foodstuffs.

4. IMPORT PROCEDURES

According to Directive 97/78/EC:

- Products of animal origin must be presented at a Community border inspection post,
- Prior notice of the arrival of the products in the border inspection post must be given in accordance with National rules of the Member State in which the border inspection post is situated.
- The consignments must be presented to the border inspection post accompanied by all the relevant certificates required in EU veterinary legislation
- Consignments will only be accepted if the products are derived from approved countries , regions and establishments as appropriate
- In certain cases, safeguard measures introducing special import conditions or restrictions may apply.
- The procedures as laid down in EC Regulation (EC) No 136/2004 are to be followed.

5. LEGISLATIVE DOCUMENTS

The following legislative documents (European Commission, 2006) state the rules and regulations regarding food law, food safety and the hygiene of foodstuffs:

- Regulation (EC) No 178/2002 of the European Parliament and of the Council laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety (also referred to as the General Food Law),
- Regulation (EC) No 852/2004 of the European Parliament and of the Council of 29 April on the hygiene of foodstuffs,
- Regulation (EC) No 853/2004 of the European Parliament and of the Council of 29 April laying down specific hygiene rules for food of animal origin,
- Regulation (EC) No 854/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific rules for the organization of official controls on products of animal origin intended for human consumption (Official Journal L 226 of 25 June 2004, p. 83), and
- Regulation (EC) No 882/2004 of the European Parliament and of the Council of 29 April 2004 on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare.
- Council Directive 97/78/EC of 18 December 1997 laying down the principles governing the organization of veterinary checks on products entering the EU from third countries,
- Commission Regulation (EC) No 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs,
- Commission Regulation (EC) No 2074/2005 of 5 December 2005 laying down implementing measures for certain products under Regulation (EC) No 853/2004 and for the organization of official controls under Regulations (EC) No 854/2004 and No 882/2004, derogating from Regulation (EC) No 852/2004 and amending Regulations (EC) No 853/2004 and No 854/2004, and
- Commission Regulation (EC) No 2076/2005 of 5 December 2005 laying down transitional measures for the implementation of Regulations (EC) No 853/2004, (EC) No 854/2004 and (EC) No 882/2004 of the European Parliament and the Council and amending Regulations (EC) No 853/2004 and (EC) No 854/2004.

APPENDIX B: LMS SCREENSHOTS

1. INTRODUCTION

The following screenshots only depict the most important functions of the LMS. Other functions such as basic administration (which might include maintaining person information) are thus not included.

2. FORMS

The *Manage Single Bovine Details* (Figure 18) and the *Manage Multiple Bovine Details* (Figure 19) forms are the main access points for viewing and/or managing of a single or multiple bovine's details. These forms also provide portals to other forms which are used for the addition of certain records into the database, as well as certain reports for statistical purposes.

Manage Single Bovine Details

FarmerID:

RFID:

EarTag:

Species:

BirthDate:

Gender:

Location:

Status:

Description:

SireID:

DamID:

Navigation:

Buttons:

Footer:

Figure 18: Manage Single Bovine Form

On the *Manage Multiple Bovine Details* (Figure 19) form, the user is able to manage a select few record at once by ticking the *check box* at the far left hand side of the form, or one may choose to apply the same changes to all of the bovine simultaneously by ticking the upper most *check box*.

One may notice that this form does not have the same portals as the *Manage Single Bovine Details* (Figure 18) form. This is due to the fact that certain aspects must be performed on a single record at a time. Furthermore, this too is one of MS Access' limitations.

FarmerID	RFID	EarTag	Species	BirthDate	Gender	SireID	DamID	Status	Location
Johan Fischer, 9010055368089		10307	Nguni	10/1/2010	Female	0818	10307	Heifer	2 -24.141584,27.93357
Johan Fischer, 9010055368089		10166B	Pinzzyl	10/1/2010	Female	0818	10307	Heifer	2 -24.141584,27.93357
Johan Fischer, 9010055368089		10145B	Pinzzyl	10/1/2010	Female	0818	10307	Heifer	2 -24.141584,27.93357
Johan Fischer, 9010055368089		10135B	Pinzzyl	10/1/2010	Female	0818	10307	Heifer	2 -24.141584,27.93357
Johan Fischer, 9010055368089		N3D098	Nguni	10/1/2009	Female	0818	10307	Cow	2 -24.141584,27.93357
Johan Fischer, 9010055368089		1093	Nguni	10/1/2010	Female	0818	10307	Heifer	2 -24.141584,27.93357
Johan Fischer, 9010055368089		07748	Nguni	10/1/2007	Female	0818	10307	Cow	2 -24.141584,27.93357
Johan Fischer, 9010055368089		0924	Nguni	10/1/2009	Female	0818	10307	Cow	2 -24.141584,27.93357
Johan Fischer, 9010055368089		08270	Nguni	10/1/2008	Female	0818	10307	Cow	2 -24.141584,27.93357
Johan Fischer, 9010055368089		10154B	Pinzzyl	10/1/2010	Female	0818	10307	Heifer	2 -24.141584,27.93357
Johan Fischer, 9010055368089		10147B	Pinzzyl	10/1/2010	Female	0818	10307	Heifer	2 -24.141584,27.93357

Figure 19: Manage Multiple Bovine Form

The *Manage Bovine Diseases* (Figure 20) form is used to apply the same disease control measures to multiple bovine, or if the user wishes, to only a single bovine by accessing this form via the *Manage Single Bovine Details* form instead of through the *Manage Multiple Bovine Details* form. This form is not only used for the diagnosis of diseases, but also for the defining of inoculations to be administered.

Figure 20: Manage Bovine Diseases Form

The *Manage Bovine Medicines* (Figure 21) form is used to apply the administration of medicines to a single bovine only. This form is only accessible via the *Manage Single Bovine Details* form. This is due to the fact that a medicine must be administered to a single disease control measure. This is necessary to prevent to unnecessary administration of medicines, hormones, etc. One may also note that a *VeterinarianID* is required. This is only a precautionary measure which is only applicable to certain medicines which the farmer should not be able to administer by himself, nor have commercial access to.

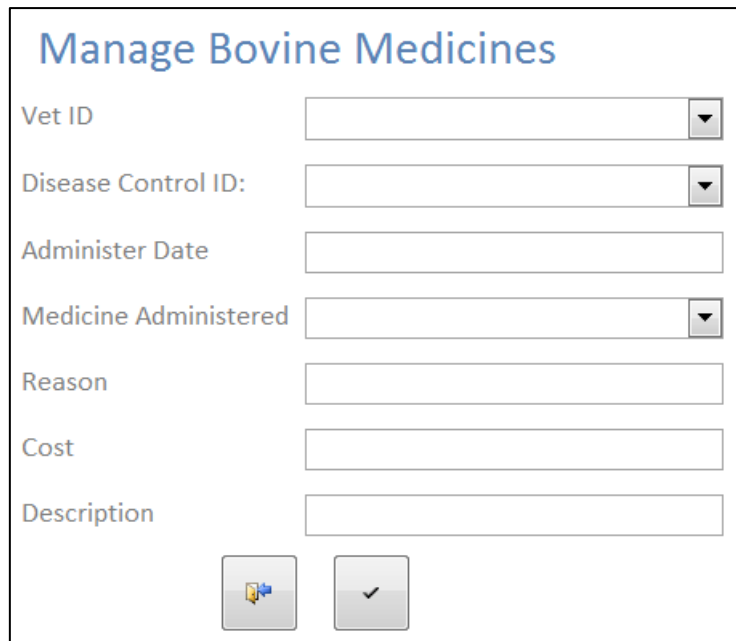


Figure 21: Manage Bovine Medicines Form

The *Manage Bovine Weight* (Figure 22) form is used to apply the weighing of the animal to a single bovine only. This form is only accessible via the *Manage Single Bovine Details* form.

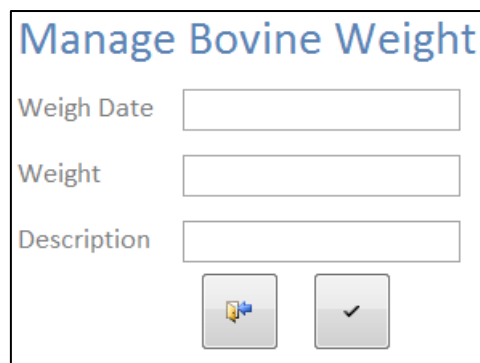


Figure 22: Manage Bovine Weight Form


3. REPORTS

The *Bovine Family Tree* (Figure 23) report is relatively self-explanatory. This report displays the details of the selected bovine (latest generation), and provides links to display its *Sire* and *Dam* details. The reason for this approach is another of MS Access' limitations. It is unable to correctly display three consecutively different, but associated with one another, records from the same table.

Further additions to this report may include displaying the *Sire* and *Dam's* other offspring respectively.

Bovine Family Tree


Farmer **Johan Fischer - 9010055368089**

EarTag	BirthDate	Species	SireID	DamID	Image
<u>Latest Generation:</u>					
38	7/12/2012	Nguni	38	83	

Sire Details

Dam Details

Sunday, October 14, 2012
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Farmer **Johan Fischer - 9010055368089**

EarTag	BirthDate	Species	SireID	DamID	Image
<u>Sire:</u>					
0818	10/1/2008	Nguni			

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Farmer **Johan Fischer - 9010055368089**

EarTag	BirthDate	Species	SireID	DamID	Image
<u>Dam:</u>					
0002		Nguni			

Sunday, October 14, 2012
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Figure 23: Bovine Family Tree Report

The *Bovine Medical History* (Figure 24) report is used to display a single bovine's, or multiple bovines, medical history. This includes its disease control history, as well as its medicinal history. Through this report one is able to determine whether or not more than one medicine was administered to a single disease control measure.

Medical History							
Disease Control				Medicines Administered			
EarTag: 10307							
Control Date	Disease Controlled	Description	Administer Date	Medicine Administered	Reason	Cost	Medicine Description
10/5/2012	Rumen Acidosis		10/5/2012	Acepromazine		R 30.00	
10/5/2012	Rumen Acidosis		10/5/2012	Ibuprofen		R 25.00	
10/10/2011	Bluetongue		10/10/2011	Dipyrene		R 150.00	
10/5/2011	Fatty Liver		10/5/2011	Benzocaine		R 100.00	
EarTag: 10166B							
Control Date	Disease Controlled	Description	Administer Date	Medicine Administered	Reason	Cost	Medicine Description
10/5/2011	Blackleg		10/5/2011	Amikacin		R 55.00	
Sunday, October 14, 2012							
Page 1 of 1							

Figure 24: Bovine Medical History Report

The *Bovine Weight* (Figure 25) report is used to display a single bovine's, or multiple bovines, weighing history. The report also displays the bovine's minimum weight, its calculated average weight, and its maximum weight. This may be used to determine the bovine's growth. Furthermore, it's important to note that MS Access is not able to accurately graph the bovine's growth – yet another limitation.

Bovine Weight				
Ear Tag	Weight ID	WeighDate	Weight	Description
10307				
	11	10/20/2012	340	
	7	10/10/2012	333	
	4	10/10/2011	315	
	1	10/10/2010	290	
Minimum:	290	Average:	319.5	Maximum: 340
10166B				
	8	10/10/2012	365	
	5	10/10/2011	335	
	2	10/10/2010	310	
Minimum:	310	Average:	336.67	Maximum: 365
10145B				
	9	10/10/2012	375	
	6	10/10/2011	340	
	3	10/10/2010	300	
Minimum:	300	Average:	338.33	Maximum: 375
38				
	10	10/20/2012	350	
Minimum:	350	Average:	350	Maximum: 350
Sunday, October 14, 2012				
Page 1 of 1				

Figure 25: Bovine Weight Report

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