Scuola di Dottorato in Scienze Veterinarie per la Salute Animale e la Sicurezza Alimentare

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Electronic traceability systems in animal husbandry: from field survey to computerized management

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VSA Veterinario per la Sicurezza Alimentare

CHAPTER 1

Foreword

1. Foreword

The Italian agricultural sector is a strategic component for our country. It is the second in importance after the engineering and produce more than 100 billion euros.

It involves:

- approximately 67.000 food and beverages enterprises;
- more than 2 million farms, mostly medium and small dimensions (only about 500.000 farms, however, are true enterprises);
- a total of more than 1.000.000 workers (400.000 in the industry sector).

But it was not always so.
In the first post-war economic dimensions of the agricultural sector were much lower because most of food production were used for own consumption. It's enough to observe that the personnel employed in the sector fell from 8 to 1 million over the last 65 years (Table 1.1).

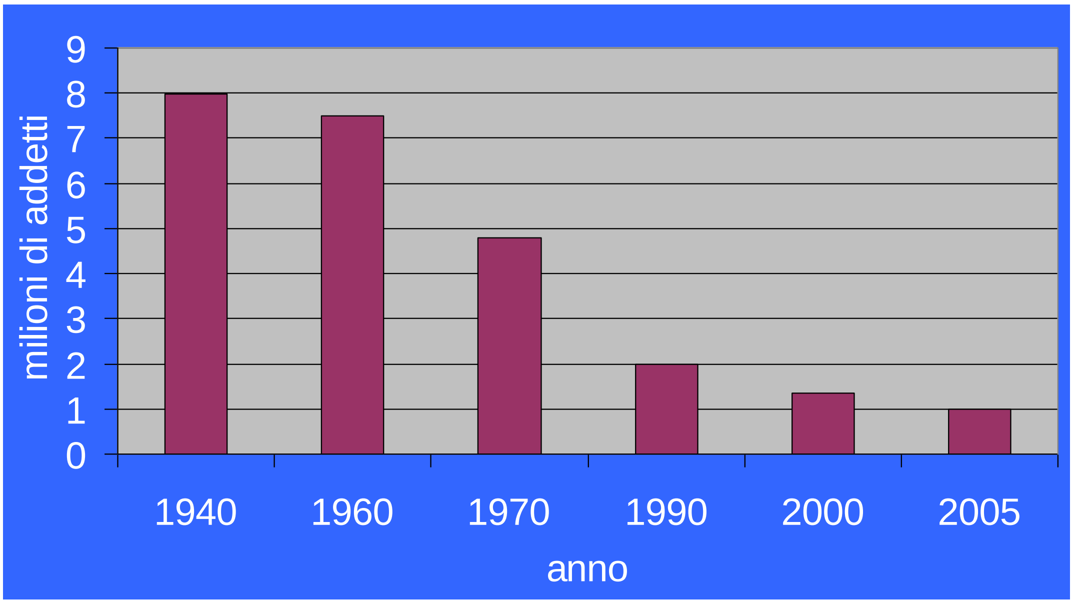


Table 1.1 - Trend of workers in the food industry from 1940 to 2005.

This detachment between producers and consumers has led over time to make important in the food production not only chemical, physical and nutritional aspects, components that were basically the only important at the time of agricultural personal consumption, but also those related to food safety and quality perceived by consumers.

To focus attention on animal husbandry products, particularly interesting in this context is the evolution of the "beef" product that, because of the well-known problems related to BSE crisis, has become the food prototype that at the level of European law, worked as a "test case" for implementing the regulations that currently affect the food safety and food quality (Figure 1.1).

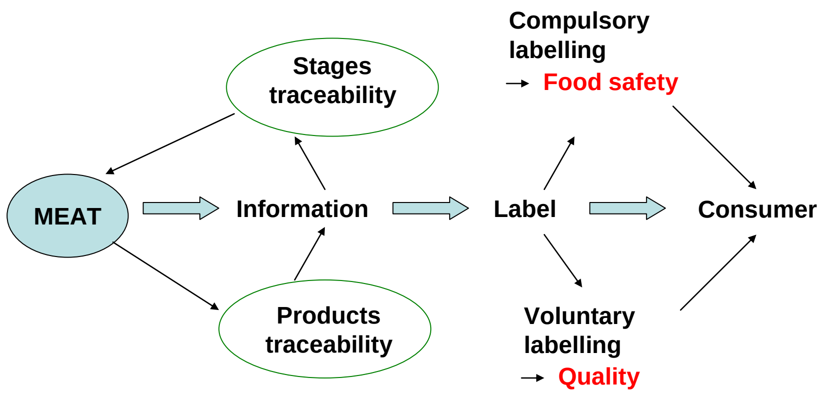


Figure 1.1 - Traceability and labelling for meat products.

So, for the food security aspect, EC Regulations 178/2002, Art. 18 introduced a regulatory framework that makes mandatory:

- products traceability: the possibility of tracing the path of a production process through all its stages: from raw materials to the finished product (in the case of beef from the feed to the meat portion in the market). The producers are directly responsible for its implementation.

- traceability of food, feed, animals in all stages of production, processing and distribution: it is the tool that allows to trace back the production process, from upstream to downstream, from the finished product to the origin of raw materials (from meat on the table to the farm).

You can not retrace the path of the product unless it has been traced.

In any case, the supply chain concept becomes of primary importance and communication between the different actors of the same can only be based on a producing process of a coherent and consistent documentation considering the aims of the system, documentation becoming itself an integral factor of the production process.

Extending the framework of this discussion, there are additional areas that are not directly related to the production process, as they don't constitute the basis for the practical implementation of the product, requiring additional documentation for traceability. Considering, for example, what is necessary, also in animal husbandry, in terms of documentation for compliance with environmental regulations. This refers, for example, to recent legislation in terms of the constraints for the protection of waters from pollution by nitrates that are creating so many problems to farmers. Again the concepts of traceability, documentation, and supply chain are the "bread and butter" of the industry.

Under these circumstances, the work has sought to develop systems for automatic recording of production events that will allow operators to improve the data collection and production of documentation both for single-stage production process of industry, either for the entire productive supply chain. This permit to make it as easy as possible for the operators themselves the possibility to respond to tasks related to regulatory or disciplinary action, relieving the closely "operational" part of the same work - which is usually carried out by staff with little attention, as considered by them not "essential" for the production - which, if not executed with precision, leads to unreliable and therefore "inconsistent" tracking systems.

In this context, the research work within the PhD was divided on the development of three different automation systems in the livestock industry:

- Study and analysis of technologies based on radio frequency identification (RFID) on the market and development of management systems applicable to different types of production in cattle and sheep and goat rearing; development of an integrated system of automated traceability in a supply chain for beef production;

- Study and development of a sensitized collar prototype with GPS technology to monitor the herds of cattle and goats flock, use of grazing areas and prevent cattle stealing;

- Study and development of an integrated system for slurry management monitoring and electronic reports drawing up in cattle breeding.

CHAPTER 2

Objectives

2. Objectives

2.1 Study and analysis of technologies based on radio frequency identification (RFID) on the market and development of management systems applicable to different types of production in cattle and sheep and goat rearing; development of an integrated system of automated traceability in a supply chain for beef production.

The activities focused on the topic here identified have concerned different types of cattle farms on the Italian territory, for which were:

- identified the most appropriate types of tags with which develop the management system;
- identified practical application of the electronic ear tags noting related issues that have arisen at this stage;
- check the performance of various reading systems which were evaluated with respect to the tags "seal".

The purpose of this first working phase was to verify the efficiency and practicability of an automated and computerized management of the information required for the maintenance of official record and of productive and reproductive parameters in farms with very different characteristics. For this reason, the parts subject to investigation and evaluation were, in particular, different types of microchips, pliers for their application, dynamic readers on the market and management software.
These elements are in some way the prerequisites for the development of subsequent phases, which consist in transferring of technology-based animal identification systems using radio frequency to the entire supply chain of beef cattle.

The bovine meat production chain is complex both under structural and organizational profile. This is due to the high number and the production diversification of operators involved, as a result of a large fragmentation in agricultural and industrial phases, of the existence of remarkable animals and meat import flow, as well as of the commercial channels complexity that is typical of some areas of the national territory.
In general terms, the production chain appears to consist of a primary step of bovine breeding, which operative mode is considerably influenced by many

factors, as the market trend, the referred geographical area, management capabilities and structural conditions of every farm. The processing phase in the slaughtering and dissection facilities follows, and a final step of selling through shops, where processed information reaches customers.

Traceability can be easily reached in each single separate step of the food chain (breeding, slaughtering, packaging and selling). Problems arise in integrating each productive process subsystem.

At present some problems and difficulties connected to the compulsory or voluntary labelling of meat (Reg. CE 1760/2000), both in terms of data entry and management, require the development of alternative systems so to guarantee food safety for final customers.

In a broader sense of supply chain benefits from the use of RFID tags include, in addition, to reducing labor costs, more efficient industry monitoring, thanks to the availability of safer data, better tracking and tracing-products (Sahin et al., 2002). This is particularly important given that markets industrialization and globalization have dramatically changed the relationship between producers and consumers both physically either temporally distancing them. We have moved, in fact, from a dimension of production and consumption mostly local to a situation, the current one, in which foods are often purchased at different times and places than where they were produced. Therefore, buyers want to check, not yet having a direct and personal contact with those who produce, quality and food safety.

Aim of the project was to study and develop an integrated automatic traceability system for the bovine meat chain based on RFID technologies and the innovative idea is represented by considering the entire bovine meat chain as an only automated system.

The project, developed in collaboration with Hi Pro Solutions, BIZERBA weighing systems and APIS Software, foresees phases of research, development and application in the bovine meat chain of new systems by using the RFID technology, to perform a return control on the sold meat for final customers.

2.2 Study and development of a sensitized collar prototype with GPS technology to monitor the herds of cattle and goats flock, use of grazing areas and prevent cattle stealing

The primary objective of the experiment was to develop a GPS collar to replace the control activities of cattle and goats grazing made by the shepherds.

2 devices have been designed and built, a specific one for cattle and one for goats, equipped with low-cost components, chosen from among those used to manage fleets of commercial vehicles, that can return in real time the position of a herd or flock and any trespassing by a pre-set virtual fence, by sending SMS alarm messages to a mobile phone.

The use of tracking software also allowed to visualize the positions of the devices on the map, to verify and analyze the routes taken, including the crossovers from the virtual fence and, therefore, to prevent possible cases of cattle stealing.

2.3 Study and development of an integrated system for slurry management monitoring and electronic reports drawing up in cattle breeding

Aim of the project was the implementation of an integrated system for animal slurry management monitoring and electronic reports drawing up in cattle breeding in order to optimize the fertilization management and reduce the agricultural impacts.

CHAPTER 3

Study and analysis of technologies based on radio frequency identification (RFID) on the market and development of management systems applicable to different types of production in cattle and sheep and goat rearing; development of an integrated system of automated traceability in a supply chain for beef production

3. Study and analysis of technologies based on radio frequency identification (RFID) on the market and development of management systems applicable to different types of production in cattle and sheep and goat rearing; development of an integrated system of automated traceability in a supply chain for beef production

3.1 Abstract

In Italy, the bovine meat production chain is extremely complex both under structural and organizational profile. This is due to: high number of operators involved; large fragmentation in agricultural and industrial phases; existence of remarkable import flow of animals and meat; commercial channels complexity. Traceability can be easily reached in each single separate step of the food chain (breeding, slaughtering, packaging and selling). Problems arise in integrating each productive process subsystem. Aim of the project was to study and develop an integrated automatic traceability system for the bovine meat chain based on RFID technologies.

RFID tags were used to identify: animals; hooks used in the slaughtering conveyor belt for the carcass transport and storing; anatomical cuts.

RFID readers were installed at: farm livestock gates; slaughtering entrance; each working station in the dissection area; stock rooms.

All the system was controlled by using a software divided into three main sections for the: livestock; slaughtering; stock room/shop.

The system entailed the following phases:

- Animal ear tag reading at farm level to identify and to record each productive step in the "*Titvlvs*" software;

- Animal ear tag reading through fixed antenna in slaughterhouse standstill corridor to send information to management software;

- Animal ear tag and hooks microchips combining in the evisceration area;

- Carcass number attributing and label writing in weighting area;

- Recording of carcass entry in dissection area, by using a photocell-spar system which identifies hooks;

- Rewritable microchip adding in each vacuum-packed anatomical cut.

- Every selling action recording, in the store/shop area, by using weighting systems connected to a web software able to perform a return control on the sold meat.

The system was used in a cooperative productive organization of Northern Italy. Tests showed the functionality of the different components and the whole integration of the subsystems.

3.2 Introduction

3.2.1 Animal identification history

The need to uniquely and permanently identify livestock is not a problem created recently. It is well known that, since ancient times, farmers were proceeding to the branding of animals to identify the property as distinguished from wild ones and those of other breeders.

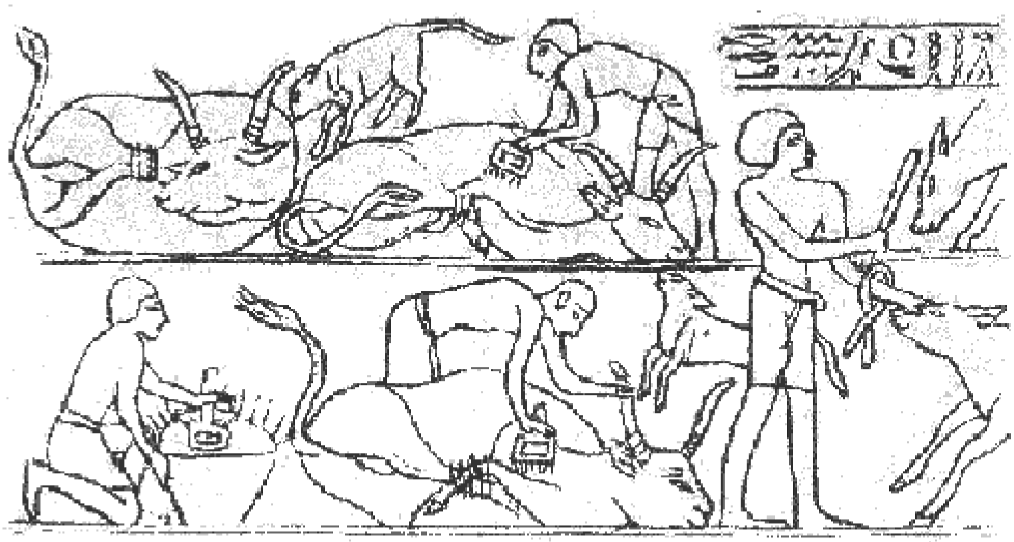


Figure 3.1 - Reproduction from an Egyptian bas-relief of 2000 BC
in which operations to brand cattle are performed.

Since animals are unable to express their own identity, the problem of farmers has always been to provide the same symbols or codes that could be uniquely and indelibly recognized and identified after time. So in the past the branding has been the practice becoming predominant for ensuring a secure identification. It, as well as with hot iron, was also made by incising the skin of the animal with sharp knives to injure, so that with healing could be recognized. Obviously this second practice does not warrant the same hygienic conditions of the fire, including an instant cauterization.
It was created a real culture around the branding operation and marks remarkably sophisticated have been developed, in many cases made with great aesthetic taste.

Figure 3.2 - Examples of symbols used in the branding operation.

In addition, the branding practice has been often assuming the character of the ceremony in the farming culture, as a moment of affirmation of the property, where the social position of farmers expressed (and still is expressed in many areas) with the increase in livestock number.

In this context, even in our globalized society remains a vivid memory of this ancestral practice. Just think about the revival of the epic cinema of the Far West in the United States, where the cowboys and their herd management have represented and still represent a foundation in the collective (Figure 3.3).

Figure 3.3 - Cow-boys during livestock branding.

If this refers to an event that is part of the communication society, is there anyway to remember that the branding practice, according to the methods described, is still implemented in the traditional agricultural communities. Here reaches very high levels of complexity as those, for example, affect the breeding of camels in North Africa, where you can find cases of animals branded with symbols in many different parts of the body, that represent, for example, the name of the tribe, the farmer, the family or the animal (Figure 3.4).

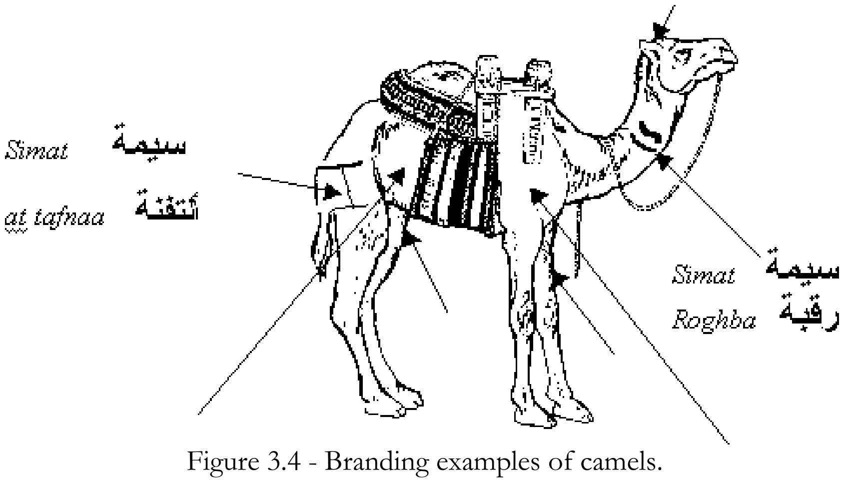


Figure 3.4 - Branding examples of camels.

However, the branding operation presents problems that are related both to animal welfare, because is for the same source of suffering, both for employees who must work to achieve it in unfavorable ergonomic conditions, and are subordinated to risk of accidents (Picture 3.5).

Figure 3.5 - The iron branding does not comply with the requirements of animal welfare.

In addition, social development in more recent times has led the need to develop recognition systems that meet not only the farmer needs, relating to its claim of ownership on the animal, but also those of the community in relation to health and food safety.
In particular, to prevent the spread of animal epidemic diseases, is necessary that the structures of veterinary medicine can keep under control the herds size to be able to implement the necessary steps for prevention, treatment and control of potentially infected animals.

In addition, more and more are the information needs expressed by consumers about the origin and health of animal origin food. The so-called supply chain certification, which is increasingly becoming a prerequisite to enter the market, can not prescind from an efficient animals recognition system.

Is for this reason that replacing the traditional practice of identification by branding alternative practices have been developing, less bloody and more manageable in terms of registration and use of data related to them. Increasingly, in fact, generic symbols have gone replacing the numerical ones in order to create series easily distinguishable even in the administration of many subjects. It's really very difficult to have branding systems that are able to represent complex numerical codes. Among the most recent and widespread practices of identification that are replacing traditional ones have to be included those involving the use of:

- tattoo done with ink;
- ear tags with identification numbers and/or bar code;
- radio frequency electronic devices.

Among the more recent methods, the use of electronic devices today is the technological frontier because it permit, at least in theory, to automate the intellectual work inherent all operations of reading, recording and data management. They it see the prospect of reaching a power of control on animal very efficient and of universal value.

3.2.2 Why to identify an animal?

In our globalized society, a generic livestock identification system must meet the needs of different groups of users, responding to the following minimum requirements:

- facilitate and/or improve the recording and updating of records or data-based animal registry;
- be secure against fraud;
- be cheap.

User	Main uses	Requirements
1 – Farmer	Production monitoring; individualized management; identification for health purposes	Ability to read code, even at relatively high range; possibility to associate the code with physiological and productive data
2 – Association	Genetic selection; management registry	Unequivocal code, valid for the lifetime: possibility to combine genetic data
3 - Merchants-slaughtererhouses	Traceability; management passport	As point 2. Possibility to associate source data and possession of animals
4 – Administration	Confinement for medical purposes; possible awards management	As point 2. Possibility of combining veterinary data and payment

Table 3.1 - Prevailing use and requirements that an identification system must satisfy in the various categories of users.

Moreover, the introduction of a generic identification element must meet the following specific information:

- have a sufficiently low weight as to be tolerated by young animals during the execution of the first identification operation;
- be matched to the animal as soon as possible;
- possess characteristics that allow easy verification of the association animal-identification element;
- allow all routine maintenance (restoration of readability in case of decay of the same) and extraordinary maintenance (replacement in case of loss or breakage), while maintaining the integrity pairing animal-identification element.

Regarding the identification element as device, it must:

- guarantee that the code assigned is univocal not only within the home country but also internationally;
- ensure the possibility to trace the source of the animal;
- be easily applied to animals, while respecting their health and physical well-being;
- be readable even in difficult operating conditions (eg.: slaughter, adverse climate);
- not be easily lost or broken ("sealing" of the device according to specific needs);
- not be easy to replace, edit or manipulate in order to prevent fraud;
- be present in animals in conjunction with another with the same ID number to ensure the continuity of the identification system also in case of its loss;
- be easily disposed.

For these reasons the use of any ID device can not ignore the contemporary setting in place of a real information system (more or less maintained through computerized procedures) that must meet the following guidelines:

- the distribution process of identifying elements must be safe and well-timed;
- identifying elements must be easily distributed from a logistical point of view;
- any replacement or re-entry process of identifying elements as well as being secure and manageable (items 1 and 2) must be integrated with the initial distribution in order to avoid inconsistencies;

- it must also be easily managed by all the players who enter the chain of approval and to these actors must be assigned clear and specific responsibilities;
- it must guarantee the permanence of registration archives and they should be integrated in a network of local and national level (between provinces, regions and state), as well as internationally.

As should be clear from these first notes, a recognition system for animals, which at first glance may appear a device with rather limited meaning when viewed in the context of our globalized society represents the basic element of a technology that are faced with complex choices in terms of strategic, managerial and operational.

3.2.3 The regulatory framework for identifying cattle and sheep and goats

The deep crisis generated by the outbreak of BSE and the difficulty of tracing the routes of the infected meat have in fact led in recent years to establish that the traceability is the most useful tool in the management of food emergencies. In this context the EC Regulation 178/2002 sets out general principles and requirements of food law, establishing the European authorities responsible for food safety and set clear procedures in matters of food safety. Article 18 of those regulations states: "It's decided at all stages of production, processing and distribution the traceability of food, feed, food producing animals and any other substance intended or likely to become part of a food or feed".
The policy outlined by the “Libro Bianco sulla sicurezza alimentare” appears to be an instrument of competitiveness and rationalization of production systems, as well as promotion of agro-food products (Albrissini, 2005).

In the food sector the Legislative Decree 155/97, which lays down general hygiene regulations for foodstuffs, was already an effective tool, but actually it is not sufficient for risks definition and analysis, critical control points and preventive measures . These rules now are clear references in the EC Regulation 178/2002 which emphasizes the necessity of the consumer confidence, providing a comprehensive traceability system that sees, finally, the need to connect to it all the documentation and systems under control. In this Regulation, the term traceability is defined as the ability to trace and follow a food, feed, a food producing animal or substance intended or likely to become part of a food or a feed, through all stages of production, processing and distribution.

In this context, the Italian standard UNI 10939, issued in April 2001, defines which are, on a voluntary way, principles and specific requirements for the implementation of a traceability system in a supply chain. The traceability is defined as "the ability to reconstruct the history and to follow the use of a product by identification documents (relating to material flows and operators of the chain)" and is underlined it is necessary to consider both the traceability of every organization either the traceability between the various organizations (Visin, 2005).

In this context, more specifically for cattle, pigs, sheep and goats identification, in Europe succeeded the adoption of several directives, which effectively influence the recognition systems used or in approval process, among which we priority remember:

- Council Directive 1992/102;
- Council Directive 1997/12;
- Council Directive 2000/15;
- Commission Decision 2000/678.

These were later gradually assimilated by our country with specific regulations that lead to the need to comply mandatory rules that differ depending on the different type of animal bred. Obviously, these rules represent the "minimum" that a generic recognition system must be able to provide. In addition, for the different categories of users identified above, can be useful identification management forms more sophisticated and complex.

Cattle identification

Currently, the cattle sector is characterized by a mandatory registry that is governed by EC Regulation 1760/2000, which sets out the obligation of identification and registration of animals and conpulsory labeling of cattle and beef products by each member state.

In this context the Presidential Decree 317/96 provides guidance for the identification of the individual animal which shall be by means of an ear tag applied to each ear within twenty days after birth and before it is transferred to a second farm.
With the enactment of Presidential Decree 437/2000 and Decree of the Ministry of Health of 31/01/2002, which established an identification and recording system that includes the Passport for the animals, the records ("herd books") held at each farm and the computerized national data base (BDN); is BDN that issue the supplier of ear tags, specified by the producer, code numbers to be affixed to the individual animal. This code is formed by the initials IT followed by 12 characters.

The ear tags shall meet the following requirements:

- they are two in number for each animal;
- are made of flexible plastic;
- they are tamper-proof and easy to read throughout the lifetime of the animal;
- they are not reusable;
- they must be attached to the animal without being harmful;
- each ear tag consists of two parts, male and female, on which is available the individual identifying codes in correspondence of the visible side;
- are yellow or red salmon for the animals entered in the genealogic books.

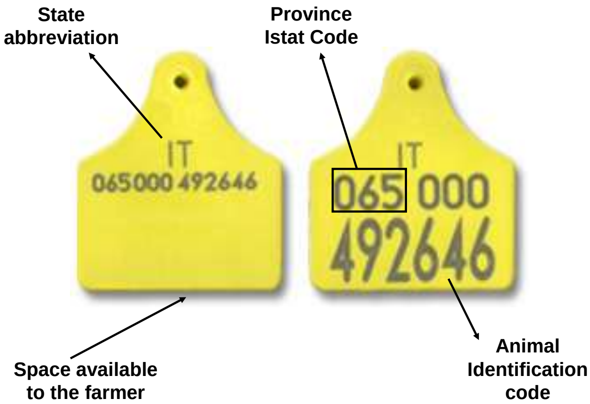


Figure 3.6 - Italian official visual ear tag.

The ear tags, left and right, are applied to both ears of the bovine, in a central position in the space delimited by the passage of the two veins of the ear, so as to prevent their possible loss due to tears or detachments.

The farmer can choose the brand and model it considers more appropriate, but care must be taken to the application procedure and especially the type of pliers suitable for the brand used.
The owner may require a quantity of ear tags not exceeding the annual requirement of livestock is responsible for.
A owner, or a delegate, requires the quantity of ear tags accessing on-line to the National Data Base (BDN), using a special function, indicating the authorized supplier of ear tags from which it intends to procure them. The Veterinary

Service checks the consistency of the order and authorize the production of ear-tags required.
The supplier receives the order of ear tags approved by the SV and proceeds to the production and shipment of stamps bearing the identification codes and sends them to the place indicated by the applicant, including the first bovine passport (“cedola identificativa”) that must be completed by the farmer when the animal is branded (Picture 3.7).


CEDOLA IDENTIFICATIVA DEL BOVINO
(da compilarsi al momento dell'apposizione del marchio all'animale e da consegnare od inviare all'indirizzo riportato sul retro)

Nuova identificazione [X] Sostituzione [redacted]

CODICE IDENTIFICATIVO [redacted] 067000000100

CODICE A BARRE

Codice azienda [redacted]

Codice del marchio della madre: IT 020 AT 054 B 126 ET (4)

Codice del marchio applicato in precedenza all'animale (1) [redacted] Sesso (M/F) M

Data di nascita dell'animale 11/07/1998 Data di applicazione del marchio 15/08/199

Data ingresso in stalla 10/08/1999 Nato in azienda ■ Razza BRUNA ALPINA

Origine dell'animale: Paesi Terzi [X] (3) Paese di provenienza: POLONIA

Detentore (cognome, nome): ROSSI MARIO Cod. fiscale RSSMR12S20F345

Proprietario (cognome, nome) (2): BIANCHI CARLO Cod. fiscale BNCCRL10L54423B

Dichiaro sotto la mia responsabilità che le informazioni da me riportate nel presente atto rispondono a verità:

Data di compilazione ...27/08/1999..... Firma Rossi Mario

(1)
(2) Dati riferiti al proprietario, da compilarsi se diverso dal detentore
(3) Indicare il Paese Terzo di provenienza
(4) Barrare nel caso di animale nato a seguito di trasferimento embrionale

Figure 3.7 - Cattle “Cedola identificativa”.

The passport follows the animal from birth to death in all its movements, which must be reported on the same and updated from time to time on computerized data base.
In addition to the numerical code and movements, the passport contains the date of birth, sex, race, the identification code of the mother (Pictures 3.8 and 3.9).
When the animal reaches the slaughter, the person in charge pick up the document, integrate it and communicate by computer all information relating to animals slaughtered.


SERVIZIO VETERINARIO - DOCUMENTO DI IDENTIFICAZIONE INDIVIDUALE PER LA SPECIE BOVINA

0429824/02

REGIONE ...... AZIENDA U.S.L. ......

CODICE AZIENDALE (1)

Codice progetto (2)

CODICE A BARRE (matricola dell'animale)

Detentore (Cognome e Nome) ...... Cod. fiscale ......

Proprietario (Cognome e Nome) ...... Cod. fiscale ......

ESTREMI IDENTIFICATIVI DELL'ANIMALE

Marca auricolare: ...... Sesso (M / F) ...... Data di nascita ......

Razza ...... Marca della madre (3) ...... Embryo transfer

Marca precedente (4) ...... Codice paese d'origine ...... Data ingresso in stalla ......

Data di rilascio ......

CODICE A BARRE (razza, sesso e data di nascita)

Timbro

Firma DEL VETERINARIO RESPONSABILE

Figure 3.8 - Front of the passport (Italian).


PASSAGGI DI DETENZIONE DELL'ANIMALE

Codice Aziendale di destinazione: ...... Identificativo fiscale allevamento 1

Data ingresso in stalla ../../.. Firma del detentore ......

Codice Aziendale di destinazione: ...... Identificativo fiscale allevamento 2

Data ingresso in stalla ../../.. Firma del detentore ......

Codice Aziendale di destinazione: ...... Identificativo fiscale allevamento 3

Data ingresso in stalla ../../.. Firma del detentore ......

Codice Aziendale di destinazione: ...... Identificativo fiscale allevamento 4

Data ingresso in stalla ../../.. Firma del detentore ......

(5) Bovino Maschio intero richiesto a premio

(5) Bovino Maschio castrato richiesto a premio prima domanda

(5) Bovino Maschio castrato richiesto a premio seconda domanda

ATTESTAZIONE DI MACELLAZIONE O DECESSO

Animale macellato/deceduto (6) in data ../../..

presso ......

Codice mattatoio ......

Comune ...... Prov. ......

Figure 3.9 - Back of the passport (Italian).

The timely update of the "herd book" for cattle born in the farm (within three days after animal identification) is under the responsibility of the holder who must transcribe, near the boxes highlighted in yellow in the following facsimile, the following information:

- the identification number;
- race;
- sex;
- the identification code of the mother;
- the letter N for animals born in the farm;
- date of birth;
- date of entry (which coincides with that of birth).

REGISTRO DI CARICO E SCARICO AZIENDALE PER BOVINI														
Allegato IV														
					CARICO O NASCITA				SCARICO O MORTE					
Num. Ordine	Marchio di identificazione	Razza	Sesso (M/F)	Codice della madre	Nato in azienda inserire N o acquistato inserire A	Data di nascita	Data ingresso	Provenienza (1) (3)	Morto in azienda (inserire M) o venduto (inserire V)	Data di morte o di vendita	Destinazione (2)	Marchio precedente	Estremi modello 4 (4)

Figure 3.10 - “Herd book” facsimile.

Please note that the farm register must have the pages numbered and signed by the official veterinarian of the Veterinary Services (SV) responsible for the area in which is the farm.
When an animal is introduced into a farm, the farmer should first check that it is correctly identified, that the ear tags are correctly applied to both ears, that holds a passport fully populated with the correct information about the animal and that individual code listed there matches the one printed on theear tags, and is accompanied by “Form 4” in accordance with Annex IV of the DPR 04/30/1996 (origin declaration) with health certificate (Part E) issued by the veterinarian of the SV of departure.
The farmer, therefore, will update the individual animal passport (back side) recording the transfer of ownership of the animal by means of its farm code, tax code, date of entry into the stable, and its signature as well as a potential application for the award.

The obligations incumbent upon the breeder from this time are:

- noting in addition to the animal identification, the purchase (point A), date of birth, date of entry, the holding of origin (code or company name and address of the holder) and the Form 4 details (number) (see facsimile register, boxes highlighted in yellow);
- the animal handling communication within seven days by sending a copy of Form 4 to the Veterinary Service of ASL responsible for the area, supplemented with personal data and identification of the animal (using, for example, a photocopy of the passport), or, if they have smart-card (electronic card), directly taking on-line animal registration on BDN at website https://anages.izs.it.

REGISTRO DI CARICO E SCARICO AZIENDALE PER BOVINI													
Allegato IV													
					CARICO O NASCITA				SCARICO O MORTE				
Num. Ordine	Marchio di identificazione	Razza	Sesso (M/F)	Codice della madre	Nato in azienda inserire N o acquistato inserire A	Data di nascita	Data ingresso	Provenienza (1) (3)	Morto in azienda (inserire M) o venduto (inserire V)	Data di morte o di vendita	Destinazione (2)	Marchio precedente	Estremi modello 4 (4)

Figure 3.11 - "Herd book" facsimile.

(1) For animals that arrive in the holding company will be written down the farm code or the name and address of the holder of the holding of origin.
(2) For animals leaving the holding company will be written down the farm code or the name and address of the holder of the destination.
(3) For animals from other countries indicate the number of accompanying health certificate issued by the competent health authorities
(4) For dead animals on the farm indicate the number of certificate issued by the competent health authorities

The animal introduced if it comes from a European Union country retains the ear tags and passports issued by the country of origin, but if it comes from a country outside the EU (third country):

- it must be noted with ear tags provided by Community legislation within following twenty days (except where it is intended directly to the slaughterhouse to be slaughtered not later than 20 days after the import);
- must be recorded on the farm "herd book" and in the BDN;
- passport must be fitted, provided by Community legislation, issued by the Veterinary Service of ASL responsible for the area.

As for the discharge of cattle there are three main types of exit:

- Sale or transfer to another farm: the farmer must:
  - ➢ check that the animal is properly identified to be sent, fitted with ear tags in both ears, and the passport duly completed;
  - ➢ fill in the boxes of Form 4 of its jurisdiction, namely Part A - IDENTIFICATION and Part C - DESTINATION (in this case the serial number sequence of the Form 4 is assigned by the Veterinary Service);
  - ➢ requiring the Veterinary Service completing Part E - HEALTH CERTIFICATE, which must be endorsed by the official veterinarian;
  - ➢ to fill the carrier: Part D - TRANSPORT;
  - ➢ update the farm "herd book" within three days after animals departure, recording exit from the farm (letter V), the departure

date, the holding of destination (Code or Name and Address of the holder) and the Form 4 details (number) (see facsimile register boxes, highlighted in yellow);
- ➢ send or deliver a Form 4 copy to the Veterinary Service of ASL responsible for the area within seven days;
- ➢ if you have smart-card (electronic card), record within seven days directly on-line on BDN animals exit at website https://anages.izs.it.

REGISTRO DI CARICO E SCARICO AZIENDALE PER BOVINI													
Allegato IV													
Num. Ordine	Marchio di identificazione	Razza	Sesso (M/F)	Codice della madre	CARICO O NASCITA				SCARICO O MORTE			Marchio precedente	Estremi modello 4 (4)
					Nato in azienda inserire N o acquistato inserire A	Data di nascita	Data ingresso	Provenienza (1) (3)	Morto in azienda (inserire M) o venduto (inserire V)	Data di morte o di vendita	Destinazione (2)		

Figure 3.12 - “Herd book” facsimile.

- Transport to the slaughterhouse: the farmer must:
  - ➢ check that the animal is properly identified to be sent, fitted with ear tags in both ears, and the passport duly completed;
  - ➢ number Form 4 and fill in the boxes within its competence, namely Part A - IDENTIFICATION, Part B - DECLARATION FOR THE SLAUGHTERHOUSE and Part C - DESTINATION (in this case the Form 4 serial number is assigned by the farmer);
  - ➢ to fill the carrier: Part D - TRANSPORT;
  - ➢ update the farm “herd book” within three days after animals departure, recording exit from the farm (letter V), the departure date, the slaughterhouse of destination (Code slaughterhouse or Company Name and Address) and the Form 4 details (number);
  - ➢ send or deliver a copy of Form 4 to the Veterinary Service of ASL responsible for the area within seven days;
  - ➢ if you have smart-card (electronic card), record within seven days directly on-line on BDN animals exit at website https://anages.izs.it.

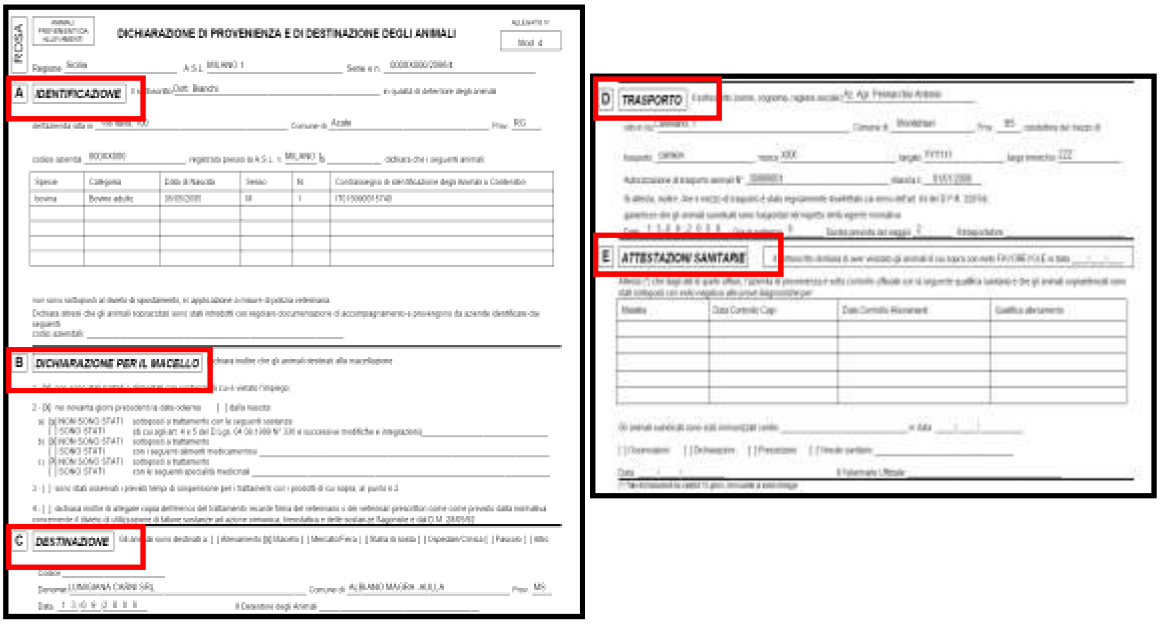
- Death of the animal in the farm: the farmer must:
  - ➢ communicate within 24 hours to the Veterinary Service of ASL responsible for the area, so that it can quickly make its controls on the animal died;

- ➢ fill in the box related to the certificate of slaughter or death, the shares on the date and place of death, on the back of the passport to be returned to the Veterinary Service of ASL responsible for the area;
- ➢ update the farm “herd book” within three days after animal death, bringing the death (M), the date of death and certificate number issued by the competent health authorities (see facsimile register boxes, highlighted in yellow);
- ➢ if you have smart-card (electronic card), record animal death within seven days directly on-line on BDN animals exit at website https://anages.izs.it.

REGISTRO DI CARICO E SCARICO AZIENDALE PER BOVINI													
Allegato IV													
					CARICO O NASCITA				SCARICO O MORTE				
Num. Ordine	Marchio di identificazione	Razza	Sesso (M/F)	Codice della madre	Nato in azienda inserire N o acquistato inserire A	Data di nascita	Data ingresso	Provenienza (1) (3)	Morto in azienda (inserire M) o venduto (inserire V)	Data di morte o di vendita	Destinazione (2)	Marchio precedente	Estremi modello 4 (4)

Picture 3.13 - “Herd book” facsimile.

The Model 4 ("pink sheet") is the declaration of origin that accompanies the animal during transport and contains information regarding the identification (Part A), the statements to the slaughterhouse with regard to medication or illegal substances (hormones) (Part B), destination (Part C), carrier data (Part D), and sanitary certification of the veterinarian who visited the animals before the move (part E) (Picture 3.14).



Picture 3.14 – Form 4 ("pink sheet").

It must always be completed in at least four copies:

- one for the holding of dispatch;
- one for the veterinary service of departure;
- one for the destination holding;
- one for the veterinary service of arrival.

The mod. 4 is pink if the animal is moved from a farm, green if it is moved from a parking stall and yellow if it is moved from a fair or market.

The Ministry of Health from 1 January 2000 holds the computerized database of farms and cattle and uses as a technical body, the National Service Center at the Istituto Zooprofilattico Sperimentale of Abruzzo and Molise (IZSAM) based in Teramo.
In the Italian system of cattle identification and registration, the National Data Base (BDN) enables the traceability of cattle. In fact, the BDN contains the information necessary for monitoring movements of cattle, contacts, country of origin.

The new system makes it participates in the management of the animal identification and recording system all the professionals, providing access to the BDN by connecting directly to the website of 'bovine registry. The site of the database operators (https:// anages.izs.it) is highly secure.

Access is through "smart card " which is released by the National Centre of registry services at the IZSAM, which allows the system to recognize the operator via a digital signature certificate. The system enables communication of data in "real time" to the BDN by the farmer, an approved delegate (CAA, AIA, etc.) by the veterinary services and the owners of slaughterhouses.

The operators which may require the allocation of a smart card containing a digital signature certificate are:

- Veterinary Services of local health units;
- Regions and Autonomous Provinces;
- The Ministry of Health;
- the paying agencies (OPR);
- the holders of the animals;
- the owners of slaughterhouses;
- the approved veterinarian;
- Agricultural Service Centers (CAA), the Italian Breeders Association (AIA) and the slaughterhouses, the trade associations that, as delegated by the farmers or slaughterers, are substituted in the statement of significant events for the upgrade;
- authorized suppliers of ear tags.

Sheep and goats identification

In accordance with Regulation (EC) No 21/2004 of 17 December 2003, from 1 January 2006 is active the National Data Bank (BDN), in which are recorded national sheep and goats farms.
All animals on a farm born after 9 July 2005 must be identified within six months from the date of birth and in any event before the animal leaves the farm of origin. In the case of extensive farming and outdoors, Member States may authorize the extension of that period up to nine months of age (at the time in Italy is not allowed this possibility).

For all animals, identification will consist of a system composed of two identifying elements:

- first identifier: ear tag applied to the left ear;
- second identifier, consisting of:
    - ear tag similar to the first;
    - tattoo;

- for goats, bracelet (not available in Italy);
- electronic identification.

Ear tags and tattoos indelibly bear a personal identification code, issued by the national numbering company allocated at the CSN of Teramo, and consists of the letters IT followed by a code consisting of 13 digits.

For animals to be slaughtered within 12 months of age is permitted with a simplified system identification only 1 ear tag bearing a code that dated back at least the company where the animal was born.

The farmer must keep a "herd book" containing from 9 July 2005:

- identification code of the farm;
- the farm address and the geographical coordinates or geographical equivalent of the company;
- the type of production;
- the total number of sheep and goats on the farm, recorded during the month of March;
- name, address and tax identification number of the keeper;
- name, address and tax identification number of the animal owner;
- for animals leaving the farm, the name of the transporter, the registration number of the truck, the identification code or name and address of the destination or, for animals for slaughter, the identification code or the indication of the slaughterhouse and the date of departure or a certified copy of the shipping document;
- for animals entering the farm, the identification code of origin and date of arrival;
- information on possible replacement of the ear tags or electronic tags.

With effect from 1 January 2008, for each animal born after that date, the "herd book" will also contain the following information:

- animal identification code;
- year of birth and date of identification;
- month and year of death of the animal;
- the breed and, if known, the genotype.

However, for animals identified with the simple way, the information referred to above are provided for each batch of animals with the same identification and include the number of animals.

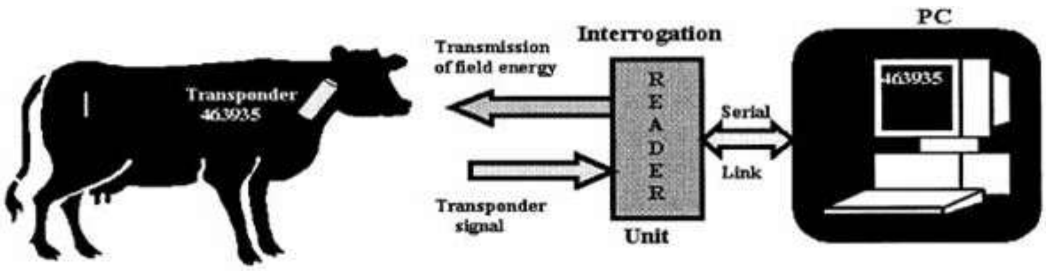
Moreover, the "herd book" must report the name and signature of the representative of the competent authority has checked the register and the date of execution of the control

In addition, the EC Regulation 21/2004 provides, point later subject to extensions, that from 1 January 2008 the identification of sheep and goats will be based on an official ear tag (size and material allowed) on the left and an electronic identification device (reticular bolus, ear or subcutaneous microchip, if authorized by the Ministry of Health), which would contain the same identification number of the ear tag, having the following characteristics:

- passive transponder for livestock for read-only applying HDX or FDX-B technology, in accordance with ISO 11784 and ISO 11785 detected by readers compliant to the same ISO 11785;
- the reading distance of the transponder should be for portable reading devices (wand, antennas, etc..) by at least 12 cm for ear tags and at least 20 cm for the bolus, for fixed devices (stationary readers, gateway devices, etc..) by at least 50 cm for both types of application support.
- the electronic identification devices at the end of productive life of the animals must always be retrieved and rendered unusable.

3.2.4. Operating principles of electronic identification

The operating principle is quite simple and outlined in Picture 3.15.



Picture 3.15 - Operating mechanism of an electronic identification system (Geers et al., 1997)

The passive tag, or transponder, is a small silicon chip attached to an antenna by which is surrounded and receives the energy required to operate when it is hit by an electromagnetic field of appropriate frequency. Chip and antenna are usually placed in a plastic coating which may take various forms, from credit card for clothing label, in the industrial and commercial sectors, from the button to the bolus in agriculture.

The reading system consists of a larger antenna, which is driven by a radiofrequency generator, radiates an electromagnetic field. When the tag enters the field above and receives enough energy to activate, in turn, can initiate a transmission to the reader. The reading system is able to detect this interaction and may initiate an exchange of data between the two units, which takes place on the airwaves and it is therefore possible even if system and tag don't communicate: the biggest advantage of this technology!

Inside the chip, the device is currently produced with the technology of electronic components, data are stored to be exchanged with the reader. Such data may be unchangeable, implanted in the chip during its production, and in this case represents an univocal identification code (similar to that encoded in a barcode) or modifiable by the reader having a variable meaning defined by the application.

The reading system (or controller or transceiver or Reader or Interrogator) manage the communication with the tag and the corporate network and transmits data read from the tag itself. Do not forget that the reader has, in the case where the contents of the tag to is modifiable, even the task of writing, under the control of the system, the data in the tag.

The transponder is then supplemented by a support in different materials (plastic, ceramic or glass) that contains within it the real electronic part.

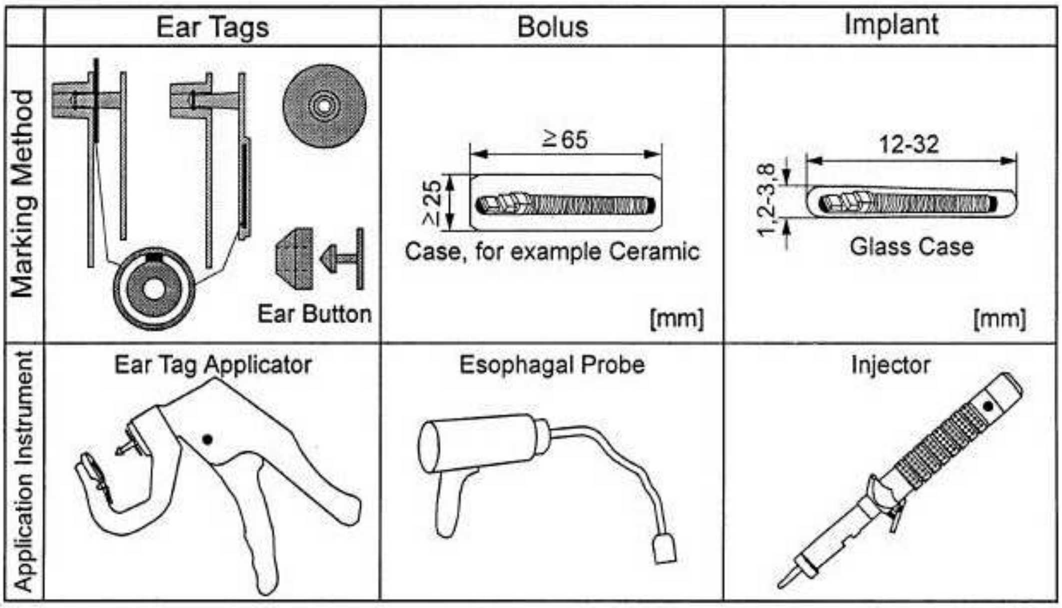
If the concept is simple, the technology that implements it must be particularly refined its application should be performed by experts.

3.2.4.1 Transponders

The devices containing the chip, for animal identification, actually on the market are as follows:

- plastic collars or caps to be faastened to the animal head;
- labels or plastic buttons to engage the ears (ear-tag);
- ceramic Boli (and glass) to be inserted in the *reticulus* by a specific device ("lanciaboli");
- glass subcutaneous supports (injections using special syringes).

In picture 3.16 is shown a schematic representation of the last three types of these devices.



Picture 3.16 –Different types of transponders with its implementation tools.

For the specific application on different animals and in different contexts, the choice of one of them must be based including the following aspects:

- there must be a reduced chance that the transponder is lost or destroyed;
- the stress to which the animal is exposed, both during the application and during its life, must be kept to a minimum;
- the location where the device has been allocated must not change over time (the transponder should not migrate from one part of the animal);
- the application site must be readily accessible so you can quickly identify the animals using mobile devices;
- the application site should be a part of the animal that is easily accessible for removal and control processes;
- not damaging portions of meat that may have commercial value;
- it is preferable that the area of application is the same on all treated animals in order to allow an optimal implementation of the fixed antennas and recognition for effective removal of the transponder during slaughter;
- must by law be recovered during the slaughter for not pose a danger to consumer health.

More specifically, to ensure a dissemination not affected by technical barriers, rules of CE 1760/2000 have established that the transponders used for animal identification should follow the following ISO standards:

- ISO 11784/1996: on the code structure;
- ISO 11785/1996: on the technical concepts of how data is exchanged between the transponder and the reader.

More specifically, the ISO 11784 defines that the code must essentially be constituted of a 64 bits sequence. Not necessarily, however, the transponder, depending on the type, transmits only these 64 bits, as the system, as we shall see later, may need additional start transmission bits, signal integrity bits, error control bits etc.. However, the bits that affect the final user, namely the one who has to base its database on what is written inside the tag, are only 64 and are distinguished as follows:

- Bit 1: application type, when equal to 1 identifying an animal, when 0 does not identify an animal;
- Bits 2-15: code reserved for possible future applications;
- Bit 16: Additional block, when set at 1 distinguishes special solutions of transponders that can have an additional memory space where to store management data (or, however, other additional information);
- Bits 17-25: country code part. The country code is set by the ISO 3166/1 that uses a three-digit decimal between 1 and 900 to discriminate between different countries. To get a figure with these characteristics is necessary to have a binary format of 10 bits (which covers a decimal numbering up to 1023). This field for values beyond the decimal code of 900 represents the manufacturer of which is discussed below;
- Bits 26-64:
    - manufacturer code part, for those countries that do not have a centralized database; the numeric code from 900 to 998 defines the manufacturer who issued the transponder on the market. It 's a non-permanent standard pending that every country has its own database in a position to release the individual codes under discussion below. ICAR (International Committee for Animal Recording) assigns this code only for those manufacturers that submit their products for approval according to ISO standards discussed here. The 999 code has special meaning to define that the transponder is used for experimental purposes;
    - individual code. These binary format of 35 bits can represent a decimal 12-digit number exactly equal to 274,877,906,944. This

value is more than enough, combined with the distinctions made by the country code, uniquely to represent the animals on a global scale for 30 years even in the case of countries with larger number of animals. The management of these codes is allocated to local database.

Moving on to explore the issues covered by ISO 11785, it first identifies a single radio frequency transmission equal to 134.2 kHz and called "ISO frequency for the IDE animal. "

Are also defined only two operation methods of the transponder: FDX and HDX.
The electronic circuits design and the transmission mode of the data are summarized in the figures in the paragraph.

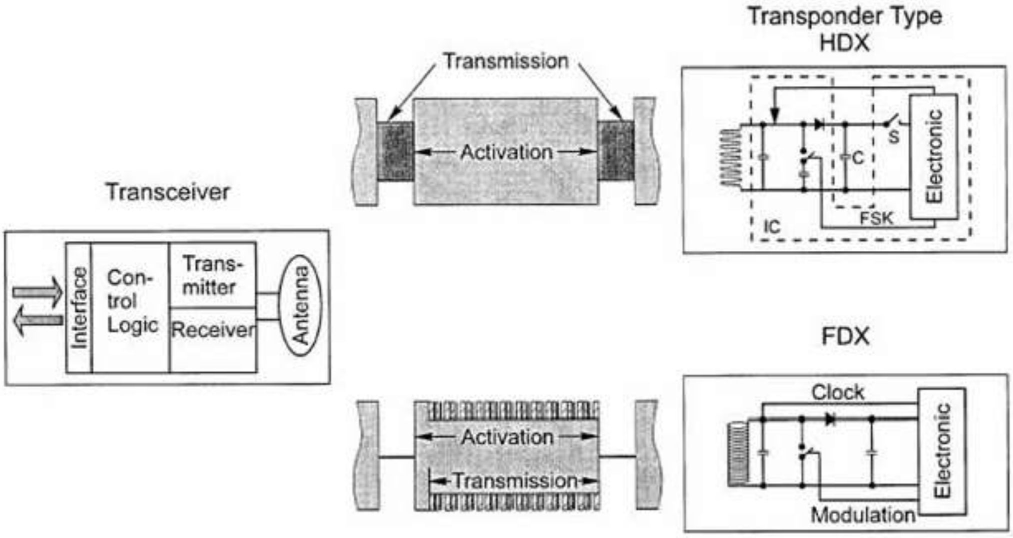


Figure 3.17 - Operation principles of an electronic identification system.

From a construction point of view, the transceiver always consists of an interface (more or less permanently connected to an external system of acquisition) that communicates with the logic control system of the device. This drives the components of transmission and reception of the reader which are both connected to the antenna. The logic control defines the sequence of periods of transmission and reception as will be specified later for the two types of devices HDX and FDX. These, as already mentioned above, consist of an antenna and a real electronic circuit.

The FDX type (full duplex), has a very simple circuit and when activated works receiving energy and transmitting data simultaneously and continuously.

The HDX type (half duplex) presents a more complex circuit that, when placed in the activating magnetic field, is characterized by operating in two phases:

- the first, receiving electromagnetic energy and accumulation of the same;
- the second, data transmission to the reader using the stored energy.

More specifically:

- the additional capacitor C connected to the antenna is charged with energy for a period of time ranging from 50-100 ms;
- after this stage of charging the same capacitor discharge energy on the electronic component and this sends the message containing the data for a period of 20 ms.

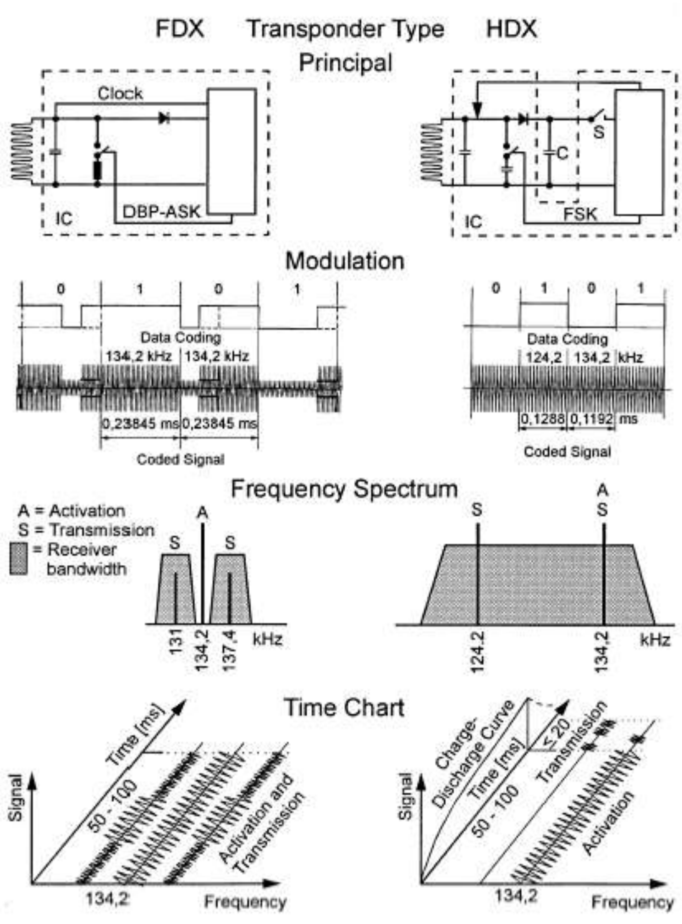


Figure 3.18 - Technicalities of FDX and HDX transponders.

The data coding and modulation process are also different between the two types. For FDX data are encoded in a differential two-stage process (DPB), creating a modulation in amplitude. In practice, the activation signal is received at 134.2 kHz and is broadcast on two different frequencies: at 131 and 137.4 kHz. The length of the bit remains constant at exactly 1/32 of the activating frequency, i.e. a bit is transmitted on 32 cycles for a duration of 0.238 ms, and then the bit-rate is the same for the two codes "0" and "1" and is equal to 4194 bits/s.
HDX transponders are coded according to the non-return to zero process (NRZ) with a modulation frequency to:

- 134.2 kHz, for the code "0 ";
- 124.2 kHz for the code "1".

The length of the bit is set at 1/16 of the transmission frequency and therefore the duration of bit is 0.1192 ms for "0" and 0.1288 ms for "1". This means that the bit-rate of "1" is equal to 7762 bits/s, while the "0" is 8387.5 bits/s.

Since this type of transponder starts to transmit at a very specific moment, i.e. immediately after the receiver pauses, would be relatively easy for the latter, to obtain what is the initial bit to start with the sequence to decode the message. This difference in the type FDX, where transmission is continuous and then the message must contain a very specific and unambiguous sequence of the head.

However, due to its operation with two different bit-rate for "0" and "1", a sequence of start message is still essential for the type HDX in order to enable the two clocks (the transponder and the transceiver) to sync.

This study to conclude that the type of message transmitted by the two types of tags is much more complex than the "theoretical" constituted of 64 bits defined by ISO 11784, mentioned above. For the FDX type in fact there is a 128 bits sequence, while for the HDX there are 112 bits. It is with this type of message and the scanning time required to activate and read the HDX tag transceiver that ISO must be able to operate.

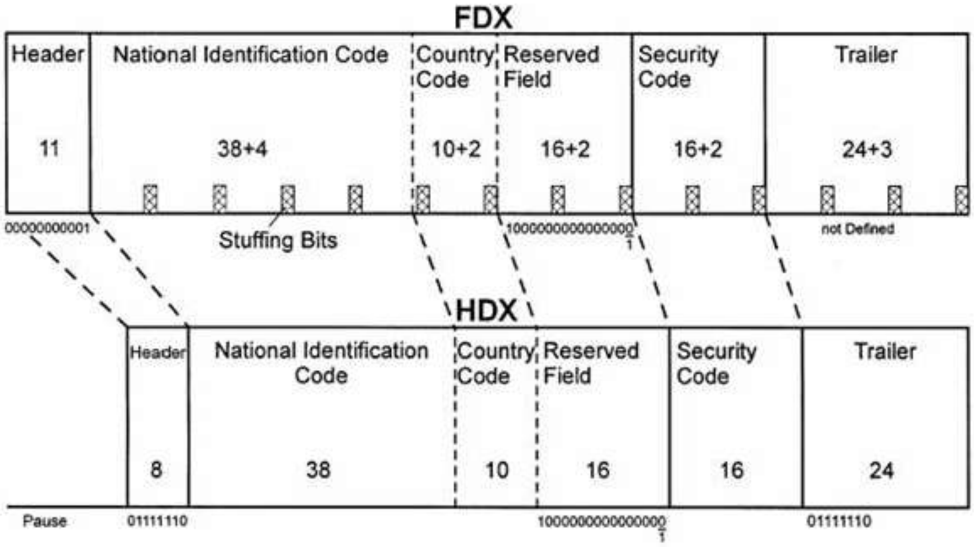


Figure 3.19 - Forms of transmission of animal identification codes according to ISO standards 11784 – 11785.

3.2.4.2 Readers

As mentioned, due to the fact that the ISO standard defines two different types of transponders, the transceiver should, to obtain approval for ISO, operate in a radio wave transmission and reception manner that are relatively complex. The transceiver, in fact, must interpret:

- two different base sequences of message;
- transmitted with different modulation frequencies;
- with different time pattern of transmission and reading.

To better understand what the problem is, imagine your radio at home that has to follow two different programs (the two transmission frequencies of tags) that transmit pieces of different songs (the codes). The first of these two programs transmits continuously (FDX tag), while the latter transmits random (HDX tag) and must be sought. Also, when this second program is found requires a change in volume to allow tuning. And the tracks of the songs should be put strictly in line to not loose its meaning.

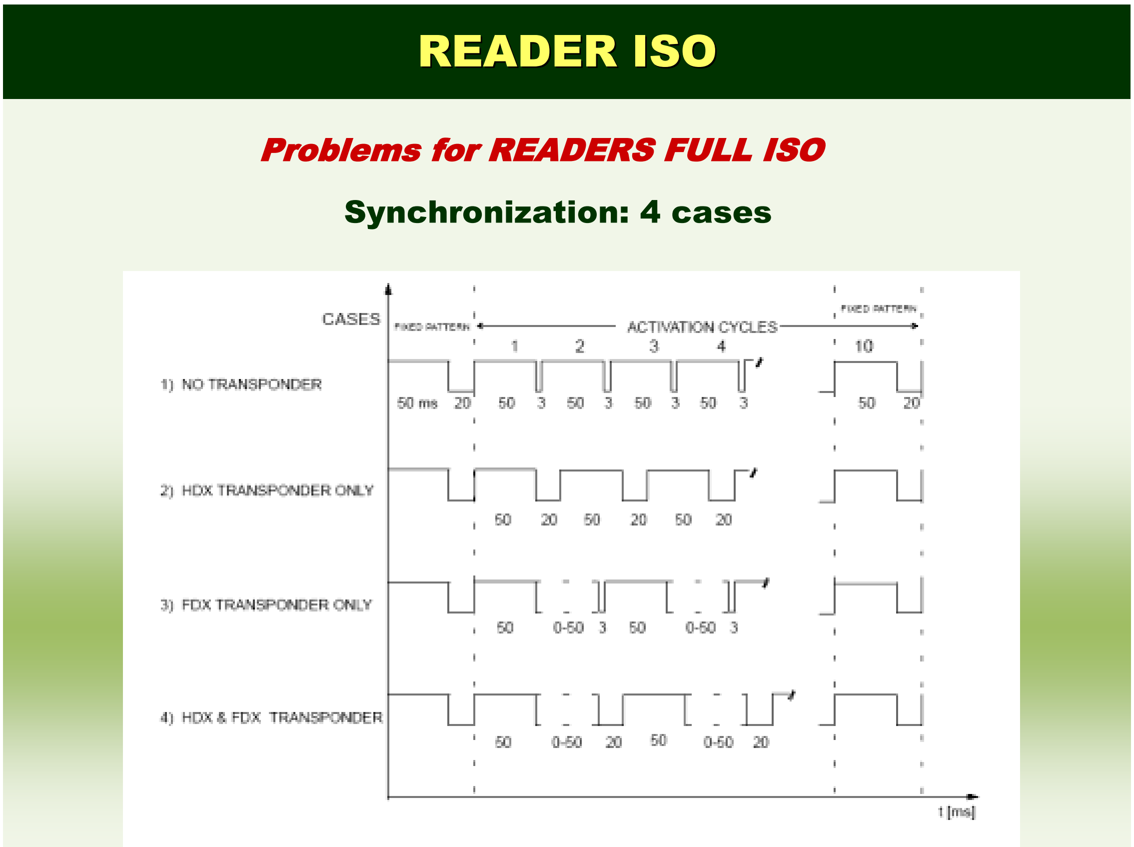


Figure 3.20 - ISO readers synchronization.

In this framework, when the standards were developed (1996), it was estimated that this would not lead to major problems. It was assumed that an increase in costs of around 10%, necessary to add to the two types of basic models a conversion software of the two types of messages and a demodulator, would be easily achieved the aim to make the two systems fully compatible. But the problem was in fact underestimated. Today, more than 10 years after enactment of the ISO, the problems related to the full operational compatibility in terms of different types of identification systems are not yet fully resolved, and the transceiver should be carefully chosen to avoid problems later in an operational phase.

As mentioned before, the two tag systems (FDX and HDX) have primarily different activation times and therefore a reader able to read simultaneously both types of devices must follow a well-defined and precise activating and reading sequence. You might think to solve the problem simply by setting the activation time of 50 ms and the reading of 20. During the activation period the FDX transponder would be empowered to respond (124 bits * 1/4194 bits/s = 30 ms) while the HDX type is loading. During the pause, the HDX type could, in turn, transmit its signal (112 bits/s * 7762 bits/s = 14 ms) while the other transponder type would remain silent. However, in practice, a more complex procedure is necessary because you must face the possibility that both the transponder either the transceiver can be in motion. For this reason the ISO 11785 requires that we work with a timeline much more complex, defined dual adaptive timing.

First, this scheme allows to increase the activation time to 100 ms. This happens when the transceiver is receiving a signal from a tag of type FDX, and this has not yet completed the full sequence. The time is extended and the sequence is fully read.
Secondly, the dual adaptive timing allows the transceiver to cut idle time of 20 ms when 3 ms from the beginning of this period is not available for reading any tags HDX. In this way, in the presence of FDX tags alone was able to increase the reading efficiency.

In addition to the above, the synchronization problem between multiple readers should be also solved, a problem that occurs in practice when multiple receivers are in the same environment interfering between them. In particular, in all these cases it is essential that if HDX tags are present reading pauses occur simultaneously. Otherwise, these tags would never be read. If you work with devices installed in fixed point and connected to the same system, synchronization is accomplished via software orchestrating the temporal sequence of operation of the devices. In the case of mobile solutions, each device must individually be able to recognize the presence of other emitters present and act accordingly. So is implemented a scanning time such that, if in a 30 ms period a device does not receive a radio frequency activation signal from another reader, is assumed that no other transceiver is nearby, and then can activate the procedure transmission-reception predicted by dual adaptive timing.
.
If, on the contrary, the receiver in question detects the presence of another device, it responds to this event with a procedure that makes him wait for a fixed period of 50 ms, so as to permit to complete its cycle.
Finally, another difficult situation to be solved requires that a stationary reader is constantly reading and FDX tags, using the dual adaptive timing never detect the response of a HDX tag because all the breaks are cut. To overcome this problem must be integrated into the procedure a standard cycle every ten cycles, which provides a fixed switching time of 50 ms followed by a pause of 20 ms.

As should be clear from this brief study, these are technical problems of a certain degree of complexity that, unfortunately, is magnified at the operational level to the environmental difficulties that characterize animal husbandry. In fact, to these readability problems of different types of tags in the same environment, you must add those relating to:

- reading distance;
- presence of electromagnetic interference;
- the presence of large masses of metal.

For the problem of reading distance, the maximum value of electromagnetic field set by regulamentations, in conjunction with the size of the tag, tends to limit the maximum values that are:

- 50 cm in the case of large-sized tags;
- 20 cm for tags inserted in injectable devices.

These performances, however, can only be achieved under ideal conditions with tag well-oriented respect to the antenna and motionless devices. In particular, if you detect any movement, everything is questioned. Suffice it to recall that an object moving at 11 km/h (3 m/s) in 35 ms (initial activation and reading time of a FDX tag) runs about 10.5 cm. A HDX tag requires a minimum standard activation time of 50 ms and 14 ms for reading, which means that under the same conditions of speed, it creates a path of 19 cm. In the first case it is half the maximum read range guaranteed by a small injection tag while in the latter this is almost reached.

As for the problems caused by electromagnetic interference (caused by the monitors, radio or other electronic sites nearby the reader) any interference that may occur, may affect even seriously the proper functioning of the system until it is completely ineffective.

Finally, the same applies to the presence of metallic objects of large mass nearby the devices; these masses can act as "sponges" in relation to electromagnetic energy which should ensure field values high enough for activation and transmission.
So, with regard to the major problems that may occur during the selection and use of the transceiver, then they also differ in terms of:

- data record ability;
- size of any display installed on board;
- ease of use by novice users;
- software flexibility;
- ability to automate antenna operation;

- ability to mount an external antenna.

Only through a proper choice of a sufficiently powerful and sensitive antenna, its correct positioning in relation to the transponder and the environment and procedurally correct use can be achieved good operating results.
The literature is full with indications of how when these aspects are not fully taken into account will not determine the conditions of efficient and effective use of electronic identification systems, especially on moving animals.

In descriptive terms, then, the types of readers can be grouped into two categories: stationary readers, in which may happen that the electronic circuit and antenna are separate, and handheld readers (portable), in which the two units form a single system.

Stationary readers

In stationary readers the antenna is positioned at fixed locations and is the animal that is forced or induced to pass through a fixed course in front of the antenna being so identified. The size of the gap must not be greater than 75 cm to be eligible for the electronic identification system.
These are the types of readers that are in automatic feeders, in the milking rooms etc., where there is an automation control on individual animals production. It should be remembered that often the manufacturers of these systems do not use the standard frequency for animals electronic identification, but also other frequencies and in some cases, active-tag, eg. the pedometer.
This is because only in recent years has been standardized electronic identification systems, while the management of these systems are installed from years, and as they do not have to discharge the duties of cattle registration can use many different electronic identification systems.

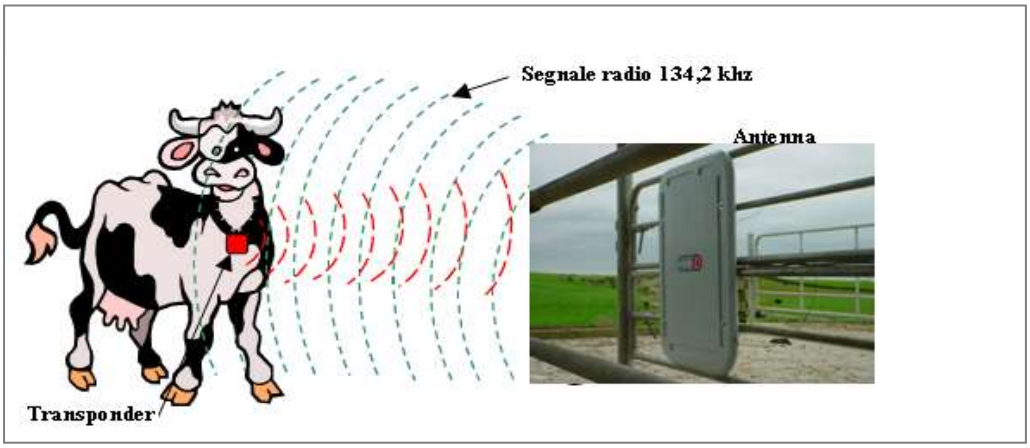


Figure 3.21 - Stationary reader functioning.

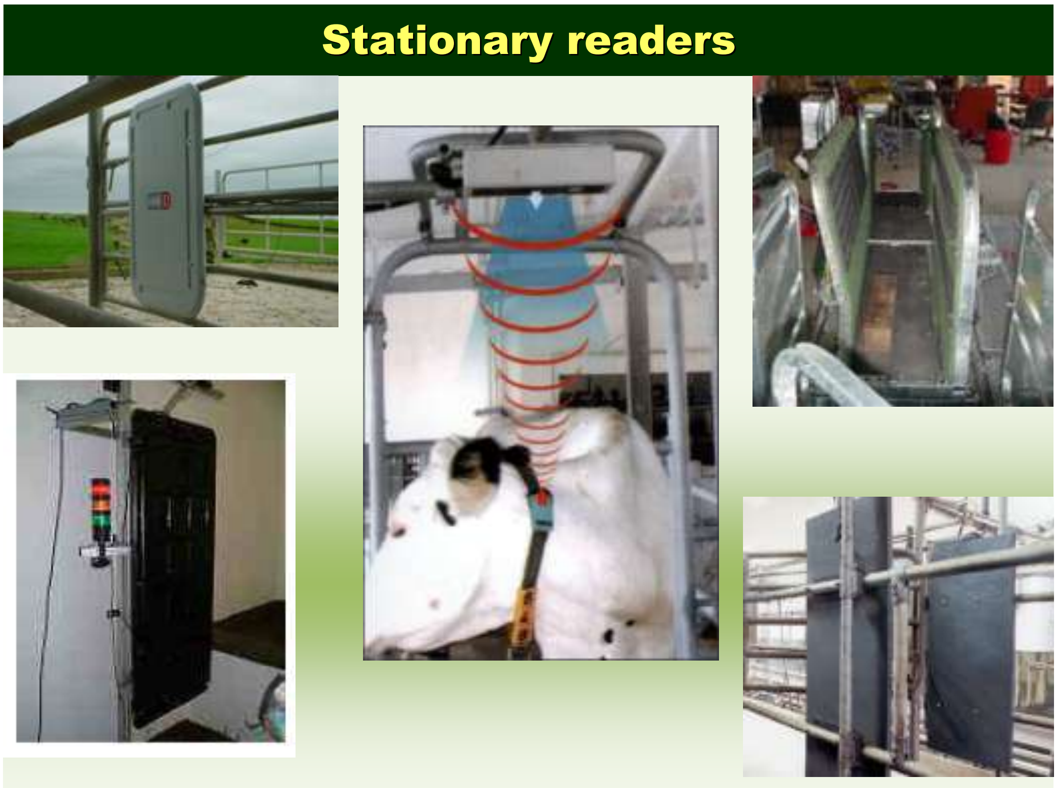


Figure 3.22 – Stationary readers types.

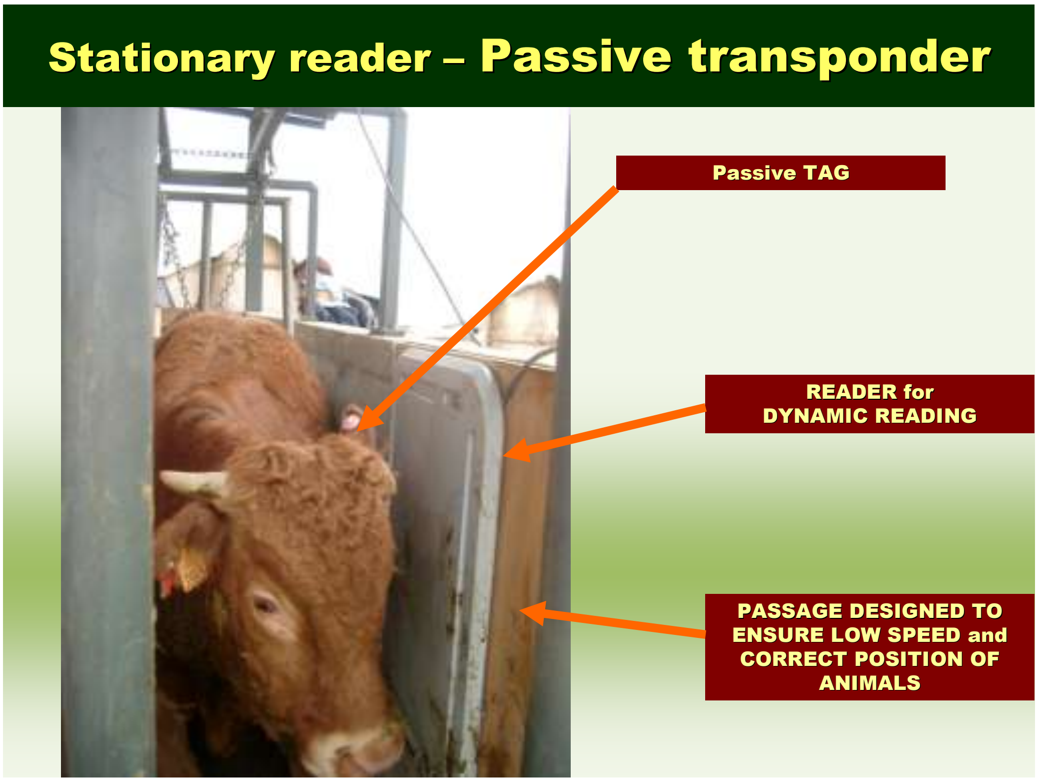


Figure 3.23 – Stationary readers for passive tags.

Handheld readers (portable)

The handheld readers are obviously powered by batteries and equipped with an antenna, keypad and display to read the transponder and store information obtained by it before transferring to the PC. The data are stored in a pull-tab type FlashCard and with a compatible player/recorder you can download information on a PC and transfer information on the apparatus.

The reading range is normally approximately between 15 and 25 cm closer to the animal and the operator must be able approach the animal to read the transponder. They are used for non-routine operations, such as registration of drug therapies outside the milking room, fertilization and recordings of special events.

Figure 3.24 - Different types of handheld readers.

Figure 3.25 - Different types of handheld readers for cattle, goats and pigs.

The operating principle of a Radio Frequency Identification (RFID) system is quite simple and basically consists of:

- Radio Frequency e-TAG (transponder): small size, passive type and consists of an integrated circuit (chip) with simple control logic functions and with memory;
- reader (wand, transceiver, etc..): a transceiver controlled by a microprocessor and used to examine, receive and store information received from the e-TAG;
- computerized management system that can process data stored in the reader in a flexible manner depending on the specific management needs.

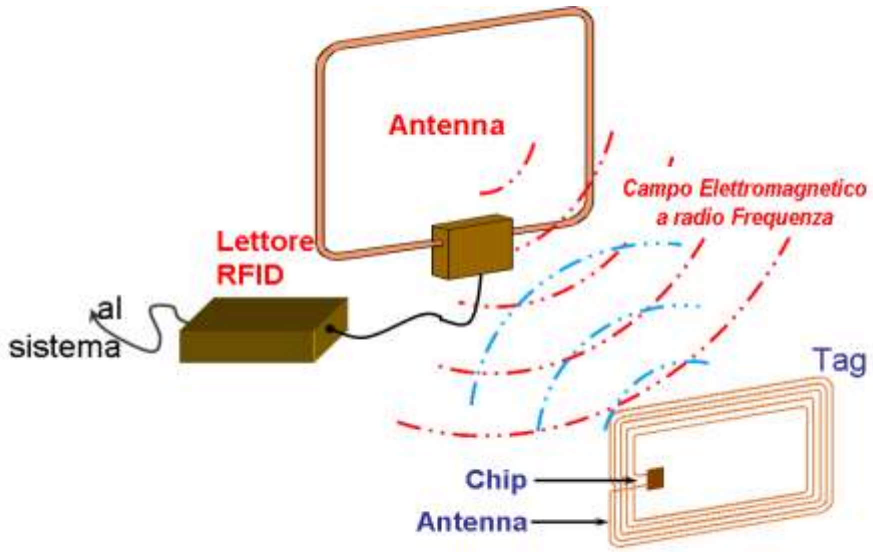


Figure 3.26 – Functioning scheme of an RFID system.

As mentioned, due to the fact that the ISO standard defines two different types of transponders, the transceiver should, to obtain approval for ISO, operate in a manner of radio wave transmission and reception of those who are relatively complex. The transceiver, in fact, be interpreted:

- two different base sequences of message;
- transmitted with different modulation frequencies;
- with the time pattern of transmission and different reading.

3.2.5 Experience of use of different tag types in different animal species

Here is a brief discussion on the various e-tags types currently available, as documented in the literature.

Injectable transponders

The injectable transponder is used not only in ruminants, but also for the identification of horses and dogs. Typically, injectable transponders are passive (Passive transponder Injected - PIT), that derive energy for their operation by an external field.
The sites of application in which several authors have tried to fit under the skin tags are numerous . For example in the case of cows, as shown in figure (Klintdtworth - 1998).

no.	body site	source	region in the animal
1	caudal fold	LAMBOOY, 1990; HASKER et al. 1992; LUINI et al., 1994	
2	coccygeal fossa, ventral and cranial direction	LAMBOOY, 1990; HASKER et al. 1992	
3	kneefold	LUINI et al., 1994	
4	armpit	LUINI et al., 1994	
5	upper part of sholder	DORN, 1987; GABEL, 1987	
6	below ligamentum nuccae	LAMBOOY, 1990	
7	caudal from nostril (lateral at the head)	LAMBOOY, 1990; NEDAP, 1991	
8	forehead (frontal at the head)	LAMBOOY, 1990	
9	fold behind the ear	LAMBOOY , 1990; WENDL et al., 1990	
10	**cartilago scutiformis (Scutulum)**	FALLON u. ROGERS, 1991; LAMBOOY, 1990; LUINI et al., 1994 PIRKELMANN und KERN, 1994 KLINDTWORTH, 1998	

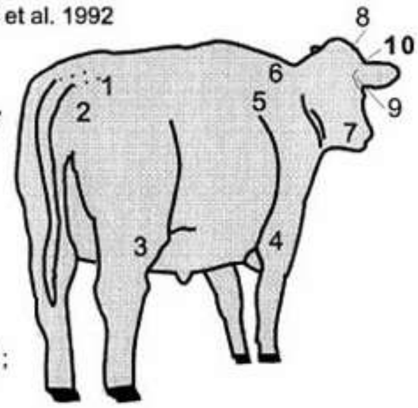


Figure 3.27 - Body sites of injectable transponders application in cattle (Klindtworth, 1998)

In general, however, the current approach is to predict their possible use at the base of the ear or in the axillary region (Stanford et al., 2001).

Adult sheep:

In sheep application sites are the underside of the ear, the ear base, the retro-auricular region and the axillary region (Conill et al., 2002). In Table 3.2, are shown the data obtained in adult sheep with injectable transponders (drafted by Nehring et al., 1998).

Table 3.2: Data obtained in adult sheep with injectable transponders		
	Axillary region	Base ear
Legibility	97.8 %	92.8 %
Losses	1.7 %	4.7 %
Breaks	0.3 %	2.5 %
Migration	1.3 %	6 %

We observe that as application site is preferred axillary region.
.

Lambs:

In lambs transponders (32 x 3.8 mm) are applied in two regions: axillary region and retro-auricular area (Conill et al., 2002). In the weeks after the application has not been found disturbances in the state of health of the subjects. By applying the PIT in very young animals occurred in 5% of cases, a penetration of the skin and it was necessary a second application after a week.

According to Conill, the ear, as application site, would be preferable in ruminants; during slaughter procedures, in fact, the head is separated from the rest of the carcass and the PIT can easily be recovered during the ear cropping or skin removing, reducing the possibility of having PIT fragments in the head or in the carcass.

The study shows that the use of small PIT applied in the ear reduces the efficiency of dynamic reading (Dynamic Reading Efficiency - DRE).
For the application of 32 mm PIT is necessary to use a different site of application compared to the ear, so are preferred the retro-auricular region and axilla, as in adult sheep and other animals.
In Table 3.3 some research data on the use of injectable transponders used in back-auricular and axillary region are reported (elaboration from Conill et al., 2002).

Table 3.3: Data on the use of injectable transponders used in retro-auricular region and axillary in lambs		
	Retro-auricular region	Axillary region
Losses	17.9 %	9.8 %
Recovery Time and percentage of discovery	< 10 sec 58.2 % < 20 sec 84.4 % < 40 sec 94.4 % < 1 min 97.6 % > 2 min 0.3 %	< 10 sec 57.4 % < 20 sec 78.8 % < 40 sec 89.1 % < 1 min 93.3 % > 2 min 4.0 %

Using PIT of the same type and same size, the average loss observed in the axillary region is greater for lambs than adult sheep. The reason is due to the application site and the behavior of young lambs. Animals with less than 2 weeks are very curious, so work with very young lambs is easier because the animal remains calm and allows the operator to make the application. In lambs of 15 days is observed, however, fear and strong reactions. The PIT loss in 30 days animals is rather similar to that occurring in lambs of 2 days or in adult animals. The loss in the retro-auricolar region does not seem affected by the age of lambs and is similar to that occurring in adult animals in the same region.

During the application there aren't transponders breaks or damages, probably due to its short duration.

The greatest PIT losses, in retro-auricular region, were attributable to the fact that this region is cut during the slaughter causing frequent breakdowns, and tracking would thus undermined, not being complete, from the farm to the end of the slaughter. The losses on lambs would be greater than those found in calves, probably because of the different procedures for removal (Connil et al., 2000).

Macroscopic damages don't occur to the carcass or the head in relation to the PIT application, respectively, in the axillary region and retro-auricolar area.

The recovery time is not affected by age or the breeding and it increases for the PIT in the axillary region and for those in the retro-auricular region. Again, recovery is recommended after the slaughter process.

Table 3.4 shows the regions in which the PIT are applied and sites where are subsequently recovered with their relative percentages (elaboration from Conill et al., 2002).

Table 3.4: Regions in which PIT are applied and sites which are then recovered with relative percentages in lambs.		
Recovery area:	Regions of PIT inoculation	
	Axillary region	Retro-auricular region
Skin	14.5 %	34. 7 %
Carcass	85.5 %	-
Head	-	63.8 %
Cervical region	-	1.5 %

Cattle:

In cattle are used PIT of different sizes (23 and 32 mm) that are injected into three sites: the axillary region, ear and upper lip. Table 3.5 shows some data on transponder application in these regions (Conill et al., 2000 and Luini et al., 1996, for the transponder 32 mm; Lambooij et al., 1999 for the transponder 19 and 23 mm).

Table 3.5: Details of the application of the transponder in cattle in different regions.			
	Axillary region	Auricle	Upper lip
Application time	37±3 sec (Conill et al. 2000)	44±3 sec (Conill et al. 2000)	51±4 sec (Conill et al. 2000)
Losses	1.7 % (Conill et al. 2000) 3 % (Lambooij et al. 1999)	5.2 % (Conill et al. 2000)	14 % (Conill et al. 2000) 10.1 % (Lambooij et al. 1999)
Legibility	98 % (Conill et al. 2000) 90-99 % (Lambooij et al. 1999)	94.8 % (Conill et al. 2000)64- 83 % (Lambooij et al. 1999)	84.7 % (Conill et al. 2000)
Recovery time	75±7 sec (Conill et al. 2000) ca.4 sec (Luini et al. 1996)	52±5 sec (Conill et al. 2000) ca. 50 sec (Luini et al. 1996)	27±2 sec (Conill et al. 2000)
Recovery	(Conill et al. 2000) < 20 sec 57.2 % < 40 sec 68.7 % < 1 min 73.1 %	(Conill et al. 2000) < 20 sec 36.6 % < 40 sec 64.9 % < 1 min 78.6 %	---

Studies indicate that the recovery time is influenced by the application position. The PIT recovery is simpler in the carcass slaughtered few hours before than in "cold" carcasses.

In all cases, recovery is recommended out of the slaughter chain, in the evisceration area, having to operate on ear and lip, and at the end of the slaughter for the axillary region.

Table 3.6 shows the regions in which PIT are applied and sites where are subsequently recovered with relative percentages (elaborate from Conill et al., 2000).

Table 3.6: Regions in which PIT are applied and sites in which are then recovered with relative percentages in cattle.

Recovery regions:	Inoculation regions		
	Axillary area	Auricle	Upper lip
Skin	10.7 %	23.4 %	8.9 %
Ear muscles	-	76.6 %	-
Head	-	-	91.1 %
Carcass	89.3 %	-	-

In this case, animals health and productivity are not affected by the application of the transponder.
Only 3.1% of cattle presented ear bleeding after application and 4.7% have been subject to drilling during the application to the lip. In these cases were reinjected transponders on the animals a week later on the same site.
3.3% of animals injected in the lip and 2.1% of those injected in the ear showed minor infections with pus formation and PIT rejection, caused by the application procedure.

The total percentage of broken transponder is 0.4%, while the percentage of readable PIT decreases with time in the lip and ear, but not in the axillary region. The losses percentage did not appear affected by the operator's manual ability and this shows that the method of electronic identification is easy to use even for unskilled personnel.

The dynamic reading efficiency varies depending on the application site: high for axillary region, middle for the ear, low for the lip. In all locations, the reading efficiency is higher with 32 mm PIT compared with 23 mm PIT.

There were no gross lesions of the carcass during the transponder application in axillary region, or head lesions during application in the lip and ear.

The results obtained on the farm, with 32 mm transponders applied in the axillary region, seem to suggest this region as the best one for electronic identification in beef cattle, despite the limitation represented by higher recovery time at the abattoir (Conill et al. - 2000).
Caja also indicates the axillary region as the place of choice for the application of transponders, while Klindtworth suggests the ear, but the procedure applied in this case is longer, so not suitable for great farms (Caja et al., 1998 quoted by Stanford et al., 2001; Klindtworth et al., 1999 quoted by Stanford et al., 2001).

Advantages and disadvantages of injectable transponder

Advantages:

- improved data transfer from the farm to a database. (Fallon, 2001);
- no errors associated with manual data transcription. (Fallon, 2001);
- easy application in young animals or small animals. (Caja et al., 1998);
- ability to identify live animal and carcass. (Caja et al., 1998).

Disadvantages:

- possibility of break, loss or damage of transponders (Stanford et al., 2001);
- transponder migration from the application site. (Stanford et al., 2001).

Ruminal bolus and electronic ear tag

Regarding the use of bolus, in his study, Fallon examines the various materials with which rumen boli can be made and compares chip application in the bolus and in the ear tag.
Rumen boluses are currently on sale in ceramics, in which the transponder is placed inside a ceramic cylinder, rumen boluses "monolithic" (composed of thermoplastic material), boluses of steel sheath (Fallon, 2001).
In beef cattle stress, caused by the presence of the bolus, is minimal (Stanford et al., 2001).
In 1 week calves, the bolus application did not appear to affect the growth and feeding (McAllister et al., 1998 quoted by Stanford et al., 2001). The digestibility is not altered in sheep and are not reported changes in cattle, sheep or goats rumen mucosa (Caja et al., 1999).

The introduction of foreign bodies (magnets, substances released from the bolus) in cattle or sheep rumen does not cause appreciable impairment of animals (Garin et al., 2003).
The loss through bolus regurgitation would have a margin of 46% in cattle (Hasker et al., 1996 quoted by Stanford et al., 2001) but is limited by changes in bolus shape and weight (Caja et al., 1999). Breakdown of the bolus have an incidence ranging between 0% and 7% (Caja et al., 1998 quoted by Stanford et al., 2001 and Lambooij et al., 1999).
Garin reports the use in lambs of rumen boluses of aluminum in two sizes: mini-boluses, which are applied during the first week of life, 9.3 x 37.4 mm, 5.2 g in weight, and small-boli, which are applied after weaning, 15 x 39.1 mm, 20 g in weight (Garin et al., 2003). The bolus application and its recovery after slaughter is species-specific, and its duration would be 24 sec in sheep, 26 sec in goat, 19 to 240 sec in cattle. (Caja et al., 1999).
The mini-bolus did not determine adverse effects in animal behavior after application. The reticulo-rumen weight and volume at different ages would be consistent with those in young ruminants. Moreover, the presence of the bolus would reduce the keratinization of the wall of the reticulum and rumen by increasing the motility of the forestomach. The appearance of the papillae in the rumen wall is consistent using both mini-boluses either small-bolus (Garin et al., 2003).
Table 3.7 shows some data obtained with boluses of different dimensions in lambs. (elaborated from Garin et al., 2003).

Table 3.7: Results obtained with boluses of different dimensions in lambs

	Ruminal bolus (9.3 mm diameter x 37.4 mm length x 5.2 g weight)	Ruminal bolus (15 mm diameter x 39.1 mm lenght x 20 g weight)
Growth, age at the end of growth and weaning weight	Not affected by bolus	Not affected by bolus
Losses	Between the fourth and seventh week	No verified

The bolus is usually recovered in the reticulum.
All boluses can be recovered at the slaughterhouse, from the reticulo-rumen of lambs. The recovery of mini-boluses may be in different locations in the forestomach of the lamb depending from their age: only 20% of mini-boluses of

animals slaughtered at weaning would be in reticulum and in those slaughtered at the end of fattening the percentage rises to 91.7%.
On the contrary all the small-bolus find themselves in the reticulum (Caja et al., 1999).
Table 3.8 shows the species-specific data on the use of bolus (elaboration from Caja et al., 1999).

Table 3.8: Species-specific data on the use of bolus		
	Sheep	Cattle
Application time	24 sec ± 3 sec	19-240 sec
Recovery time	8 sec adult sheep, 5 sec lambs	12-15 sec
Recovery percentage	100 % adult sheep and lambs	98.9-99 %

Table 3.9: Advantages and disadvantages of bolus and electronic ear tags		
	Ruminal bolus	Ear tag
Advantages	It can not be removed without surgery. (Fallon 2001).	Cheaper than bolus. (Fallon 2001).
Disadvantages	More expensive brand headset. (Fallon 2001). For recognition of animal breeding is a need for additional external method of identification. (Fallon 2001).	It can be easily removed and replaced. (Fallon 2001).

3.2.6 Use of RFID system and related issues for different categories of users

As briefly mentioned above, according to different categories of users of RFID systems, different types of prevalent use and operational issues can be detected, as well as various preconditions in order to maximize their use, and only through a careful evaluation of all the technical, environmental and operating characteristics, can be chosen the equipment and the optimum system to adapt to a specific management-productive reality.
The main beneficiaries in livestock sectors can be summarized as follows:

- breeders: in this context, the possibility to obtain, using an RFID system, an individualized management of the farm in an automated way permit to

combine to each subject a large number of productive-physiological parameters. Among the most interesting found “on field” must be remembered in dairy farms qualitative and quantitative parameters of the milk produced (no. somatic cells, protein and fat content, daily production, etc..), while those linked to meat traceability (high frequency of loss of ear tags in factory farms) and to production data such as weight gain and feeding system. It seems clear, then, how the ability to constantly monitor the administration, registration and verification of the withdrawal periods for drugs used cuold be a key factor in any production company.
The problems that are often found in the farming realities are primarily related to operational difficulties (inadequate facilities, unqualified personnel or poorly tolerant toward changes in working practices, extremely variable environmental conditions) and the need to use tools that interact with each other in a simple and intuitive way, without very elaborate procedures (eg. data transmission from a handheld antenna to a palm and then to a PC should be as automated as possible).

- associations: they are often in an intermediate position between farmers and the rest of the chain and the position of having to manage many different kinds of information from individual companies. These may include associations of race (ANaBoRaPi, Anafi, ANABIC, ANAS, UNIRE etc.), associations for the management of production data and statistics (AIA, APA, etc.), associations that offer services for animal husbandry and agriculture (Coldiretti, Confagricoltori etc.), farmers associations in the possess of production and/or labeling disciplinary (CQCB, CCBI, COBE etc..), associations representing the interests linked to particular geographic areas or production, producer cooperatives and associations developping specific marketing strategies or promoting a particular brand.
  The problems in this segment of the chain are linked in particular to the quantity and variability of data to manage, and therefore the study of highly flexible software systems that can be adapted to specific needs.
  Just think of the development of an integrated system of electronic identification designed for a cooperative of producers that give milk for cheese or for genetic selection of a beef cattle race.

- traders/slaughterers: For traders the possibilities and benefits of RFID systems are mainly related to the management of individual, transport, sanitary documents and the possible surplus that can generate a reliable animal identification method that limit possible fraud. It I sufficient to think about sanitary and of traceability issues existing in many countries and the usefulness of a system that can monitor, for example, imports of

livestock. The main difficulty in this area is represented by the large number and scattered picture of the industry, as well as the poor tend to work together.
The slaughterhouses, as well as the benefits of document management, standardized procedures for the recognition by electronic identification may lead to a complete and guaranteed "traceability" of thesupply chain. During slaughtering and cutting it is clear the extreme complexity of the system to develope, which starts from the recognition of live animals have to transfer and integrate these data through the various stages to appliances such as weighing and labeling machines, up to the balance of the store, ie the final consumer.

- administration: it is evident that the structures that need to manage centralized data bases where the data processed in the previous stages need to be stored and processed for a variety of purposes (eg.management of cattle premiums) may be particularly interested in possible developments that can "streamline" and further automate the complex practices, reducing input errors which are still quite common. The problems arise from a "crossroads" of multi-directional data and the need to use a single "path" that enables optimal communication of information. To illustrate, is possible to consider the data processing by the National Data Bank (BDN) of informations that come from the farmers, and that must combine data coming from slaughterhouses, which have to communicate the records to the specific "OCM Carni data base".

3.3 Materials and methods

3.3.1 Breeding area

Animals electronic identification provides many advantages in terms of management, beginning with the reduction in time and labor costs and reduce reading-recording errors respect to conventional ear tags visual identification (Artmann, 1993, Caja et al., 1999).

In a preliminary phase was also carried out a reading test of the ear tags at office level, ensuring the optimal reading distance of newly developed 50 transponders and 50 "open-head" e-tags, previously used in some farms.
The results showed a complete reading of the 50 electronic brands supplied for the project in question by a distance of 30 cm, while for the " open-head "

identifiers the distance was 26 cm. At longer distances were found for both reading failure at a variable percentage.

Figure 3.28 – Handheld reader HHR3000 Pro (ID&T – Norway) and e-tags used in the test

For the experimentation development were used electronic ear tags (Flex button, Demaplast, Italy), two types of RFID handheld readers (Edit wand, EditID, New Zealand; HHR3000 Pro, ID & T, Norway) and two stationary readers (Edit Crush Antenna, EditID, NewZealand; Edit Sheep Antenna, EditID, NewZealand) in the different types of farms.

The ear-tags were applied with a special pliers (Unifix) after immobilization of the animals with auto-capture at the manger, or at the weighing station (farm 1), in the case of adult cattle, while calves were immobilized directly on the ground in the boxes. With regard to milk goats, however, the restraint of animals occurred in part with auto-capture at the manger and in part directly in the housing boxes.

Stationary RFID readers (fixed antennas) were installed at the weighing station entrance (farm 1), at the milking room entrance (farms 2 and 5) and at the cattle catching station inside the corral (farm 6).
The e-tags reading with handheld readers took place at the weighing station for the farm 1, while in other cases took place in the crib, in the milking parlor entrance or directly in the boxes were animals are bred, according to the different types of breeding and to the animals age.

During the selection of the farms involved, the ear tags application, reading tests and monitoring required were found the following information:

- farm personnel interest about new technologies, particularly in RFID system;
- production, structural and management characteristics of the farms involved;
- ear tags application time;
- difficulties in ear tags application;
- personnel involved;
- ear injuries;
- post-application annoyance events of the animals;
- e-tags reading efficiency of different readers;
- electronic tags loss:
    - during the application;
    - at 24 hours after application;
    - after 1 month to 6 months.

An overview of the number of e-tags applied, of the application method used and the of RFID readers types used in different farms is given in Table 3.10.

In the description of the implementation of the system for the breeding phase, for each of the reality studied the implemented activities and partial results will be reported more specifically.

N	Breeding typology	N. *e-tag* applied	*e-tags* application procedure	RFID readers Used	Tests
1	Cattle beef (Fattenig and "cow-calf" line)	• 48 on fattening beef • 9 on calves < 3 months • 11 on 45-60 days .calves	• Through immobilization with auto-capture at weighing station (fattening beef) • Through manual immobilization directly in boxes (calves)	• Stationary (gap antenna at weighing station entrance) • Handheld	• *e-tag* application time • *e-tag* reading efficiency • ear injuries verification • *e-tag* losses within 6 months
2	Dairy cattle	• 48 on heifers • 12on calves < 5 months	• Through immobilization with auto-capture in the crib (heifers) • Through manual immobilization directly in boxes (calves)	• Stationary (gap antenna at milking room entrance) • Handheld	
3	Dairy cattle	• 118 on adult cows	• Through immobilization with auto-capture in the crib	• Handheld	
4	Cattle beef ("cow-calf" line)	• 34 on adult cows • 4 on adult bulls • 13 on calves	• Through immobilization with auto-capture in the crib	• Handheld	
5	Milk goats	• 78 on adult goats	• Through immobilization with auto-capture in the crib • Through manual immobilization directly in boxes	• Stationary (gap antenna at milking room entrance) • Handheld	
6	Cattle beef	• 68 on adult cows • 62 on calves	• Through immobilization with auto-capture in the crib •	• Stationary (gap antenna at animals capture station) • Handheld	

Table 3.10 - e-tagapplied , application procedures and RFID readers used for tests

3.3.2 Slaughtering and dissection phases

With regard to the slaughterhouse and dissection phase, the project is complex, due to the considerable flow of information to be managed and to the various production stages implemented; consequently, also the information and electronic equipment, as well as collection, analysis and data transfer methods used were particularly articulate.

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At the slaughter and dissection level of, the technological equipment in use includes:

- CATTLE CRUSH ANTENNA - READER CONTROL UNIT (EditID, New Zealand): placed at the corridor of rest for the animal identification inputs to slaughter facilities and prior to evisceration station for combination with microchips to the hooks;
- EMS readers and photocells;
- microchip applied to the hooks of progress of the carcasses;
- software for slaughter;
- dissection software;
- system read/write e-tag to be applied to cut food vacuum packing.

3.3.3 Store and shop area

As for the store and shop management, the following equipment has been installed:

- management software (OpenStore);
- reader/writer of RFID codes;
- weighing machines with an integrated RFID reading system.

3.4 Results and Discussion

3.4.1 Breeding area - Innovative management systems based on RFID technology in different types of production in cattle and sheep and goat

Cattle consistency is referred to the experimentation time.

Farm Noè Achille Giovanni – Castano Primo (MI) – 062MI007/1

Cattle consistency:
Calves < 6 months: 30
Calves from 6 to 12 months: 40
Slaughter cattle from 1 to 2 years: 3
Rearing males from 1 to 2 years: 15
Rearing cows from 1 to 2 years: 15
Other cows: 100
Total: 203 (143,80 Adult Bovine Unit – UBA)

Cattle typology:
Fattening beef (Limousine, Blonde d'Aquitaine)
"Cow-calf" line (Limousine, Blonde d'Aquitaine)

N° microchip: 70 (calves) – 98 (cows)

Here it has not been evaluated in particular the application system of electronic ear tags, but the validity of the interpretation and management of the information obtained.

In addition, we have tested an electronic identification system based on a combination of the official animal tag with a progressive electronic number by using the Edit handheld wand connected with Meazura Aceeca Palm, able to capture data related to the animal by reading the bar code of the passport.

Figure 3.29 - Use of PDA for reading passport data.

The results were not particularly noticeable from the operational point of view of the difficulties of handling the equipment that requires the simultaneous use of a reader and a PDA connected by a cable, of the difficulty of reading and recording/combinig of numerous data on field and of functional limitations of the instrument (eg. the palm has many gaps in temperatures below 0 ° C or reading the bar code of a passport when lighting conditions are not optimal).

For some problems, it was able to offset by a change in software that allowed to modify some work practices, eg. a preventive matching and loading of animals data in the office. However, the next opportunity to request from the BDR electronic ear tags bearing the correct identification number of the animal has moved the work to a careful analysis of procedures for the formal request for such brands and towards research and analysis of different and more functional instruments compared to that in use, with the collaboration of Demaplast srl, a company specializing in the molding of plastics for animal identification.

The results certainly more satisfying, at this stage are represented from automation of procedures for transferring data from the system reader/PDA to the management software *Titvlvs* of Consorzio Qualità della Carne Bovina of Milan.

Farm 1 - Scuola di Agricoltura Ferrazzi e Cova (Villa Cortese) – 248MI004/1

Cattle consistency:
Calves < 6 months: 20
Calves from 6 to 12 months: 10
Slaughter cattle: 102
Rearing cows from 1 to 2 years: 20
Rearing cows > 2 years: 20
Bulls: 3
Total: 185 (112,20 Adult Bovine Unit – UBA)

Breeding Typology
Fattening beef (Charolaise, Limousine, Blonde d'Aquitaine, french crossbred, Simmenthal)
"Cow-calf" line (Limousine, Blonde d'Aquitaine)

N° microchip: 48 (fattening beef) – 20 (calves)

Despite personnel preparation and availability were found significant operational and management difficulties. In the fattening farms often the structures are simple "boxes" and although in this case has developed a good system of cattle movement through access systems from every single box to the corridor leading to the weighing crush, loss of time is considerable given the extreme difficulty of reading directly in the boxes with handheld readers even though of the required length. Animals are not especially used to be handled and are therefore often restless.

It is estimated that in terms of operations are required at least 3 operators to apply ear tags within a satisfactory time; the operational procedure can be briefly described as:

- cattle movement from a single box to the corridor; the time required for this operation is extremely variable depending on the strength displayed by the animals, but for a box of 8 animals can be estimated between 2 and 5 minutes. The age of the animals has not shown significant influence, since younger and lighter animals are addressed more easily but tend to often "turn back";

Figure 3.30 - Cattle movement through the corridor.

- closing the group of animals in a specific oxbow in order to avoid the return of the animals; the time required is less than 1 minute;

Figure 3.31 - Oxbow in the capture system.

- individual animal capture; this operation is extremely variable, but using two operators at the extremes of capture system can be estimated around 1 minute;

Figure 3.32 - Capture system.

- ear tag application; ranging from 30 seconds to 2 minutes;
- ear tag reading; very short time: the reading is quite instant both with a stationary reader either with handheld wand, more time is required for any data combination such as weight, sex, race etc.;
- release the animal and address to the box; phase that does not involve particular problems because once the system to catch the animal is open it tends to move naturally towards the corridor.

As is clear from this description transponders application and reading are not a significant problem. In fact, overall, the time required for a box of 8 animals varies between 15 and 30 minutes and the only operation of application affects approximately 30 to 50%.

Issues:
In terms of e-tags application issues are identified relating to ear injury of the animal in 2 cases out of 48 applications (4.16%); in both cases were particularly heavy animals in the finishing stage and the wounding is attributable to more difficult and slow release of the pliers in animals with particularly thick skin of the ear, which were disturbed by the operation.

Losses:
In the 6 months of observation there were no losses of ear tags and this is particularly interesting if we compare these results with those found in the same structures using "open-head" microchip, in this case there weren't injury cases of the animals using pliers Zee Tags, equipped with an automatic release, but during more than a year of testing were detected 3 ear tag losses (3.33%),

probably partly due to incorrect application, as highlighted in the following figure.

Figure 3.33 - Ear e-tag applied.

The access structures to the manger represent in this type of farm a major cause of losses, and in this stable since there aren't auto-capture systems and being the feeder front predominantly occupied by horizontal tubular bars is greatly the possible points of friction are limited.

Figure 3.33 - The manger.

At the farm of the School of Agriculture Ferrazzi and Cova a work was also conducted for automating weighing procedures of the animals identified by ear tag and and for estimating the cost savings in terms of time of these operations. Once a month for 6 consecutive months, 6 boxes of electronically identified animals and 6 control boxes were weighed. This test has detected a reduction of

working time of about 4 minutes/box (total of 24 minutes less for each day) due to the recognition of the animal and the ear tag editing on the display of the scale (Tru-Test SR2000) . In addition to this were found 8 errors of manual data entry of 288 overall digits (2.77%), mainly due to poor legibility of the tags that were often dirty or partially covered by hair.
During two days of weighing the recognition of electronic identifiers and a manual matching of weight measured by the balance through the handheld antenna HHR3000 (ID & T) was carried out, having a time saving of about 16 minutes per day.

Figure 3.34 – RFID reading system and weighing scale.

Cow-calf line: 20 microchip (calves less than 3 months of age)
The barn is divided into milking cows with access to the feeder box similar to the barn for fattening beef. The cows are all electronically identified by bolus showing a code number that does not correspond to the visual tag, so the work was focused on calves born in the farm.
During the first phase the application of electronic ear tags to 9 calves younger than 3 months was provided, while in a second phase electronic identifiers have been applied to 11 newborns calves aged between 45 and 60 days.

The application was made directly in the box, where the calves had been previously isolated, because the farm capture system is not suitable to catch

young animals, but given their low weight application on the ground can be considered sufficiently ease and rapid (50-60 s).
The marked animals showed no particular discomfort during and after application, neither traumatic consequences in the following days, and after 2 months of the first application there were no losses of tags.

The electronic ear tags reading was performed with handheld reader (HHR3000 Pro, ID&T, Norway), it always proved easy, although it was carried directly into the housing box, with a percentage of missed readings of 0.8% (1 out of 128).

Farm 2 - Az. Agr. Rolla Luigi (Carugate) - 051MI001/1

Cattle consistency:
Calves < 6 months: 15
Calves from 6 to 12 months: 20
Slaughter cattle from 1 to 2 years: 10
Rearing cows from 1 to 2 years: 35
Dairy cows: 65
Total: 145 (104,0 Adult Bovine Unit – UBA)

Cattle typology: Dairy cattle (Holstein Friesian, crossbred cattle)

N° microchip: 48 (heifers) – 12 (calves)

In this dairy farm were conducted tests and demos relating to RFID systems, especially in the milking room where two fixed antennas are located at entrance and a synchronized reader can differentiate the readings.
Adult cows are all identified by rumen boluses showing a different code from the identification number of the animal, so it appeared very interesting a direct comparison between readings of bolus and ear e-tags.

In the first phase ear tags were applied to 48 heifers, not having boluses, directly in the manger, with auto-capture system. The microchip application was easy, with times ranging on average between 20 and 90 seconds per animal, justified by the habit of dairy cows to be manipulated. The largest time losses occurred to "call" - to trap them at the manger - the heifers more suspicious or hierarchically of lower levels, so accustomed to eat when the crib is more free.

There were no obvious signs of ear injury due to the application and only 2 slight cases were observed, probably related to incorrect affixing of the tag, but limited to few minutes post-application.

The first reading tests have been performed through the use of handheld reader HHR3000 Pro, since the animals were placed in a separate area from the milkingroom, with very good results both in terms of efficacy and reading distance (1,8% of missing readings on a total of 112).

In the second phase were applied electronic identifiers to 12 calves under the age of 5 months directly in boxes where they were housed, without highlighting particular problems in terms of application and reading by the handheld wand.
The application time was between 50 and 60 s, while the missing readings were equal to 1.1% (1 out of 94 readings).

In this phase the readability of ear tags, previously applied to heifers, has been even tested, through a fixed antenna placed at the entrance gate of the milking parlor. The placement of the stationary reader (EditID Crush Antenna, EditID, New Zealand) was not suitable for ear tags reading, as too low in position as designed for ruminal boluses reading, so that the ear tags reading was not effective because the high speed of heifers entry, not accustomed to the milking room. To resolve this problem, it has been decided to place in a horizontal position a fixed antenna of smaller size (EditID Sheep antenna) connected to a different control unit. This solution was comparable in reading efficiency to that specifically designed for boluses. The higher frequency of missed readings (1.6% out of 440) occurred in heifers that first entry into the milking room because of the greater speed of transit in front of the antenna.

With regard to e-tag loss, 3 months after the application it was verified only one case, probably due to incorrect application of the tag and off-center, as evidenced by the hole on the ear.

Farm 3 - Az. Agr. Sala Enrico e figli (Bellinzago Lombardo) - 016MI022/1

Cattle consistency:
Calves < 6 months: 50
Calves from 6 to 12 months: 60
Rearing cows from 1 to 2 years: 60
Dairy cows: 120
Total: 290 (192,0 Adult Bovine Unit – UBA)

Cattle typology: Dairy cattle (Holstein Friesian, Jersey, crossbred cattle)

N° microchip: 118 (cows, heifers)

In this farm it was decided to provide a similar experience to that developed in the Farm 2, since the farm has very similar characteristics. This is based both on the interest shown by the technical responsible to innovative meat traceability systems, either on the recent opening of a farm agritourism, in which the promotion of their products is certainly important.

118 ear tags has been applied to adult dairy cows. Given the presence of auto-capture system in the manger, the application did not lead to particular problems, with a time of affixing the electronic brands similar to those found on farm Rolla (20 to 90 seconds per animal). In this case there were no obvious signs of injury to its ear discomfort due to the application of its manifestations.

After 2 months the loss of two electronic identifiers has been highlighted, defensible in an extremely latera position application due to the presence of farm tags in a central position and to the probable constant friction against the auto-capture system.
During the ear tags reading verification has been used HHR3000 handheld reader, with very satisfactory results - both in the manger and at the entrance into the milking parlor – obviously considering the impossibility of such antenna to read continuously. In the manger was found 1,1% non-read tags on a total of 360.

Farm 4- Az. Agr. Galatea (Sulbiate) - 217MI001/1

Cattle consistency:
Calves < 6 months: 9
Calves from 6 to 12 months: 4
Slaughter bulls from 1 to 2 years: 4
Rearing cows from 1 to 2 years: 7
Other cows: 36
Total: 60 (45,0 Adult Bovine Unit – UBA)

Typology: Cattle beef ("cow-calf" line)

N° microchip: 34 (cows) – 4 (adult males) – 13 (calves)

The trial involved 34 adult cows, 4 calves and 13 adult males under the age of 5 months; 9 adult cows were excluded, to which were already been placed on rumen boluses.

The barn is divided into two paddocks with a central feeding lane and the cribs are in a bottom wall and presents a tubular inverted U for cattle trapping.

Figure 3.35 - Auto-capture system.

The major difficulties were found during animals capture, in particular with regard to younger animals, due to their small size and the difficulty to remain locked in this kind of auto-capture system.

Figure 3.35 – Trapped animal.

The time required for e-tags application on adult animals in these working situations resulted particularly long, overall of 4 to 5 minutes per animal, despite the employment of three operators.

Considering the difficulty in maintaining the animals in the capture system, the ear tags were applied without prior removal of visual ear tags, yet in terms of application, annoyance detection and injuries of the animals there were no

special issues, although in these conditions would be extremely useful automatic release pliers.
On calves, in consideration of the issues mentioned above, the microchip application was carried out directly on the ground immobilizing the subject in the housing box, with a time of approximately 50-60 s.

e-tags reading was made by using the handheld reader HHR 3000 Pro (ID & T, Norway) and a reading system consisting of an Edit wand (EditID, NewZealand) connected via serial cable to a palm. Both readers have guaranteed 100% of readings (92, 22 and 56 respectively for adult cows, calves and adult males with the first wand; 98, 24 and 60 respectively for the same groups of animals with the secondreader) even if the use of the first device, equipped with an integrated palm, has proved extremely functional in terms of operating system compared to the second consisting of the reader, a palm and communication cable.

During the first 6 months after the application, were not observed electronic ear tag losses.

Farm 5 - Az. Agr. Colombo s.s. (Gorgonzola) – 108MI015/3

Consistency: Goats: 275 (41,25 UBA)

Typology: “Camosciata” breed

N° microchip: 78 (goats)

This farm raise dairy goats, and the structures consist of a central structure housing the animals and an opened structure under roof divided into four boxes intended for the accommodation of 4/6 adult male animals.

The principal barn is a brick closed structure with a central feeding lane and animal lateral containment structures with modular boxes; on the half of the barn there is a mobile barrier that allows to create a corridor within which is possible to move the animals housed in boxes on the east side of the barn to the milking room. The farm can be seen from the management point of view divided lengthwise into two parts: in the first part are kept new born animals, young male animals and pregnant goats, while in the second part of the barn the lactating goats.

Despite its small size in terms of structure and number of animals raised, the farm management is well structured, with "auto-capture system" in the manger and the preparation and food ration administration by feed mixer cart.

Figure 3.36 – Goats auto-capture system.

The farm owner has immediately shown interest in the project and in particular to a structured and computerized management of the “herd book”, that in that moment showed significant gaps, so the preliminary working stage has focused primarily to solve these problems and on education of farm personnel about the correct working procedures and the use of the equipment (RFID reader and computerized management software).

It was also studied the possibility to install a stationary reading system at the passage toward the milking room, but for both managerial and structural characteristics, it was considered best the use of the handheld wand HHR3000, specifically programmed for manage the necessary data to draw up the “herd book”. This considering the facilitating reading animals in the manger and the development of an automated system for transferring data from that instrument to the computerized herd book sotware (Libro Stalla Informatizzato – LSI) and the printing of the documents required (model 4, “herd book”, animals cumulative registry).

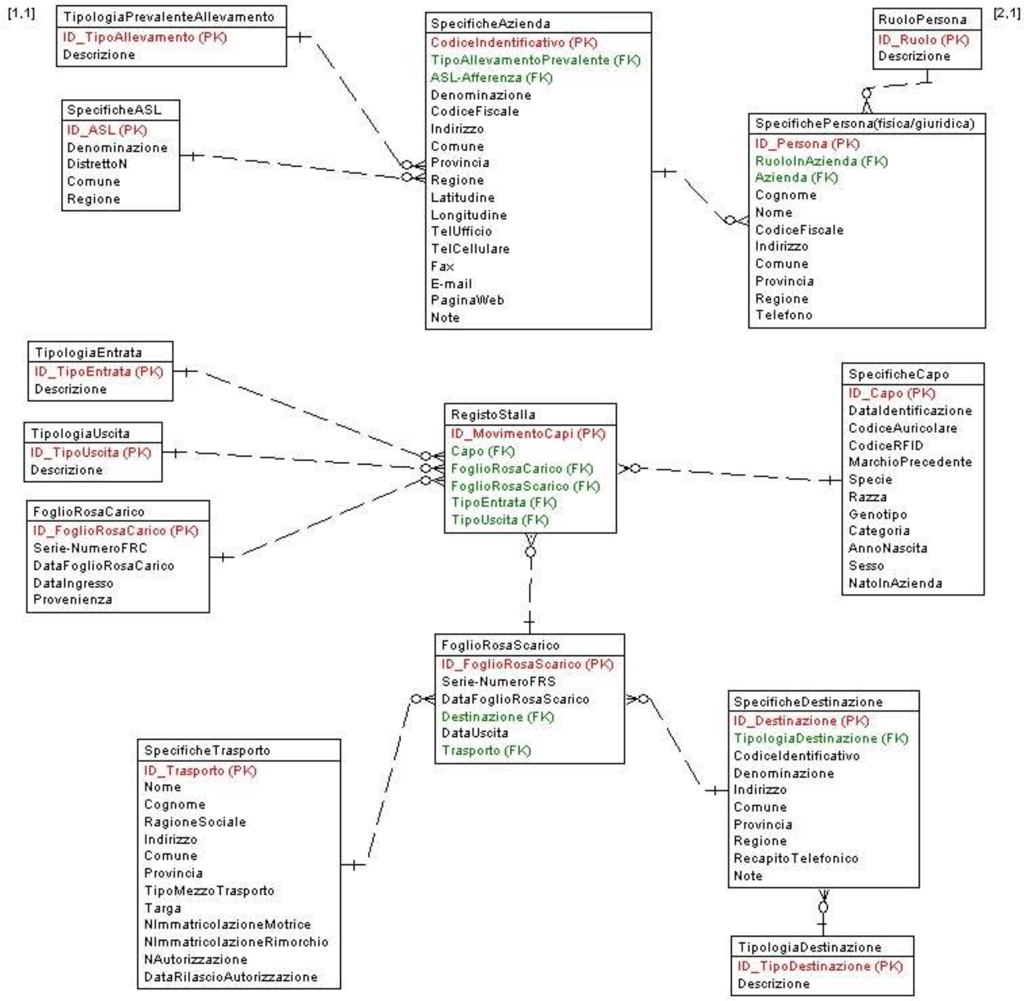

Figure 3.37 –Data base programmation (LSI software).

A total of 78 e-tags were applied to lactating goats, without highlighting particular problems in terms of operating with timing of application, employing two operators, of 20-30 s per animal using the auto-capture system at the manger and 30-90 s/head through animal immobilization directly into the housing box.

These data are significant when compared with those detected in cattle in similar operating conditions, ie use of auto-capture systems showed applicatione time of 20 to 90 seconds in the farms 2 and 3 up to 5-7 minutes verified in the farm 4.

The main operational difficulty encountered consisted of identifying the optimum point of e-tag application on ear size significantly smaller than in cattle and less visible ribs and veins. Surely can be attributed to this fact the frequent signs of discomfort occurred in particular during the application on the first group of animals (about 60% of cases), events that were significantly reduced in the subsequent groups (<20%).

Figure 3.38 –Ear e-tag application to milk goats.

From an organizational point of view it was not possible to apply transponders to the group of goats at a final pregnancy stage, because of the risk of abortion, and young subjects, because of the anatomical dimensions of the ear and the farmer reluctance considering the possibility to brand them up to 6 months of age.

The transponders reading has been tested in the manger, and reading failures (1.1% to 280) were only due to the auto-capture system incorrect functioning and, accordingly, to too short reading time for the handheld reader.

At 1 month from the application has detected the loss of a single e-tag in a subject in which, when applied, there was the formation of a fold at the top of the inner ear.

Farm 6 – El Amanecer (La Plata – Argentina)

Typology: Cattle beef (Aberdeen Angus)

N° microchip: 68 (cows) – 62 (calves)

The experience developed in the field of electronic identification through radio frequency technology has been internationally transferred, at the experimental farm of Facultad de Ciencias Veterinarias (Universidad Nacional de La Plata, Argentina). The farm El Amanecer has characteristics substantially different from those found in our area, mainly based on the exploitation of pasture and presenting grazing animals with very different morphological and productive characteristics. Therefore management problems and needs very different from those until now considered in this report have been highlighted.

The first working step has therefore focused on the study of the specific needs of the farm and on the *ad hoc* programmation of the HHR3000 reader, in particular allowing the management of delivery data and a combination of electronic identification of the calf with the mother. A transferring data system to a PC has then been developed, so that the reader could be optimally integrated and automated with the management system in use which provides for the subdivision in groups of animals.

Figure 3.39 –Ear e-tag application to cattle.

The application operational phase has been particularly easy, for the preparation of university staff and functional structure for collection, handling and capture of animals (*corral*).

Figure 3.40 – Cattle collection.

On average we have found application times ranging between 30 and 50 seconds per animal, with animals already placed inside the corral (*manga*) with four operators involved.


Figure 3.41 – Corral corridor.

From the point of view of ear injuries and annoyment events the results can be considered excellent, even according to the capture system that does not upset the animal and allows for optimal operation.
In the four days following the application does not appear to be any loss of ear tags, while at 6 months the loss was limited to one microchip applied on an adult animal.


Figure 3.42 – Cattle capture system..

Electronic ear tag reading was made by using:

- stationary antenna (EditID Crush antenna), placed at the location of trapping animals inside the corral, and control unit (EditID Control Unit). The reading efficiency was 100% out of 260 readings conducted on adult cows and of 224 readings conducted on calves;
- handheld reader (HHR3000 Pro, ID & T, Norway), along the *corral* corridor and by the operator involved in the management of the herd (*gaucho*) directly on the pasture during the operations carried out on horseback for the division of groups of pregnant and non pregnant cows. The reading efficiency was 100% out of 154 readings conducted on adult cows and of 163 readings conducted on calves.

In addition, the weighing system consisting of Tru Test XR3000 scale and load cells was combined with the reading systems, to automate the matching of the animal identification recognition with its weighing.

Figure 3.43 – Reading system combined with weighing system.

On 8 March 2008 it was organized at the farm El Amanecer, a demonstration of the developed system which involved about 65 persons working in agriculture and animal husbandry - farmers, livestock traders, representatives of private companies and representatives of trade associations and regulatory authorities in Argentina (Senasa and Ministry of Agriculture) - surely gaining excellent feedback.

During the day it was presented the management system using RFID technology for livestock grazing, which was then operatively shown through a dynamic reading of the transponder applied and the combination of weighing data both with stationary reader either with handheld wand HHR3000.
It was then shown the system used to transfer data collected through the reader HHR3000 to the management software developed.

The following discussion has shown a strong interest for this technology and attention has been placed in particular on how the system's efficiency is based on the initial data, recorded in the transponder, and on the importance of the correct and practical management of such data.

The final phase of work was dedicated to the education of the operator who manages the herd (*gaucho*) the verification of the use of the handheld wand, in particular for the division of groups of non-pregnant and pregnant heifers. The results can certainly be considered encouraging.

Figure 3.44 – Gaucho managing the herd trough the handheld reader.

The overall results in terms of average time of application of the microchip, ear injuries, losses and failure to read the e-tag of the tests conducted in the six farms involved in the trial are summarized in Table 3.11. These results are similar to those reported in the literature (Cox et al., 2006).

	Calves	Heifers-cows	Adult bovines	Goats
Microchips [n]	107	268	52	78
Minimum and maximum application time [s]	50-60	78-133	135-210	20-90
Ear injuries [%]	-	-	3,8	-
Losses within 6 months [%]	-	1,5	-	1,3
Readings [n]	501*- 224**	816*- 700**	470*- 216**	280*-390**
Reading failure [%]	0,4*-0,0**	0,7*-1,0**	1,1*-0,9**	1,1*-1,8**

*with handheld reader; **with stationary reader;

Table 3.11 - Average microchip application time, ear injuries, e-tag losses and reading failures in the 6 farms coverei by testing

3.4.2 Breeding area - Cattle and sheep and goats registry management through IT and RFID technologies

Cattle sector

For the recording of data relating to the individual animal and their subsequent transfer to the registry management software has been used a handheld wand EDIT (EditID, New Zealand) connected via serial cable to a PDA (Palm ™ Meazura, Aceeca ™, New Zealand) able to match the electronic tag number with the cattle visual number, in addition to a number of additional information about the single animal such as sex, race, date of birth, etc.. The handheld reader used is also equipped with an optical bar code integrated that allows the acquisition of the data produced by the cattle passport (Figure 3.45).

Figure 3.45 - Acquisition system of individual animal data at the enterprise level through RFID reader- PDA system.

For the informatic Registry management it has been implemented a computerized management software capable of responding to the complexity of the bovine registry and of the wide range of data related to it, which took about three years of development also involving a company specialized in agro-food industry software (APIS Software).

The system of recording data at a farm level composed by the handheld reader connected via serial cable to a palm has made it possible to successfully combine the number of electronic tags to visual animal tags in all herds in which it was used and showed full functionality in the transfer of recorded data to the management software *Titvlvs*. Limits, however, have been highlighted by the optical bar code when downloading data from cattle passport in unfavorable environmental conditions. In particular, the extreme cold in winter or excessive lighting have compromised their use. In addition, the reader connected via serial cable to PDA has proved unwieldy under normal operating conditions of the field.

Respect to the software *Titvlvs*, considering the final use by farmers of an association of beef producers (Consorzio Qualità della Carne Bovina), we opted for a web-oriented solution that would allow farmer-user via internet access through their own login, and while the system administrator (CQCB) to consult in real-time the database for inspection and technical oversight.
Overall, the system developed allows the automated transfer of information registered with the palm to the farm PC and an automated drawing up of the specific informations to their destination "fields" in the management software (Figure 3.46).

Figura 3.46 - Software interface to import data from handheld to Titvlvs.

The software *Titvlvs* presents a form input divided into two sections: Breeder, which manages data of the legal representative, and Breeding/s, where data related to one or more farms of the same owner should be added.
From the first window the farmer can manage a number of lists:

- slaughterhouses and seats;
- carriers;
- suppliers and customers, divided into suppliers/customers, market/fair, Hospital/Clinic, disposal companies, Pasture and Genetic Centre.

Each user has the ability to insert individual operators belong to the individual lists, which will then be visible to all users.
For slaughterhouses and suppliers/customers there is the ability to indicate whether they have obtained a permit to transport. If so it will also automatically entered in the list of carriers.
The main functions of the management software include:

- Animals load
  On the window Load Management are displayed entries in farm of cattle and the program allows a search by date and lot. From the same window you can print the list of cattle loads registered with their data (Origin, Pink Sheet- Form 4 number, Entry date, Entry reason, animals number) and, in order to facilitate the input of the animals, through the button "Transfer" you can directly import the animals from a farm present in the system by

calling up the number of Form 4 and the farm of origin. The creation of a new batch of cargo require to edit both load data on the Form 4, either general data on the individual animal to register. These data can be entered manually or automatically inserted through a special program built into *Titvlvs* for reading bar codes of the passport.
The software also provides a range of IT controls in order to facilitate data entry (eg in case of selection "Birth" as entry reason the field "Farm of origin" is self-compiled under the name of the farm and fields "Carrier", " pink sheet number ", "pink sheet date" are disabled and, while for the details of the animal is self-compiled "farm code/subcode" "and the word "calf "in the field "Entry category", and the fields "Date application ear tag" and " compilation passport date" become mandatory) and to limit entry errors (such as controlling the length of characters that make up the tag of the animal and of the mother, according to state recognition of origin);

- Unloading animals
  The window Unloading Management displays cattle exits and the program allows a search by date and number of pink sheet. As for the event of loading, from the window "Unloading summary" it is possible to print a detailed list of discharges recorded, and selecting the desired cattle exit through the "Print Form 4" can be printed pink sheets, self-compiled.
  The creation of a new cattle exit provide the input of Form 4 data, and the "Add animals" botton create a link to the list of animals loaded through which you can select the ones to unload, searchable by part number or identification number, date of entry or, if used, through the management of the barn.
  For discharge events are planned a series of controls, such as enabling or disabling of fields based on the destination of the cattle (slaughterhouse, farm etc.).

- "Herd book"
  It allows the automatic compilation of the register of loading and unloading, as taken from data entered in the system, on official format recognized by the Vetrinary Services;

- Cattle list
  By selecting "Cattle list" is possible to access the window "Cattle list management", where there is a list of animals included in the system, with the ability to search animals foridentification number, to include the animals unloaded, to sort the list by date of entry or by box. In this

section you can view data on each individual animal and its load and possibly its exit.
By selecting the button "Print" leads to a series of filters for the preparation of reports with different multiple selections of custom printing (Figure 3.47);

Figura 3.47 - Software interface for the preparation of customized reports.

- Barnes list
  The program enables the management and allocation of individual animals to a specific barn and box. From this screen you can select one or more animals to be moved to another barn or box, see the detail of the selected animal and print custom reports;

- Export Data
  By selecting the botton "Export data" there is the ability to create export file (batch file) in the format recognized by the regional database (BDR); the files that the program is able to produce and save, by selecting start date and end date, include the cattle registry (CANA), load movements (MCEN) and exit movements (MCUs). At present this function is being tested in seven farms that refer to two different local offices of Agricultural Assistance Centers (CAA);

- Consultation database
  The software provides, finally, the ability for the administrator (CQCB) to check for internal management and commercial purposes, the whole archive or selected farms through a series of filters.

Sheep and goat sector

In implementing the system of animals electronic identification the following devices have been used:

- ear e-tags Flexa button (Demaplast, Italy);
- RFID handheld reader HHR 3000 Pro (ID & T, Norway) equipped with an integrated and programmable PDA (Figure 3.48).

Figura 3.48 - Left: handheld RFID reader with integrated and programmable handheld; right: e-tag to the ear of an animal.

For the computerized management of the Registry have been developed a specific programmation of the RFID reader and a management software, called Computerized Book Stall (LSI), trying to meet the specific needs of sheep and goats farms and usable on any Windows PC. To implement the system the data approach followed was relational for the construction of the database (DB) and its subsequent "query" (Atzeni et al., 2006), while the user interface was built in Delphi (Borland, 2002) by using the new data access provided by this development environment.

Exploiting the potential of the RFID reader to be programmed and it has been developed an executable specification for the antenna, i.e., we have identified seven main events relating to an animal: new identification, purchase, receipt, sale, temporary exit, death, male recognition. The antenna handles individually each event and each one can be associated with the reading of one or more RFID codes. The antenna store for each code, i.e. for each animal, all events that have been associated by the user. Through the antenna designed in this way you can:

- acquire the RFID codes distinct for events of entry (new identification, purchase, return) and exit (sale, death, temporary exit);
- identify the male animals;
- set some parameters (date and time of reading, farm of origin, species and breed of animals, etc.).
- check the data recorded on the antenna and change any errors.

The LSI software developed is essentially composed of:

- a database (DB) in which data needed for breeding and load and exit of individual animals management are stored in a persistent way;
- communication with user interface for consulting the DB and data input and modification;
- the preparation to print exit documents Form 4, official "herd book", cumulative current situation.

Just this last point, being the ultimate goal of LSI, lead to the requirements on which to base both the architecture and functionality of the software. In other words, the software must be able to answer the following needs of the user:

- insert and modify data related to the farm (farm, personnel, Veterinary Service), to the barn archive (animal) and transactions (pink sheets);
- browsing of data stored in the database related to: animals, farm register and pink sheets (for example, placing a RFID code can view all entries and exits of the animal on the farm, entering a period of time can be viewed all entries or exits that occurred in that period, etc.).
- printing modules: preparing the forms printed ("herd book", annual farm situation, pink sheet of discharge).

The capabilities of LSI can be grouped into four categories:

- archives: allows inserting, editing, and consulting information about the farm and the personnel, sanitary services reference, animals, transport documents. The information required are mainly those used in the subsequent completion of documentation;
- events management: relates to the updating of information relating to entries or exits of the animals in or from the farm. This part can be independently maintained by manually entering the RFID codes of animals affected by the events, or the software recognizes events

downloaded from the antenna and not yet updated and proposes them to the user;

- forms: from this page you can fill out and print the information on the “herd book”, farm situation and the transport document. The modules are self-compiled in the official format (Figure 3.49);
- antenna management: refers to the acquisition of automated information previously recorded on the antenna and for the different events, approved and proposed to the user who has the task to test them, modify them and store them if necessary. Of course, downloading data from the antenna to the PC must be made at an earlier stage by the software supplied with the antenna itself.

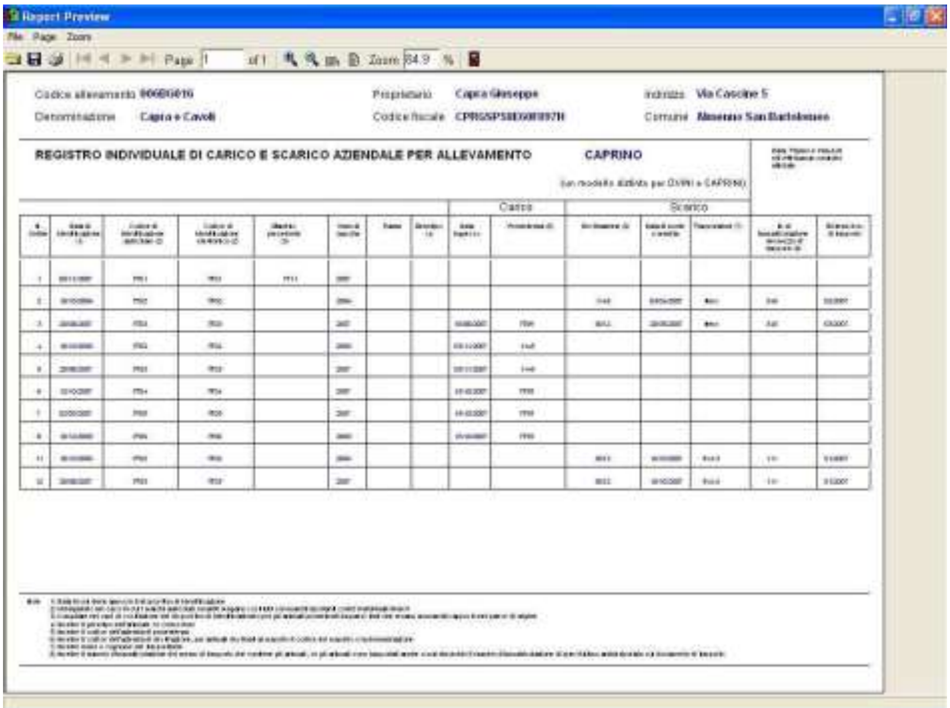

Figura 3.48 - Examples of forms printed by LSI: “herd book”.

3.4.3 Slaughtering and dissection phases

When arriving in the slaughterhouse, animals first stop in the standstill corridor at the entrance, where they receive an *ante-mortem* health inspection and a visual identification by a veterinarian. In this place a fixed antenna has been installed, so that the reading of microchip of animals can be made. At present, those animals with electronic ID do exclusively come from the “Consorzio Qualità della Carne Bovina” (CQCB), a cooperative for production of bovine meat, and are registered in the databank of the Cooperative itself. This way, the slaughterhouse management software automatically receives the incoming animals belonging to the Cooperative, with every information referring to the compulsory labelling and, through an automated control, is eventually authorized the voluntary labelling with optional data (foreseen by a specific Disciplinary of the Cooperative, with Ministerial authorization nr. IT054ET).

Once the operations of daze, bleeding and skinning are made, carcasses come to the evisceration area: there is a second threshold antenna here, and a system made up by a photocell and a EMS reader of RFID (13,56 MHz) codes, installed on the conveyor belt (Figure 3.50).
The fixed antenna reads the potential tag (ear tag or ruminal bolus), while the photocell on the conveyor belt detects the passage of the numbered hooks (to which the shanks of the carcasses will be hanging until the dissection area); on the surface of these hooks a microchip has been installed (one per each hook), so to computerize the operations of identification of the slaughter animals and then of the dissected parts, only by using electronic hooks. The passage of hooks before the photocell activates the reader, which identifies these hooks by reading the microchips inside, and in this phase the combination between animal ear tag and two hooks (one for each side) takes place. In the weighing area, if the animal was supplied with a microchip, it is assigned a slaughter progressive number and data are automatically visible on the screen, so that the operator just has to authorize the printing of labels (Figure 3.51); if, on the contrary, the animal had no microchip, on the screen all the identification numbers of the animals in the slaughter program are present, and the operator has to visually verify the ear tag purposely left on the carcass and to select from the list the correct one.

Figure 3.50 - Combining system of the microchip to identify animal and microchips on the hooks.

Figure 3.51 - Software for slaughtering.

From now onwards, to every animal identification number correspond a progressive number in slaughtering and two hooks identified by a microchip. On the slaughtering conveyor belt, near the weighing machine, two photocells are present, linked to two EMS readers of RFID codes. The presence of the double system photocell-reader allows not only the identification of the hooks and, consequently, of the two bovine sides, but also to detect their advancing direction along the slaughter chain (Figure 3.52); in fact, during slaughtering, the direction of both bovine sides toward the refrigeration cell (at the very end of the aerial weighing machine) will activate the first photocell and so the reader, so that the system, by detecting its direction, allows the following operation (charge or discharge).

Figure 3.52 - System photocell-reader to read the hooks and to detect the advancing direction of the bovine sides.

When both sides are drawn from the refrigerating cell or the store to be sent to the dissection area, they pass before the photocell on the right of the aerial weighing machine and activate the reader that detects the microchip present on the hook and the ongoing direction along the chain; data referred to both sides are recalled by the slaughter software and sent to the weighing machine, so to detect their new weight after the loss due to the cooling and put this last value in the dissection software.

In the dissection area there are three areas more with a photocell; to one of these a RFID reader is combined, to identify hooks (and consequently animal sides/quarters). The tag data collector is applied on the high conveyor belt, coming from the store cells, since in this step the final destination of meats is set; they can enter a working phase to be dissected or leave the factory to be distributed to external clients.

In both cases, data recalled from the previous weighing machine on the way out of the cells, and sent to the dissection software, are used to print delivery documents or to continue in the working.
From now onwards the traceability of meats is committed to the sole transit of the hooks before photocells: the last identification of the chips combined with the hooks determinates the creation of progressive numbers (unambiguous progressive number of label) combined to the hooks in the following steps. Like this, the first hook detected by the antenna of the dissection during a working session will be the first to pass before the photocell of the vacuum-packing or dissection area.

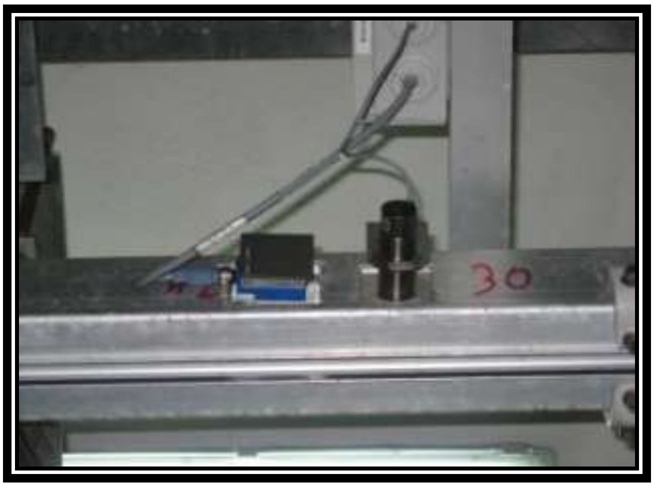

Figure 3.53 - System EMS reader-photocell in the dissection area.

Both areas are equipped with an aerial weighing machine so to combine to the traceability data, recalled by the dissection software, the weight of the single worked cuts. These data are displayed on two screens, called ST, placed under the electronic identification point of dissection.
The meat vacuum-packing area is equipped with a balance to which are combined a printer for the creation of adhesive labels with a PDF code (containing all the traceability data) and a device for reading/writing food tags to be put inside the vacuum-packages (Figure 3.54).

Figure 3.54 - Device for reading/writing food RFID tags to be put inside the vacuum-packages.

3.4.4 Store and shop area

Both systems can be used in the store of the Agricultural Cooperative San Rocco in Pontevecchio in Magenta (Milan): here, an optical reader that can read PDF data of the label, and an antenna, that can read data referred to the microchip, acquire data on the management software of the unsold stock of the shop (OpenStore) (Figure 3.55). Besides, a writer of RFID codes has been installed, used for creating tiny RFID "flags" for counter displays, in which is thus kept the code of the original lot.

The counter balances of the shop are equally equipped with a reader, which function is that of reading counter "flags" and so to recall the number of the lot they refer to, and to print the compulsory related information and in case optional ones on the receipt released to the client.

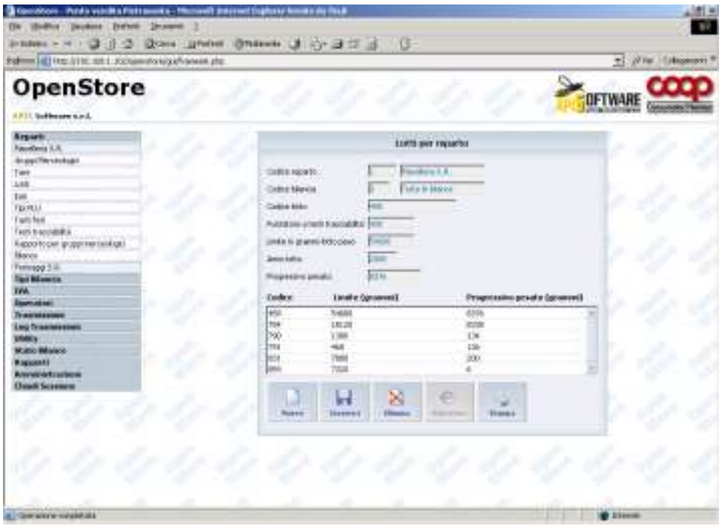

Figure 3.55 - Management software of the store/shop (OpenStore).

The integrated system developed at the facilities of slaughtering, dissection and sale of the Cooperativa Agricola San Rocco in Pontevecchio di Magenta (MI) is at present in the prototype stage, and during 2009 and 2010 were tested operational integration between the various stages, and specifically:

- e-tags reading applied to animals with stationary antenna located at the gateway corridor at the entrance of the slaughterhouse;
- automated transfer of information relating to the animal entering from the management software software *Titvlvs* to slaughterhouse software;
- reading test of the e-tags applied in the hooks through EMS-photocell system and applied to animals bystationary reader, and their combination at the evisceration area of the slaughterhouse;
- reading system of microchips applied to the hooks, recognition of the advancing direction of the carcass and automated labeling with mandatory and possibly additional information;
- reading systems and matching with "weightings" in the dissection area;
- labeling system of individual anatomical cuts and writing of food e-tags to be inserted in the vacuum-packed package;
- data acquisition system at the store/shop by reading the RFID code of the food e-tags;
- acquisition system of additional information relating to the animal by the counter balances by reading the RFID code of tiny RFID "flags" for counter displays "flags";
- automated transferring system of daily quantity of meat sold from counter balances to the management store software "OpenStore.

The system has been effectively tested during during the period March 2009 - September 2010 overall on 122 animals equipped with electronic identifiers, with a particular attention towards the integration of the different steps and to back-data; results showed a complete functionality of the system and a favourable administration of the whole productive process, from the entrance of cattle in the step of slaughtering to the issue of the receipt for the final customer, particularly referring to the maintenance of traceability data.

3.5 Conclusions

In the initial stage, the research consisted in the analysis and use of animal electronic identification systems based on electronic ear tags and handheld and stationary RFID readers in different productive reality: beef cattle (cow-calf line; fattening; pasture), dairy cattle and goats.

In general, from the operational point of view there has been a greater ease of introduction of animal identification systems based on RFID technology in dairy cows farms. In these situations, in fact, the benefits are attributable to the presence of: animals tends to be more docile and more used to being handled, more suitable housing facilities that usually include the presence of auto-capture system in the manger, trained staff to handle a significant data number also using special software.

The highest percentage of loss of e-tags found in the farms of dairy cattle, however, is largely attributable to the structure of auto-capture and increased handling of animals caused by the repeated entry in the milking room not always designed in an ideal manner.
In beef cattle farms, particularly those that are exclusively for fattening, you are confronted with animals in general tend to be more restless, simplified breeding structures, which often provide only a box division with no special systems for the capture, and a organization and management generally poorly developed.

This results in microchip application time considerably higher and higher risks for operators involved, difficulties to read directly in the boxes and less operators willingness in data management.
Farms with a "cow-calf" line are somehow an intermediate situation between the two above.

With regard to milk goats the main benefit is related to the small size of the animals, which are easier to handle than cattle. The disadvantages are due,

however, to the small size of the ears that make it difficult to enforce the microchip and increase losses, and to a "herd book" management with many lacks respect to cattle farms.
In conclusion, although this analysis of this phase of work should be extended to a wider period of time, experience has proved satisfactory in terms of results, showing a growing interest in RFID technology by operators of this sector involved and the achievement of a substantial stability of the identification system. Furthermore, compared with previous studies on the means of electronic identification, the results in terms of application, reading and losses of e-tags certainly appear encouraging.

The electronic and computer solutions developed for reading, storing, transferring the information recorded in the stable, and its further processing for the preparation of computerized documentation in accordance with the regulations, have shown functional and easy to use for farmers.
In particular, with regard to the cattle industry, 7 battery beyond the drafting of the computerized documentation is in a testing phase the sending of computerized records of animal movements directly to the Lombardy regional database (BDR), completely avoiding the use of paper documentation.

The integrated traceability system has been developed for the slaughter and dissection houses and the store/shop of the Agricultural Cooperative San Rocco, set in Pontevecchio di Magenta in the province of Milan, since they are part of the "Consorzio Qualità Carne Bovina" (Cooperative for Production of Bovine Meat), that owns a "Labelling Disciplinary" that obtained the Ministerial endorsement that allows bovine meats coming from associated breeders to be labelled with further information to the compulsory ones, so to guarantee more transparency on the peculiarities of the product for the final customer.

The operational steps that characterize the integrated automated traceability system in the bovine supply chain are briefly summarized below and described in a graphic showing a diagram of the slaughterhouse's plant.

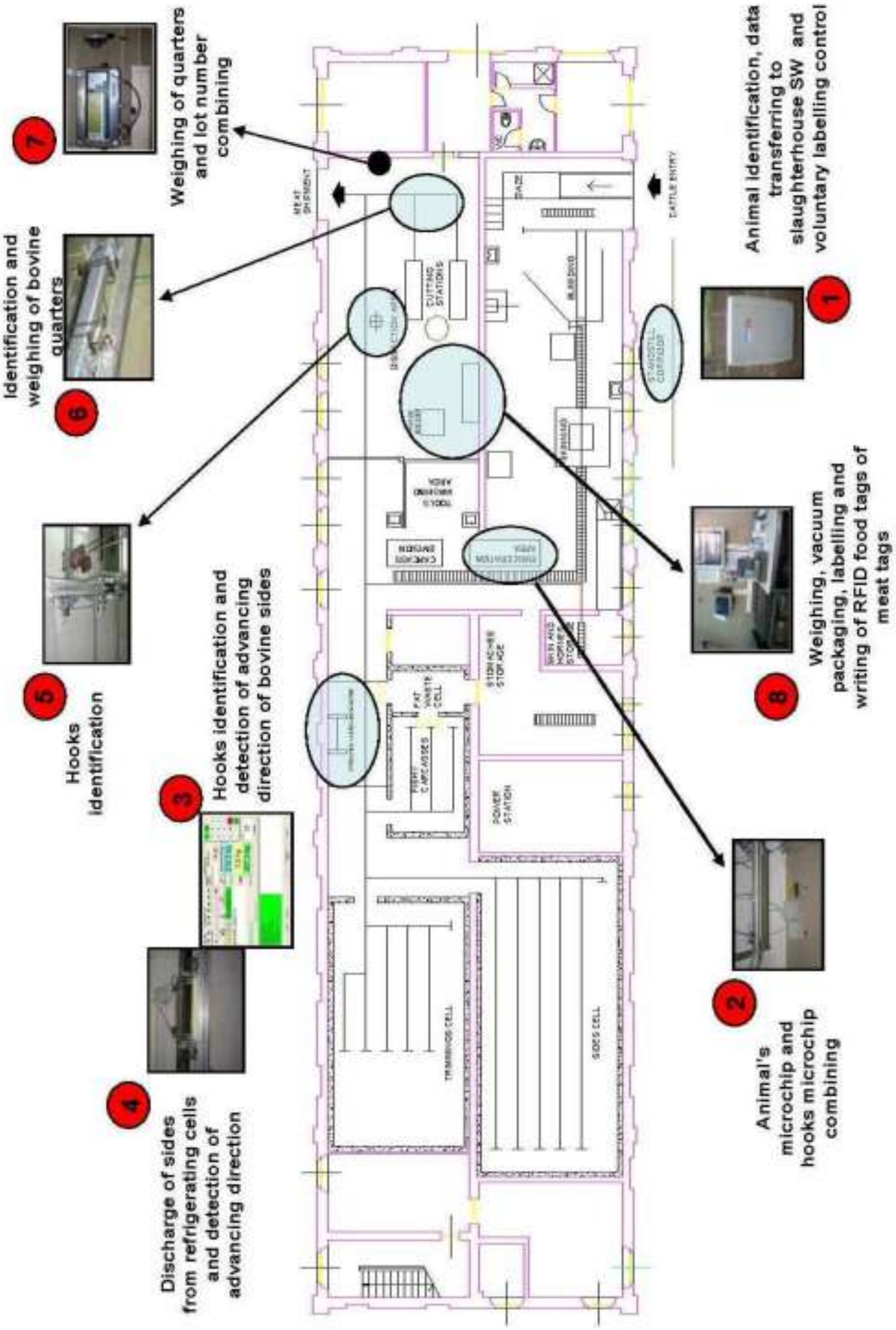

Figure 3.56 - Operational steps that characterize the integrated automated traceability system described in a graphic showing a diagram of the slaughterhouse's plant.

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CHAPTER 4

Study and development of a sensitized collar prototype with GPS technology to monitor the herds of cattle and goats flock, use of grazing areas and prevent cattle stealing

4. Study and development of a sensitized collar prototype with GPS technology to monitor the herds of cattle and goats flock, use of grazing areas and prevent cattle stealing

4.1 Abstract

For cattle and sheep and goats raised at the pasture occurs increasingly the problem of finding shepherds for the control of herds and flocks.
Increasingly, therefore, are presented to entrepreneurs problems of knowing the position of the animals for their recovery for management purposes and the need to avoid that they encroach into areas off-limits to them.
To find the location of animals and, therefore, replace the continuous activity of control over grazing by shepherds, one of the devices currently in use is the GPS (Geographycal Position System).

In a first phase a GPS sensitized collar was developed for a goats flock, using a software on the market, MyTrack, to manage the mapping and data stored on the locator and its programming.
The grazing area has been demarcated with a virtual fence and exploiting the Geofence function of the tracking system was possible to monitor the entry and exit of the flock from the preset area, and, in the case of an intrusion alarm sent by the tracking device on the mobile phone of the breeder, we proceeded to view the position of the device on the map with MyTrack software.

The implemented system has made it possible, despite the difficulty of receiving satellite signals that characterize the experimentation area, to identify the flock locations within the pasture in real time and displays the route, replacing the monitoring activities conventionally made by the shepherds.

Cattle stealing, for Italian legislation, is an aggravated form of theft, which occurs with the removal of three or more head of cattle or sheep in order to profit from it (Article 625 n .8 - Penal Code).
Since 2000, however, theft of livestock is a huge comeback affecting the entire country. In fact, in 2008 one hundred thousand head of cattle were stolen and intended to illegal slaughterhouses. It is, therefore, an offense that goes beyond the direct interests of agriculture affecting the whole community and, more specifically, product quality and public health.

The approaches taken so far to try to counter the cattle stealing phenomenon were limited to the territorial surveillance, on the other is not always feasible, especially in grazing areas often characterized by difficulties of access and remoteness from the business center.

Specifically, the second phase of the work, in collaboration with the APA of Forlì and Cesena provides the development of a prototype collar sensitized with GPS technology and management software developed *ad hoc*.

The developed system was based on the integration of the following mechanical, electronic and computational components:

• SAT locator (CSP Mediasystem) with GPS receiver SiRF Star III high sensitivity, the GSM/GPRS quad-band for the connection and powered by a rechargeable lithium-ion battery;
• External battery sealed lead acid with dimensions of 151x65x95mm and weighs 2.7 pounds, applied at the lower end of the collar and connected in parallel with the internal battery of the GPS locator in order to increase the operating time;
• GPS and GSM antennas integrated and applied at the top of the collar
• Software for mapping, recording data logged by the GPS locator and its programming was developed in collaboration with the company ARVAtec ® (Italy).

4.2 Introduction

For cattle and sheep and goats raised at the pasture occurs increasingly the problem of finding shepherds for the control of herds and flocks, and even when these workers are available, their remuneration is relatively high and weighs heavily on production costs. Increasingly, therefore, are presented to entrepreneurs problems of knowing the position of the animals for their recovery for management purposes and the need to avoid that they encroach into areas off-limits to them. Especially this latter fact leads to problems of relationships with other actors in the grazing areas, or adjacent to them, leading to unpleasant discussions that frequently tend to degenerate. In fact, in these cases can emerge from the unconscious of the different operators the ancestral dualism farmer-breeder that produced and produces a lot of damages for both.
The adoption of GPS systems in farming equipment to implement precision farming techniques and automatic driving machine has been for years the focus of researchers and practitioners (Lazzari, 2006).

To find the location of animals and, therefore, replace the continuous activity of control over grazing by shepherds, one of the devices currently in use is the GPS (Geographycal Position System). GPS receivers placed in collars, in multiple versions that provide different methods of data downloading (directly from the collar after his recovery, with transmission via VHF-radio or radio modem via local networks or satellite or, more recently, by phone or GSM GPRS) are used from time to monitor ex-post or real-time wildlife. In the field of animal husbandry, the GPS has found applications in studies relating to ethologists and pasture management (Rutter et al., 1997, Turner et al., 2000; Bailey, 2001; Ganskopp, 2001; Barbari et al., 2007) while is quite recent the proposal to use the same to support the management of pature in an automatic way through the technique of virtual fence (virtual fencing), thus avoiding having to install traditional or electric fences (Bishop-Hurley et al., 2007).
GPS technology comes the latitude, longitude and altitude by triangulation of radio signals transmitted by a system of 24 satellites geo-orbiting.
Detailed descriptions of GPS technology was provided by many authors (Moen et al., 1997, Rempel and Rodgers, 1997, Rutter et al., 1997, Hulbert et al., 1999, Turner et al., 2000).

In relevant aspects of animal monitoring, the major difficulties encountered in the development of devices to be used for the different needs were to have GPS devices accurate enough, especially in forest environments (Barbara et al., 2005), and of low cost. In this latter regard the problem of integration of the GPS receiver with the various ancillary devices for data recording, storing, processing and eventually transferring has always hindered the creation of simple, compact, lightweight and low cost systems. Recently, with the evolution of GPS technology appeared on the market systems for tracking commercial vehicles fleets that are intended to signal to a central means of deviations from a predefined route. These systems have been miniaturized and, recently, have been proposed on the market in configurations to suit the needs for personal security and tracking the movement of small pets. In these systems major, storing, processing, data transmission and reception of the settings have been integrated into a single electronic board meeting the objectives outlined above integration and miniaturization.

In parallel, we have witnessed the development of two innovations that, as an option, can be integrated into such devices. These technologies and SiRFInstantFixII and geofencing.

As regards the former, as mentioned, one of the limitations of the use of GPS in pasture areas is related to the screen effect that the leaves of the trees have on the GPS signal, resulting in decreased measurement accuracy.

The use of conventional GPS technology provides the use of algorithms to calculate the position of the receiver based on the known position of the satellites from which the receiver receives a radio frequency signal. The position measurement accuracy is related to the number of satellites the receiver can recognize during its operation. A normal GPS is powering up initially does not know the location of the satellites. First you must perform the "hook" to satellites. In situations where the part of the visible sky is limited, the receiver can take up to several minutes to acquire a sufficient number of signals with an acceptable accuracy to determine its position. Each satellite must then remain attached for at least 30 seconds to give the receiver the necessary information to make calculations of position (technical term "fix"). The satellite route data thus acquired then remain valid for a period of 2-3 hours. If during the period of acquisition, the signal is lost by a single satellite (the satellite is "decoupling") because masked by the presence of an obstacle (usually in grazing areas a rock wall, a fence, a tree) may be required several minutes to hang up the satellite and restore the foundations of sufficient data to calculate the position.

With SIRF technology the receiver has a software and a memory that can predict the position of satellites with an advance of 3 days. For this reason this kind of device is capable of operating even in weak signal environments, as typically happens in the presence of slopes in the woods, where the radio signals from satellites are shielded from the area's topography.

The second technology that was recently implemented in GPS technology for motor vehicles and personal protective is geographic fences (geofences). In the schedule in support of the system is now available a mass memory and a chip with enough computing power that can implement the firmware taking the functional characteristics of real GIS simplified type. In these devices can be loaded (via computer or by telephone) data demarcating areas and setting out the action it should take the system of recording and transmitting data when the GPS position measurement falls within these areas. In particular, for applications of interest here, there is the possibility that the system sends an alarm signal whenever it comes out feeling surrounded by a fence with this, one or more responsible of the occurrence of this event.

4.3 Materials and methods

4.3.1 Goats sector

The experiment was conducted in two successive periods (30 April-9 June 2008 and 17 June to 30 July 2008) at a farm (http://www.agriturismogulliver) in Valsassina in the province of Lecco. Particular attention was placed to the choice of this farm in order to validate the use of GPS collar in uncomfortable situations. The farm, in fact, lies in a valley of river origin, surrounded by a mountain chain that rises to a height of over 1.000 meters high, covering an area almost completely covered by a thick forest of hardwoods. For these characteristics, the difficulty of receiving satellite signals are very high, the limit of the foreseeable technological capabilities for GPS and GSM coverage area is not particularly reliable.

Considering the size of the flock (14 milk goats and an adult male) and the ethologic behavior of each animal - which tend to follow the leader - it was decided to use a single collar brought by the male to track the movement of the group (Figure 4.1). The collar was made by a professional satellite tracking device (GEOPOINT) equipped with a GPS receiver SiRF Star III with high sensitivity , GSM / GPRS quad - band(850/900/1800/1900 MHz) for the remote connection, and powered by a lithium-ion battery (1000 mAh). The main features and specifications of the device are shown in Tables 4.1 and 4.2.

Figure 4.1 - The GPS collar developed for tracking the flock.

Function	
Send location	SMS. After receiving the command sms the device send a message with location data to the phone number that sent the message
Automatically send location	Through the network GSM/GPRS the device can, in a programmed period, send an SMS or connect via GPRS to provide position data to a mobile phone or a PC, allowing to follow in real time the movement of the device
Recording path	the device can record location data for the subsequent reconstruction of the path taken by the location software MyTrack
Geofence and circular geofence	allows you to monitor the entry and exit from a preset rectangular or circular area
Speed limit	displays the speed and lets you set a limit to the excess of which an alarm is issued

Table 4.1 - Main functions of the satellite tracking device used.

GPS receiver	20 channels – 159dBm SiRF star III
GSM frequencies	850 / 900 / 1800 / 1900 MHz
GPRS	Class 10
Data memory vers. BOX	512 kBytes FLASH non-volatile
Data memory vers. STD	2 MBytes FLASH non-volatile
Communication port	n.1 USB
Sensors	Accelerometer
Material	ABS UL94-V0
Size/weight	74x74x23 mm / 120 gr
Battery	Standard Li-ion 1000mAh
Conformity	CE

Table 4.2 - Technical specifications of the satellite tracking device used.

To manage the mapping and data stored on the locator and its programming was used MyTrack software. In Figure 4.2 are shown all the elements that are part of the implemented system.

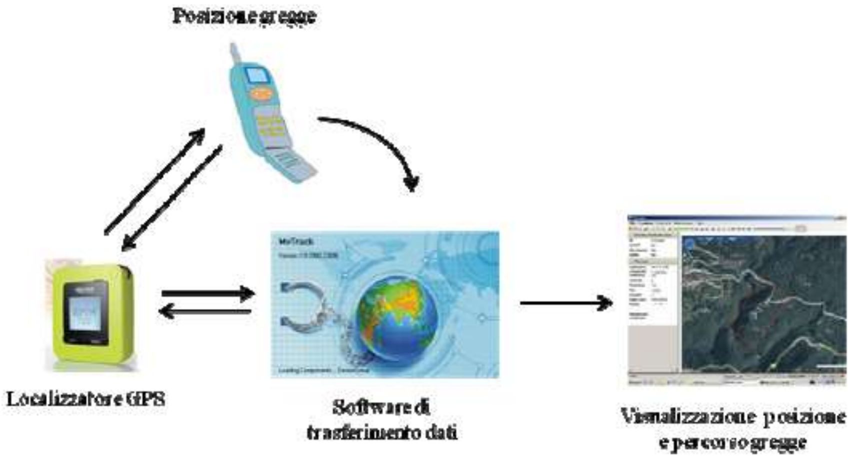

Figure 4.2 –Implemented system components.

The GPS collar was placed on the animal after the morning milking of theflock, immediately before it was sent out to pasture. In the late afternoon when the flock comes back to the farm for the evening milking, the collar was removed and proceeded to download data on PC. The battery of the device was subjected to recharge every night.

The grazing area has been demarcated with a virtual fence and exploiting the Geofence function of the tracking system was possible to monitor the entry and exit of the flock from the preset area. During the hours of grazing, through periodic interrogation by means of the tracking device, was tested for the position of the flock in the pasture and, in the case of an intrusion alarm sent by the tracking device on the mobile phone of the breeder, we proceeded to view the position of the device on the map with MyTrack software and, therefore, to recover the animals that had gone beyond the area granted to them.
The position data stored by the device and daily downloaded on the PC, however, have been used for display on the map with MyTrack the paths and trespassing of the flock from the pasture area.

4.3.2 Cattle sector

At a later stage of experimentation, it was decided to transfer the positive experience developed in goat sector as a basis for developing further sensitized collar with GPS technology applicable to cattle grazing.
The activity was divided into 4 main phases:

- analysis of commercially available technology suitable for specific production needs of the farms involved and the development of a prototype of collar;

- testing in the breeding of beef cattle School of Agriculture Ferrazzi and Cova of Villa Cortese (MI) to assess its ergonomics and practicality;

In particular, the collar has been reviewed in accordance with the following characteristics:

> - do not disturb the animal while still providing strength and stability;
> - receive and transmit signals in a variety of environmental and breeding conditions;
> - be easily applied and removed in order to transfer data to the central system (PC).

Figure 4.2 - Sensitized collar prototype with GPS technology.

- testing phase of the GPS collar prototype on a farm with animals having available a wide range for motion (Az. Agr. Sabbiona of Brembio - LO), in order to verify the operational functionality of:

> - detection System;
> - data transmission and analysis;
> - Geo-fence system.

During this phase has been identified the incompatibility of the external antenna supplied with the collar, as it represents a possible point of "hook", that in two circumstances caused the detachment of the collar itself. It was then proceeded to change the collar using a different form of flat circular antenna located inside the collar, in subsequent tests proved to be an optimal solution.

- Following discussions with the APA of Forlì and Cesena, in whose area of responsibility, specifically the area of Bagno di Romagna in the Apennines, there were frequent cattle stealing phenomena, it was decided to establish a partnership to implement a management software on according to specific needs identified, however, starting from the experience developed in previous research and testing.
  The preliminary stage of work focused on the study of the optimal system of allocation of the various components to be inserted in the collar and the search for suitable materials.

In summary, the collar is composed of:

- GPS-GSM-GPRS device and batteries placed in the lower portion of the collar;
- antenna for GPS signal: located in the upper portion of the collar and plugged in it;
- antenna for GSM signal: located in the lower portion of the collar and connected directly to the device.

4.4 Results and discussion

As for the goat sector, during the first experimental period (30 April-9 June 2008) totally were detected and recorded by the localizer 1965 events of which 18.9% (372) relating to the loss of GSM (GSM Signal OFF) and 16.6% regarding the "release" from the satellite (Satellite FIX OFF). In this regard, however, it should be noted that the “hook” with the satellite took place in a relatively short time, only in some cases surpassing the 60 s. In the same period, moreover, had been found 13 trespassing (EXIT Geofence) from the virtual fence that required the intervention of the farmer for the recovery of the flock.

In the second experimental period (17 June to 30 July 2008) totally were detected and recorded by the localizer 3771 events: 18.4% (694) relating to the loss of GSM signal (GSM Signal OFF) and 18.7% (705) regarding the "release" from the satellite (Satellite FIX OFF). Again, like the above, the “hook” of the satellite is done in a short time only in some cases surpassing the 60 s. In the same

period, moreover, had been found 29 trespassing (EXIT Geofence) from the virtual fence that required the intervention of the farmer.
Regarding the cattle breeding, the placement of antennas, as described in "Materials and Methods", was designed specifically for the purpose of having two completely separate receiving line, because the device has an additional alarm that is sent in case of loss of GPS signal, but it must be able, for example when cutting or tampering with collar, it is possible to send an alarm message via the GSM network. For the search of suitable materials for the construction of the collar, was initially tested a particular canvas, determined to be not suitable as it is not strong enough and as it has presented significant problems for the screws. It was therefore decided to use the leather, material extensively tested on grazing animals accustomed to the use of bells; subsequently was tested a particular coating material, polyethylene foam, closed cell (Plastazote ® , ZOTEFOAMS, UK), with really good results in terms of significantly decrease the possibility of injury to the animal skin while improving the water resistance, wear and so on.

With regard to the management software, ARVApastore v.1.0 were provided the following sections:

CAD (Figure 4.3)

- ability to import shape file (vector-boundary fences, such as the cadastral units) and ECW files (aerial photographs) or raster, and the different types of imported files can be viewed on the main software screen superimposed;
- designing virtual fences; the software allows to set up 10 fences as polygons (up to 12 vertices) or as nooses, pointing the center and the radius; the device (collar) sends an alarm for any entry/exit to/from any virtual fence set;
- by selecting a specific fence created appears the polygon area, perimeter and number of vertices, while the for the noose is indicated area, circumference and radius;
- provision of the layer: allows the management of the display of the map file imported and to calculate the real distance between points.

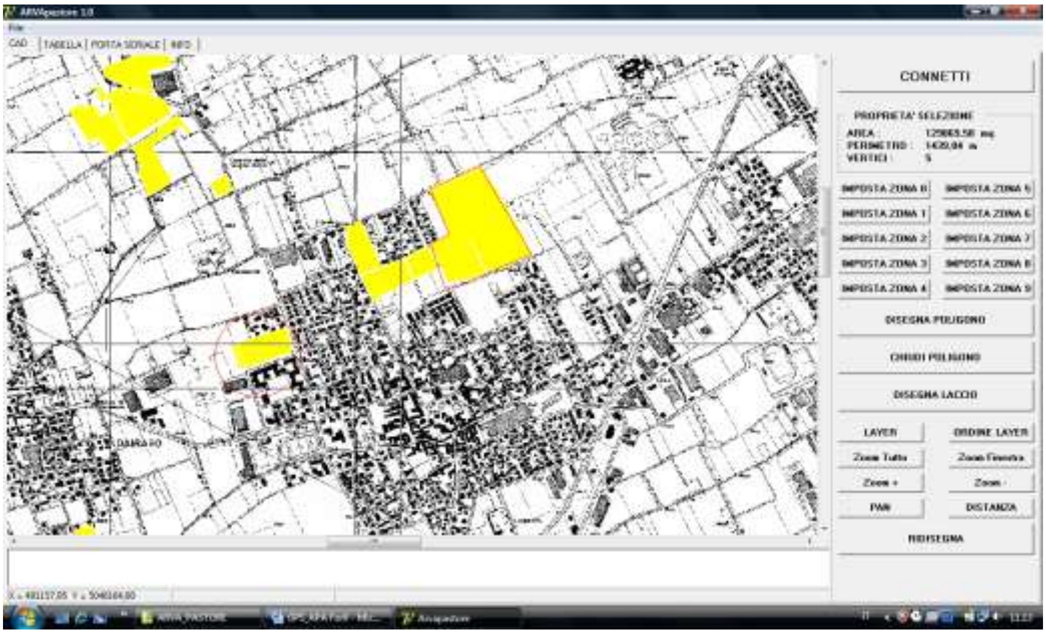

Figure 4.3 - Map setting with virtual fencing (CAD).

TABELLA

- display of fences set: the software allows to identify the fences with some basic information, the first box is identified with P if it is a polygon and with R if it is a noose, while the other boxes indicate latitude and longitude of each vertex for polygons or latitude and longitude of the center and the radius of the noose;
- setting the name of the device: in order to give a more friendly approach to the farmer, in this section, you can name the device, which will appear when receiving the alarm alerts via SMS;
- destination alarm: the program lets set up to 3 mobile phone numbers, to which will be sent alarms;
- tolerance alarm: it has the ability to set a defined area of pre-alarm, ranging from a minimum of 10 meters.

4.5 Conclusions

The implemented system has made it possible, despite the difficulty of receiving satellite signals that characterize the experimentation area, to identify the herd locations within the pasture in real time and displays the route, replacing the monitoring activities conventionally made by the shepherds. Geofence function of the satellite tracking devices were also successfully found the animals trespassing from virtual fences pre-set, putting the farmer in a position to make a rapid recovery of the flock. With regard to GSM signal loss, finally, a performance improvement could be achieved using a GSM/GPRS SIM card with two automatic switching on the operator with the best signal, so as to ensure maximum coverage.

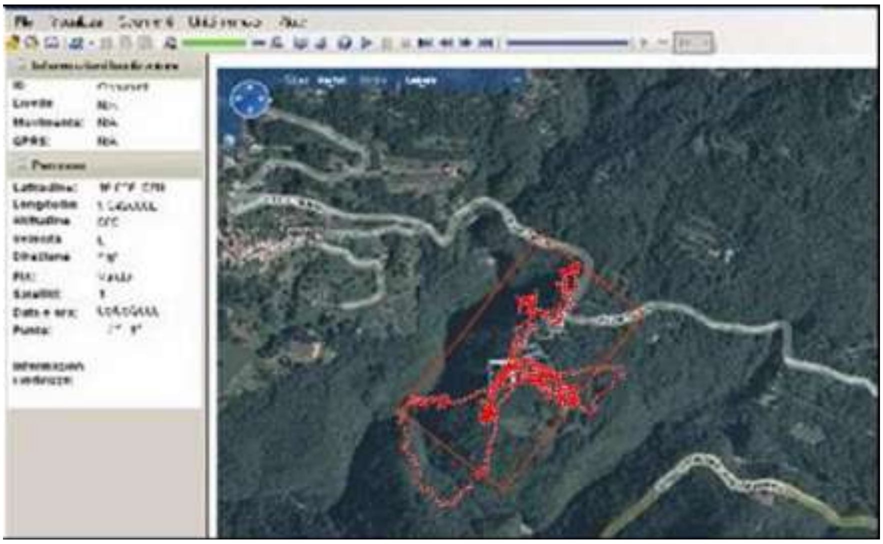

Figure 4.3 - Positions and geo-fence trespassings of the flock displayed by My Track software.

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CHAPTER 5

Study and development of an integrated system for slurry management monitoring and electronic reports drawing up in cattle breeding

5. Study and development of an integrated system for slurry management monitoring and electronic reports drawing up in cattle breeding

5.1 Abstract

Over some years a new concept, identified as "precision farming", was introduced to improve field and farm management from agronomical, technical, environmental and economical perspectives through the use of new technologies, such as global positioning systems (GPS), sensors, satellite images and geographical information systems (GIS). Environmental and food safety regulations are becoming more and more hard-and-fast asking farmers to increase their organizational and technical skills for a well-integrated agro-territorial management. Aim of the research activity was the implementation of an integrated system for animal slurry management monitoring and electronic reports drawing up in cattle breeding in order to optimize the fertilization management and reduce the agricultural impacts.

The developed system was based on the integration of the following mechanical, electronic and computational components:
- slurry production control subsystem, based on ultrasound sensors applied to slurry pits and pressure sensors applied to a slurry spreader;
- slurry spreading subsystem, constituted by an electronic card specifically developed and by a GPS/GSM device applied to tractors, able to automatically recognize the linkage with a slurry spreader and to notice its position on field;
- recording and spreading data visualization subsystem, based on a GIS able to elaborate slurry distribution maps with relative distributed quota and spreading periods;
- palm PC with a specific software (FarmWorks®) for field operations recording and data transfer to farm PC;
- management software (FarmWorks®) for field data filling and electronic reports drawing-up.

The developed system, tested in a Northern Italy farm during 2008, has shown full functionality enabling to monitor animal slurry management (storage, collecting, spreading) and to optimize agricultural operations and fertilization management under an economical and environmental point of view.

5.2 Introduction

On animal farms slurry is become the dominating in-farm fertilizer that is applied to grassland as well as to many arable crop species (Schellberg and Lock, 2008). Slurry is a liquid organic fertilizer containing mainly nitrogen (N) but also phosphorus (P) and potassium (K) in varying amounts depending on origin (cattle, pig, poultry) and animal feeding (Van Kessel and Reeves, 2000).

Over the last decades the increasing intensity of animal husbandry increased amounts of slurry leading to local over-fertilization and nutrient release to the environment (Hooda et al., 2000; Sangiorgi , 2003; Bleken et al., 2005). As a consequence slurry management has become an increasingly crucial component in the operation of animal farms. Following the European wide recommendations to control slurry application depending on crop demand and environmental conditions, automatic control technologies have been developed to support farm field operations and to minimize waste and pollution. In recent years global positioning system (GPS) has become common on manure and slurry spreaders.
A GPS system can accurately indicate the spreader location in a field and when coupled with a device for indirect flow control, it can provide precise slurry or manure application rates and record where the organic fertilizer has been applied allowing the producer to optimize nutrient usage and respect environmental concerns for nutrient loss.

Aim of the project was the implementation of an integrated system for animal slurry management monitoring and electronic reports drawing up in cattle breeding in order to optimize the fertilization management and reduce the agricultural impacts.

5.3 Materials and methods

The system for animal slurry management monitoring was implemented at the experimental farm of the Agricultural School Ferrazzi and Cova (Northern Italy). The farm covers 150 hectares and about 200 beef cattle are raised.
As first step a farm mapping with the introduction of the single land registry plots laid upon an aerial photograph in a Shape file format (.shp) and the partition or grouping of the lands according to their use (Figure 5.1) was carried out through the use of a mapping and layering software (Farm Site, Farm Works Software, Hamilton, IN, USA).

Figure 5.1 - Farm mapping through the use of a mapping and layering software FarmWorks®.

The monitoring system was implemented at two different levels.
At a first level the system was based on the use of a personal digital assistant (PDA) with a specific software (Farm Trac Mate, Farm Works Software, Hamilton, IN, USA) for recording field operations, downloading data into a farm PC, and printing detailed reports of spreading activities (Figures 5.2 and 5.3).

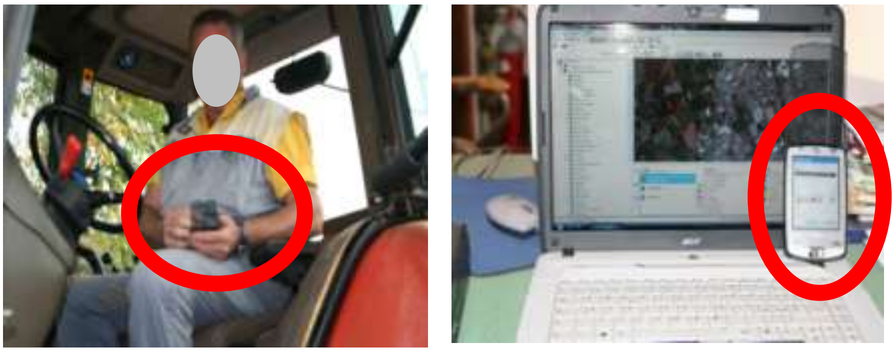

Figure 5.2 - On the left: data entry carried out by the operator before spreading activities; on the right: at the end of the spreading activities data were downloaded into the farm PC

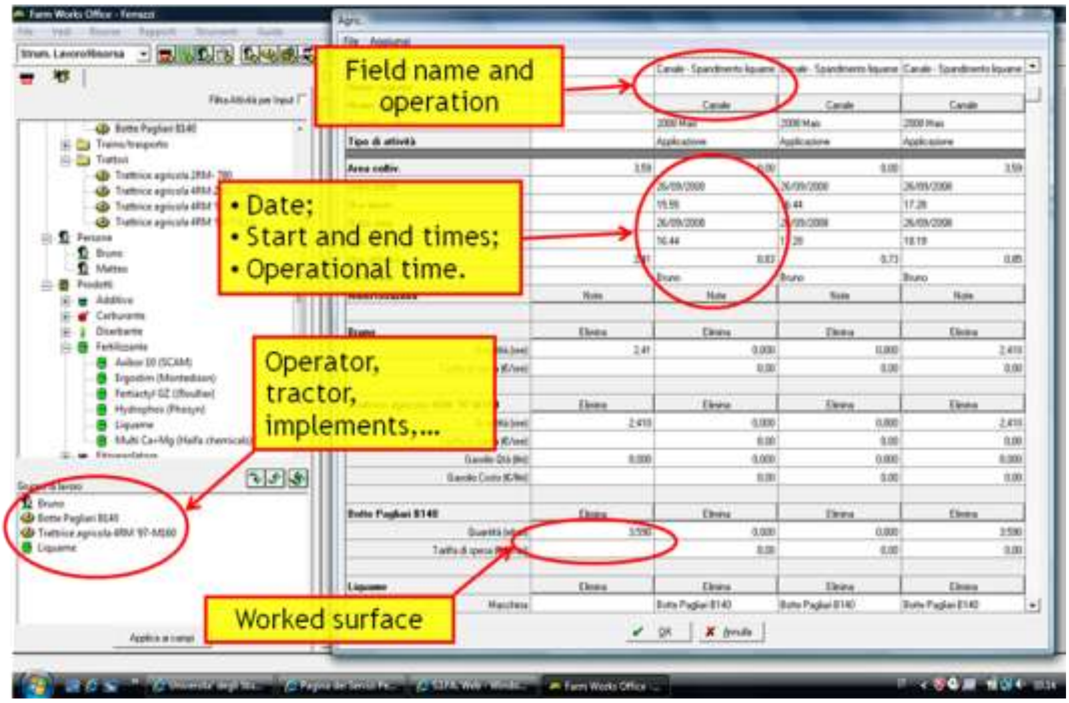

Figure 5.3 - Electronic report of spreading activities.

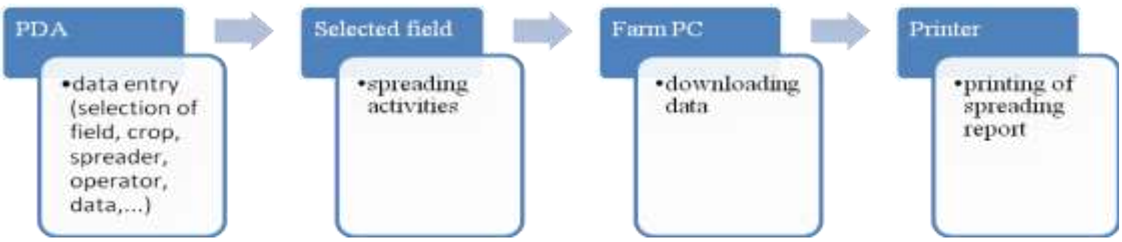

Figure 5.4 - Flow diagram of the procedure followed to monitor the slurry management at farm level.

A second level foresaw the development of an automated monitoring system based on the integration of the following components:

- GPS datalogger installed on the farm tractor to record at 10-s intervals track-logs of tractor movement during the spreading activity on selected fields. GPS data acquisition was activated by the detection of motion using an accelerometer placed inside the datalogger. The setting in motion of the tractor power take-off (PTO) was recorded through a digital input sent to the datalogger. A GSM/GPRS card ensured the GPS data and the PTO power on data transfer at 10-s intervals to a server;
- Radio Frequency (RF) transmitter installed on the slurry spreader for sending its identification code to the datalogger when the spreader was

coupled with the tractor. The identification code was sent to the server via GPRS;

- pressure sensor (Figure 5.5) installed on the drain valve of the spreader. Opening and closing the drain valve was recorded through a digital input sent to the datalogger, and from this to a server via GPRS;
- ultrasound sensors (Figure 5.5) applied to slurry pits and linked to a specific datalogger which can generate a tension from 0 to 10 V, proportional to the distance of the slurry surface from the sensor. Through a specific algorithm the distance was converted in a volume and the value was sent to a server via GPRS;
- computer assisted guidance system (Arvanav2, ARVAtec s.r.l., Italy) composed of an integrated GPS receiver and a specific software (ARVAnavPC software, ARVAtec s.r.l., Italy). This system allowed to draw virtual paths on the fields showing the way to follow and the surface already worked;
- field records software (Farm Trac, Farm Works Software, Hamilton, IN, USA) and mapping and layering software (Farm Site, Farm Works Software, Hamilton, IN, USA). The integration of these two software allowed fields data elaboration, printing detailed reports of spreading activities, converting fields data into slurry distribution maps with the relative slurry distributed quota and spreading periods.

Figure 5.5 - On the left: pressure sensor installed on the drain valve of the spreader; on the right: ultrasound sensor applied to the slurry pits

Over the experimental period a further version of the automated monitoring system was implemented installing the GPS datalogger directly on the slurry spreader rather than on the tractor following an “implement-oriented architecture” (Figure 5.6).

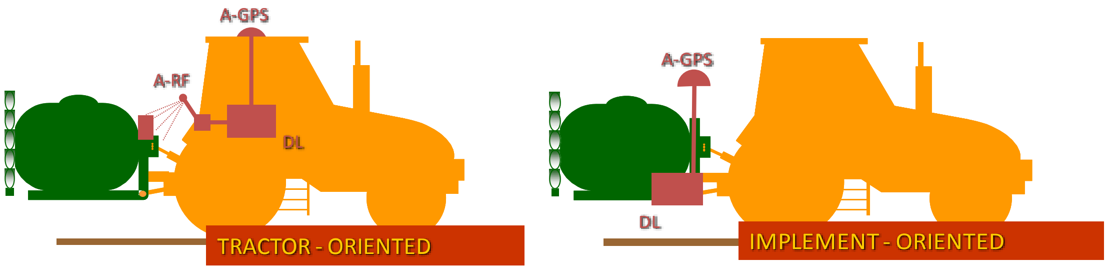

Figure 5.6 - On the left: “tractor-oriented architecture”, the data acquisition system is installed on the farm tractor; on the right: “implement-oriented architecture”, the data acquisition system is installed on the agricultural machinery

A flow diagram of the procedures followed to monitor the slurry management using an automated monitoring system is shown in figure 5.7.

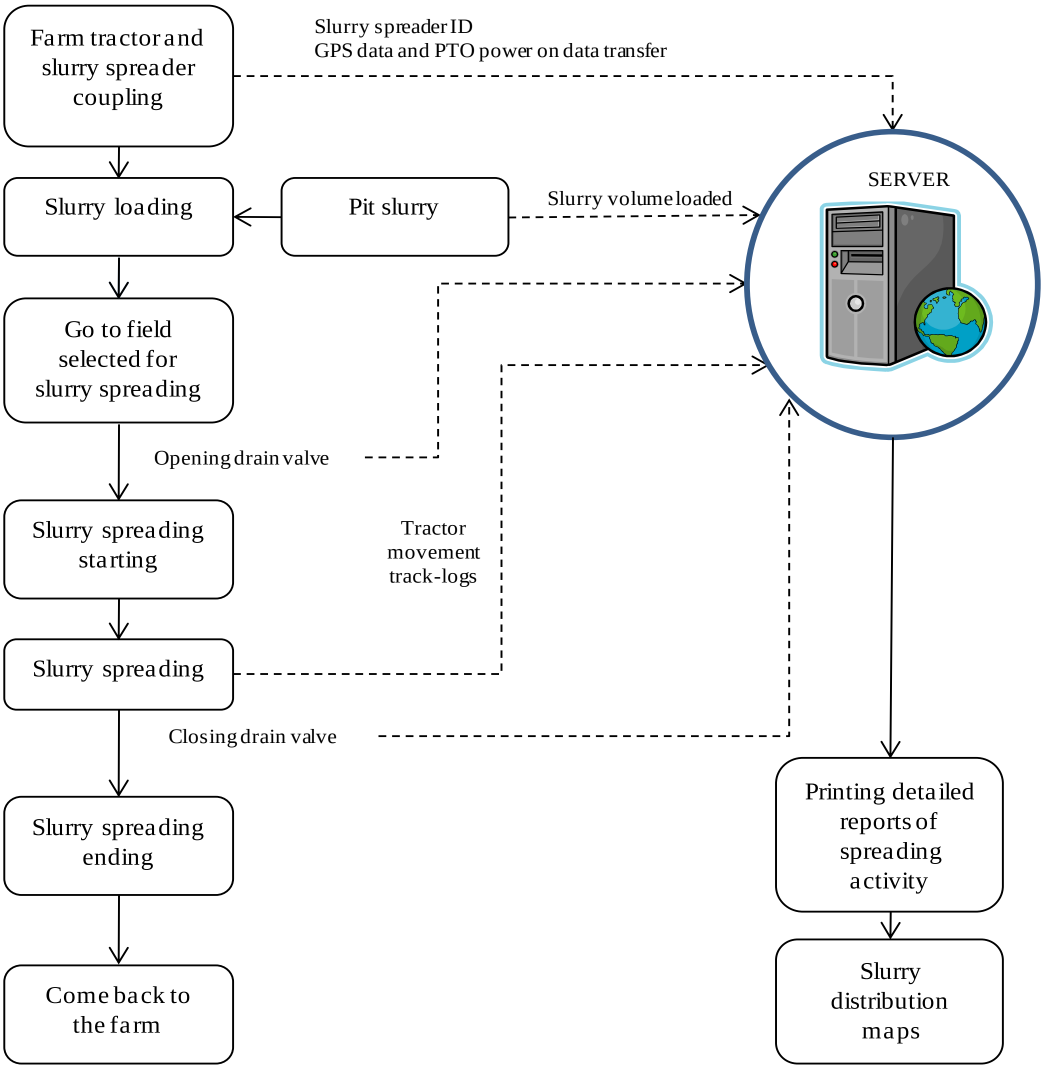

Figure 5.7 - Flow diagram of the procedures followed to monitor the slurry management using an automated monitoring system

5.4 Results and discussion

The system for animal slurry management monitoring developed was tested at the experimental farm of the Agricultural School Ferrazzi e Cova (Northern Italy) over 2008 and 2009 and further tests are still in progress.

The first objective of the project consisted of a correct use and full functionality of software products supplied to the farmer.
Overall, the importance of the handheld as a tool for creating an initial database has been rapidly assimilated by the farmer, data transferring to the management software installed on office PC is stable and the following processing of the data

collected for preparation of detailed reports is a valuable tool for corporate management purposes.

Through the data loggers installed on tractors every work path is coupled to a tractor code and a machine code. The data contained in the smart card are downloaded regularly on management software in order to automatically reconstruct and validate the activities conducted and recorded on individual plots. In practice, the list of individual activities related to each plot is the logbook that was completed manually with the identification of the products used, is to establish the database necessary to provide the necessary reports for compliance with the norms regulation.

Results showed a good effectiveness of the system, both at the basic level (using a PDA with a specific software for recording field activities) and at the higher level (fully automated recording of field activities) in monitoring animal slurry management at farm level.

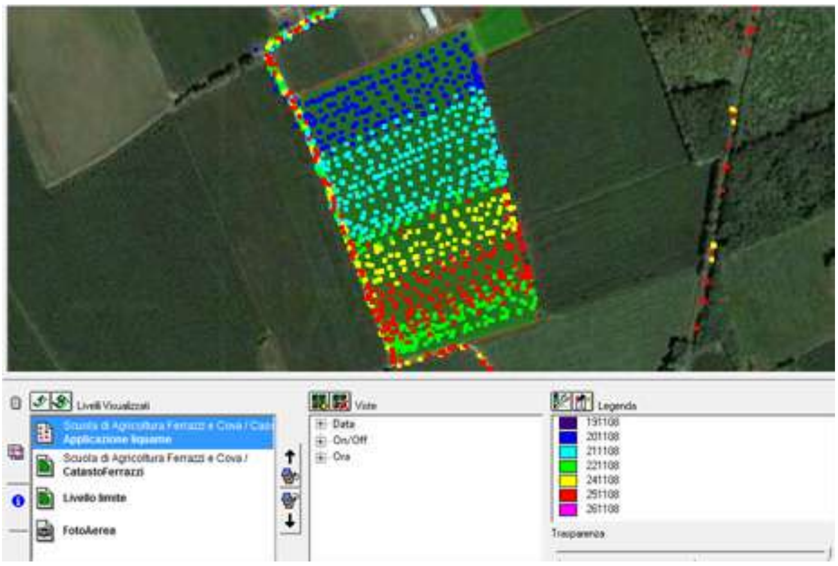

Figure 5.8 – Slurry spreading validation system.

Ultrasound sensors applied to slurry pits highlighted some limit in measuring the right volume of slurry stored in the pits since it has not always been possible to keep the minimum distance of 60 cm between the sensor and the slurry surface, needed for correct measuring. Moreover in the presence of foam on the slurry surface an overestimation of the slurry volume stored in the pits was observed.
For these reasons the sensor was subsequently substituted with an immersion pressure sensor, which showed full functionality.

Figure 5.9 – Ultrasound immersion sensor.

The computer assisted guidance system allowed to record breakpoints in slurry spreading activities permitting the operator to go to the farm to supply the tank and then coming back to the exact point of the interruption. In this way a better homogeneity in covering the soil with the slurry was reached.

Figure 5.10 – Semi-automated computer assisted guidance (ARVAnav2).

Farm mapping allowed to define off limit areas (artesian wells, canals, rivers, etc) in which spreading was interdicted in accordance with the Nitrates Directive (91/676/ECC).

5.5 Conclusions

The system implemented, both at the basic level using a PDA with a specific software for recording spreading activities and at the higher level that foresaw a fully automated recording of the activities using several mechanical and electronic components, reached the goal enabling to monitor animal slurry management (storage, loading, spreading) and to optimize agricultural operations.

But while the basic level of the system limits the monitoring of slurry spreading only at farm level, the use of GPS dataloggers that transmit all the data related to the spreading activities to a server via GPRS could enable to monitor the slurry spreading and to formulate accurate fertilization plans on a large scale (district, region) opening a new way in farm management.

Figure 5.11 – Slurry spreading.

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CHAPTER 6

General Discussion

6. General discussion

The barriers that currently hamper the information management on farms by means of computerized and technologically advanced products are related to environmental-structural and organizational and cultural causes.

Overcoming these barriers requires a gradual introduction of computer software based on the use of "friendly", easy to use and intuitive interfaces and the highest possible degree of automation in the process of collecting data with respect to all parameters that are relevant for the analysis of the consultative processes.

The boost that the other sectors of society are giving to the agricultural sector because this makes clear its production processes in order to ensure food safety and quality of products is, for the same, an exogenous factor which is impossible to depart from the penalty of exclusion from market. On how to deal with the problem of developing solutions that are both affordable and of high technological level comparable with that of other agricultural sector is the glue that underlies the research initiatives that have been presented in these notes. What must be clear however is that the technicians should be involved in the technical extension and the operators themselves to seize the opportunities that the technological research and makes available to them.

This is not so much in the logic of those who want to be innovative at any cost, but the logic which intends to take into account not only the direct benefits of the adoption of technologies (to solve the problem of traceability and transparency in the chain), but also those indirect, however, are not secondary in importance. In fact, the adoption of information technology described above allows technicians and operators to have available data and information that could be extremely useful in the management at all levels of decision-making processes. These data and information, if properly engaged in decision support systems and used to increase the efficiency of enterprises, can lead who uses them to considerable economic benefits.

CHAPTER 7

Summary

7. Summary

The Italian agricultural sector is a strategic component for our Country. It is the second in importance after the engineering and produce more than 100 billion euros.

However, the detachment between producers and consumers has led over time to make important in the food production not only chemical, physical and nutritional aspects, components that were basically the only important at the time of agricultural personal consumption, but also those related to food safety and quality perceived by consumers.

To focus attention on animal husbandry products, particularly interesting in this context is the evolution of the "beef" product that, because of the well-known problems related to BSE crisis, has become the food prototype that at the level of European law, worked as a "test case" for implementing the regulations that currently affect the food safety and food quality.

So, for the food security aspect, EC Regulations 178/2002, Art. 18 introduced a regulatory framework that makes mandatory:

- products traceability: the possibility of tracing the path of a production process through all its stages: from raw materials to the finished product (in the case of beef from the feed to the meat portion in the market). The producers are directly responsible for its implementation.

- traceability of food, feed, animals in all stages of production, processing and distribution: it is the tool that allows to trace back the production process, from upstream to downstream, from the finished product to the origin of raw materials (from meat on the table to the farm).

Under these circumstances, the work has sought to develop systems for automatic recording of production events that will allow operators to improve the data collection and production of documentation both for single-stage production process of industry, either for the entire productive supply chain. This permit to make it as easy as possible for the operators themselves the possibility to respond to tasks related to regulatory or disciplinary action, relieving the part closely "operational" of the same work - which is usually carried out by staff with little attention, as considered by them not "essential" for the production - which, if not executed with precision, leads to unreliable and therefore "inconsistent" tracking systems.

In this context, the research work within the PhD was divided on the development of three different automation systems in the livestock industry:

- Study and analysis of technologies based on radio frequency identification (RFID) on the market and development of management systems applicable to different types of production in cattle and sheep and goat rearing; development of an integrated system of automated traceability in a supply chain for beef production;

- Study and development of a sensitized collar prototype with GPS technology to monitor the herds of cattle and goats flock, use of grazing areas and prevent cattle stealing;

- Study and development of an integrated system for slurry management monitoring and electronic reports drawing up in cattle breeding.

CHAPTER 8

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