EUROPEAN COMMISSION

Community Research

ROSEI – FINAL REPORT
Version: 1.0

Grant Agreement number:	315222
Project Acronym:	ROSEI
Project title:	Robust Sheep Electronic Identification
Funding Scheme:	FP7-SME-2012 (Research for the benefit of specific groups)
Date of latest version of Annex I:	2013-08-02

Project Co-ordinator : Mr. Helmut Ruppert
Agrident B.V
Tel: +49 1728131229
E-mail: hruppert@agrident.com

Project Website: www.rosei.eu

Participants:

1. Agrident B.V.
2. Roxan Developments Ltd
3. Page-Up
4. TLR Ltd
5. UK Intelligent Systems Research Institute
6. Norges Miljo-Og Biovitenskaplige Universitet
7. Michael P. McHugh

Contents

1. Final Publishable Summary Report

Executive Summary

This report summarises the work conducted by the project consortium during the 24 month period of the ROSEI project (1st December 2012 to 30th November 2014). Further reference to the work conducted can be found in the project deliverable reports and in the periodic reports submitted at M9 and M24.

ROSEI is funded under the Seventh Framework Programme (FP7) for EU research and is entitled "Robust Sheep Electronic Identification"

The ROSEI project has successfully developed a UHF RFID based system that can be used to monitor and record sheep movements either individually or when moving in large groups. This system has been tested and demonstrated in real sheep management scenarios to show the major benefits it can offer to farmers, market operators, food processors and transport operators.

The ROSEI system has been shown to work exceptionally well with a high reading success rate, measured in a range of different flock movement scenarios. In the main trials a 100% read rate was achieved when using two antennas and a metal race and allowing the flock of 100 sheep to run through 3 to 4 animals abreast. Overall, for all trials when running sheep with ROSEI tags unhindered through races, the reading success was better than 99.9%.

This has been achieved with a very small and light UHF ROSEI tag, and without the need for complex and expensive reader/antenna configurations. Compared to the now prevalent handheld LF technology this means significantly less effort for farmers, transport operators, market operators or abattoirs that need to record sheep movements. The system can read data from a flock of 100 sheep, running through a wide race with the UHF setup and register all in less than a minute. The ROSEI UHF antenna/reader solution is lightweight, comparably inexpensive, well suited for flexible (easy to move) use on individual farms and is easy to integrate into trailers or large transport vehicles.

The implemented and demonstrated livestock management system can be used to provide complete traceability of sheep movements including initial birth recording, movements between farms and markets and transfer to meat processing companies.

The increased accuracy and immediate availability of the data to users on a cloud based database will result in improved information for food traceability, veterinary surveillance and better ways of dealing with disease outbreaks.

The efficiency gains achieved by being able to automatically read and record tag data on sheep when moving through control points at speed in large groups will bring major efficiency gains to hauliers, meat producers, farmers and market operators.

Summary Description of Project Context and Objectives

It is clear that group (batch) identification is not an adequate method to trace sheep movements across the EU, as the Foot & Mouth outbreak in 2001 demonstrated. Once animals move through different holdings, farms, or markets, it is very difficult to track where each animal is going without individual identification and recording. Should there be a disease outbreak, the uncontrolled movement of animals could cause further, and rapid, spread of disease over a large geographical area. Therefore tracing each individual animal is vitally important to control infectious diseases. However, compliance with the EC legislation for 100% assured tracking of livestock is difficult to deliver with the current mandated LF systems, having a reported recall of only 90% of tagged sheep in group movement situations. This non-compliance could potentially result in financial penalties of up to 50% of individual farm subsidies.

The objective of the ROSEI project was to develop an RFID tagging system offering a robust & reliable solution to provide real-time validation and verification of tagged sheep in flock conditions. The proposed LF & UHF dual band solution was aimed at longer range & faster read rates for seamless flock and herd scanning, thus enabling farmers to comply with the strict legislation for sheep monitoring & tracking. ROSEI permits the implementation of advanced livestock management systems that utilise EID to accurately monitor the husbandry of animals in the food chain and will contribute to the EU integrated approach to food safety, 'Farm to Fork'.

To achieve these outcomes new technology components were identified for development, these allow RFID to operate properly in this sector. The specific technical targets identified for performance and compliance were:

- Dual operation RFID tags at 134.2 kHz (LF band) and 867MHz (UHF band)
- Long range LF operation (target >2m)
- Long range UHF operation (target >20m)
- Integrated anti-collision performance for LF and UHF
- Matching enhanced reader system
- Robust mechanical tag encapsulation – lifetime attachment to a sheep
- >99% Recall reliability at sheep races
- Affordable economic solution for farmers
- New livestock management capability

The R&D activities were implemented within 7 defined work packages. These being:

Work Package 1:	Technology requirements for livestock management scenarios
Work Package 2:	Auto-tuned dual band LF/UHF antenna development
Work Package 3:	Standards compliant anti-collision capable LF RFID development
Work Package 4:	Advanced livestock management systems
Work Package 5:	Dual Band LF/UHF reader development
Work Package 6:	Integration of Sub-assemblies and system testing
Work Package 7:	Field Trials

Description of Main S&T results/foregrounds

Auto-Dual Band LF/UHF Antenna

Two different types of UHF tag antenna have been considered and tested for the ROSEI tag; these antennas are a folded dipole and a short dipole. The folded dipole spans both sides of the folded tag; the short dipole can be housed in one side of the tag and can be implemented in the existing Roxan Tagfaster format. In order to produce a reasonable read range from the short dipole a ceramic substrate with a high dielectric constant is used. Both of these antennas were evaluated using a design of experiments approach. Due to issues with integration of the folded dipole, and also poor performance in a format suitable for integration, the consortium decided to proceed to integration and field trials with the short dipole option. Testing showed that the design was suitable for the ROSEI application with ranges of between 1 and 3m during characterisation tests and when testing with a phantom.

Passive RFID tags are subject to detuning which leads to a reduction in read range. Two approaches for auto-tuning of the UHF tags were considered to combat the problem and provide an auto-tuning capability for the ROSEI RFID tag. For both options, implementation would require rework of the transponder itself and, as such, simulations have been performed to show how such an implementation would operate in practice. In discussions, the consortium confirmed that operation without auto tuning is preferred due to cost and complexity of adding this functionality.

The LF antenna design calculations and developments showed that improving on the range of existing LF tags is extremely challenging and more so in the constraints of the existing tag geometry. Based on these conclusions it was decided to use existing developed LF Antenna solutions, either integrated in the same tag as the UHF antenna or by implementing in a separate tag to the UHF.

Standards compliant anti-collision capable LF RFID Reader

The wide use of RFID asset tracking and the volume of goods to be traced poses a problem when a reader attempts to interrogate numerous transponders at once, and for sheep this is no different. If each transponder in the magnetic field replies at the same point in time, the reader cannot arbitrate between their identification numbers, due to the collision of the multiple responses modulated on the carrier frequency. The collisions reduce the efficiency of the system, cause delays and waste energy. To overcome this issue, discrete time slots are allocated to each transponder in various ways, to minimize these collisions. As part of the ROSEI project several anti-collision algorithms were investigated and recommendations were made as to the most appropriate for use in achieving maximum efficiency for reading sheep in flock situations. The studies concluded that the ROSEI project will concentrate upon the adoption of the anti-collision protocols provided by the UHF and LF transponder devices selected for use within the project. Other protocols were identified that could give a better performance and future work was proposed that could realise and evaluate these protocols

The development and testing of a handheld LF Reader supporting anti-collision protocols was implemented by Agrident BV using the Agrident Integrated Reader 300 (AIR300) LF reader. The AIR300 is designed to fit into the expansion end cap of the Psion Workabout Pro handheld unit. The module has an on-board LF antenna and a connector for an external LF antenna. The Psion Workabout Pro uses a Windows CE operating system. In order to allow application development Agrident have developed a .NET DLL (dynamic linked library) that implements the serial protocol required to communicate with the AIR300 LF reader module. Testing was completed by Agrident using a commercial Hitag transponder with satisfactory results. This developed LF reader was integrated with a UHF reader module and UHF antenna to produce a dual LF/UHF handheld reader.

Dual Band LF/UHF reader

A NORDIC ID UHF Reader module was integrated by Agrident into the Psion based LF reader. Agrident has developed ALU100 software to run on the Psion that provides a common interface to both the UHF and LF reader modules. The dual band handheld reader provides a common interface via Bluetooth to the Android based ROSEI App. that has been implemented by Page-Up.

ISRI has developed the dual antenna solution for the dual handheld reader. Two new antennas were modelled and simulated; in addition, five off-the-shelf antennas were also considered. These antennas were assembled with the existing Psion handheld reader to determine the read ranges. After detailed analysis, it was found that a commercial off-the-shelf multilayer antenna, with additional tuning, could offer a read range of 0.5m and also be accommodated within the given form factor. The UHF antenna was tuned to operate at the required frequency within the developed housing.

A stationary reader system has been specified and tested to enable the capture of a large number of sheep in flock conditions whilst moving through control points such as a race or onto a trailer.
The study showed that to increase the sheep capturing rate at least two antennas are required. As such, the Impinj Speedway R420 reader module was chosen which has the ability to accommodate multiple antennas. Two antennas with a wide beam width (>70^0) from MTI were assembled with the Speedway R420 reader module for trials.
Agrident developed software (ALU200) to run on a PC that provides interfaces for both the UHF and LF Stationary readers and provides a common interface over Bluetooth to the Page-Up developed ROSEI App running on an Android based mobile device.

Integrated Robust UHF/LF Tag

The target of mechanical integration of the dual tag was to integrate the UHF and LF components within a conventional ear tag. The final design achieves the target specification of 24 x 4.5 x 5.5 mm size for the tag body. Manufacture of the tag is completed in two parts, with the main body injection moulded before the RFID component placement then a layer of nylon is over-moulded to fully encapsulate and protect the components. The hinge design contains structural support to prevent failure of the devices. A separate pin is then inserted that is used to fix the tag in place. The final design requires a dual tag approach – one containing the LF components the other the UHF components in order to meet the target size specification. Test results demonstrate an average read range of 2.14 m ± 0.45 m, with two-thirds of the 145 tags tested being detected at within 10% of the targeted read range or higher. It was also shown that inclusion of LF components, the antenna location on the ear and the antenna coupling to the ear had negligible effects on range results.

The target range for UHF operation was greater than 20 metres, however the developed UHF tag has achieved a read range of 2.14 m ± 0.45 m which has demonstrated to be sufficient to record 100% of sheep when moving in groups through races up to 1.6m in width. The range of the tag is limited by the size of the UHF antenna that can be mounted within the Tagfaster tag and due to the requirement of the design to be resilient to the detuning effects caused by proximity to the animal ear. Designs that had ranges greater than 10m were evaluated but these had sizes of almost 10cm in length (compared to the tag body length of 2.5cm) and were not resiliant to the detuning effects caused by proximity to fatty tissue.

The target range for LF operation was greater than 2 metres. A study was done on how to increase the range of existing LF tag designs through use of multi-wound antennas and using high resistivity soft ferrite cores. The investigation showed that a range of 0.5m could be achieved with these enhancements but 2m could only be

achieved through an increase in the reader power. The consortium decided to focus on the development of a UHF Tag with a read range of greater than 2 metres that could read sheep in flock conditions and continue to use LF tags, compatible with existing standards, to be able to read individual sheep at short range.

The developed dual UHF/LF system can be implemented through a dual UHF/LF Tag or through the use of spearate LF & UHF Tags (one in each ear).

Biocompatible ROSEI UHF Tag

NMBU carried out additional Biocompatibility trials on the ROSEI tag following recommendations made at the RP1 review meeting. The additional trials performed studied:

- How easy is it to apply the ROSEI tags with the presently available equipment?
- Retention and robustness of the ROSEI tag – does it stay on, and do the electronics inside the tag function after being exposed to the on-sheep environment for some time?
- Will applying a disinfecting solution to the tag and ear at tagging reduce the risk of infection?
- How does the ROSEI tag perform in terms of infection risk? (when compared to a common button-flap tag)

The studies concluded that overall biocompatibility of the ROSEI UHF tags is good, and welfare effects are acceptable, but areas of improvements that could be made to the mechanical design of the tag and tag-applicator were identified. The ROSEI UHF tags have good retention rates and excellent robustness: no tag in the study stopped working and visual identification was easy to read after more than 3 months on the sheep.

Integrated and Validated - Advanced Livestock Management System

The design, testing and verification of the Livestock EID platform has been successfully completed and documented by TLR. The test verification document (D4.4) describes the tests that have been carried out on the central database, web site and API functions as part of the delivery of the advanced livestock management platform. As the underlying data structures, described in the Software Architecture Specification (D4.3), utilize TLR's existing CASI and EBlocks databases, explicit test validation of these are not covered, but instead have been incorporated into the testing of the functionality of the web site and web API.

Two systems have been developed; a handheld reader system to enable operators to record and recall data for individual sheep; a Market/Abattoir/Transport reader to enable the recording of data from a large number of sheep moving through control points such at markets, abattoirs or for large movements by transport operators.

The individual components of the system have been integrated together and testing carried out to verify that the performance is in line with the system requirements.

The handheld system consists of Dual UHF/LF Reader (Agrident/ISRI), ROSEI Livestock Management Sytem (TLR), ROSEI Android Application for Mobile (PageUp), ROSEI UHF and LF tags (Roxan/ISRI)

The Market/Abattoir/transport system consists of PC running ALU200 Software (AGRI), LF Reader & UHF readers (AGRI + 3rd party), ROSEI Livestock Management System (TLR), ROSEI Android Application for Mobile (PageUp), ROSEI UHF and LF tags (Roxan/ISRI).

The integration testing proved the capability of the system to be able to transfer data to/from the readers via a mobile based application to the cloud based Advanced Livestock Management platform.

Field Trial tested – Advanced Livestock Management System

The main sheep trials and experiments were designed by NMBU in cooperation with the other partners, and carried out at NMBU's on-campus Research Animal Centre and at partner Michael McHugh's farm in Ireland. In addition, small-scale trials were done by ROXAN in Scotland. All animal trials were performed in farm environments using setups simulating important tasks in commercial sheep husbandry.
The field trials performed were based around sheep moving in groups through races, reading sheep in a weigh cage, reading sheep being loaded on/off trailers and the reading of ranging animals at a fixed point (salt lick/feeding site).
Detailed analysis of all the results was performed to be able to check the robustness of the system, to be able to optimize the system and make further recommendations for improvements.

In summary, the ROSEI system has been shown to work exceptionally well. The results are extremely positive with a high reading success measured in a range of different flock movement scenarios.

In the main trials, we achieved a 100% read rate when using two antennas and a metal race and allowing the flock of 100 sheep to run through 3-4 animals abreast. We completed 2800 individual passes without a single failure. Overall read rate for all trials when running sheep with ROSEI tags unhindered through races, the reading success was better than 99.9%.

Loading animals on/off trailers we achieved an overall read success of 98% when using a single antenna. We concluded that additional trials would need to be done to optimize the number/arrangement of antennas to be able to improve the read performance.

Trials/usability tests of the dual ROSEI Handheld reader were performed on sheep tagged with both LF and UHF tags. The reading ranges were ≈ 10 cm for the LF and around ≈75 cm for the ROSEI reader, leading to clear differences in the way the operator could register IDs of the sheep inside the cage: using the ROSEI reader meant the user did not need to bend down as much, especially when the animals held their heads low.

We demonstrated the ability of the system to read a flock of sheep that were contained within an open enclosure system by reading them at a fixed point such as a lick station. Data from all of the reads could be recorded on the reader and the system has the ability to transfer this data remotely to cloud data base via mobile network.

Potential impact and main dissemination activities and exploitation results

The ROSEI consortium has developed and demonstrated a system that can be used to accurately record, trace, monitor and identify sheep.

Two systems have been developed; a handheld reader system to enable operators to record and recall data for individual sheep; a Market/Abattoir/Transport reader to enable the recording of data from a large number of sheep moving through control points such at markets, abattoirs or for large movements by transport operators.

The system includes a UHF RFID tag that is encapsulated in an existing Roxan Tagfaster tag body. All the field trails and demonstrations implemented the UHF tag in one sheep ear and an approved LF tag was used in the other ear. A dual UHF/LF tag has also been developed and demonstrated but this was not the preferred option of the consortium due to the constraints of fitting into the Tagfaster body. The developed system supports standard anti-collision protocols in both the LF & UHF systems to enable sheep to be accurately read in flock conditions.

It has been demonstrated that a ROSEI UHF RFID system can be implemented that can accurately read sheep moving in dense groups. This has been achieved with a very small and light UHF ROSEI tag, and without spending a large amount of time fine-tuning the antenna setups. Compared to the now prevalent handheld LF technology this means a lot less work for the farmers, transport operators, market operators or abattoirs that need to record sheep movements. You can run a flock of 100 sheep through a wide race with the UHF setup and register all in less than a minute, while reading individual sheep with a handheld reader with a typical 10 cm maximum range is time consuming and will lead to more handling being necessary. The ROSEI UHF antenna/reader solution is lightweight, comparably inexpensive, well suited for flexible (easy to move) use on individual farms and is easy to integrate into trailers or large transport vehicles.

The implemented and demonstrated livestock management system can be used to provide complete traceability of sheep movements including initial birth recording, movements between farms and markets and transfer to meat processing companies.

The increased accuracy and immediate availability of the data will result in improved information for food traceability, veterinary surveillance and better ways of dealing with disease outbreaks.

The efficiency gains achieved by being able to automatically read and record tag data on sheep when moving through control points at speed in large groups will bring major efficiency gains to hauliers, meat producers, farmers and market operators.

Main Dissemination activities

The dissemination events that have taken place during the ROSEI project are as follows:

1. Workshop with Partners, 19th December 2012, ISRI in Melton Mowbray
2. Visit to Farm , 12 March 2013, Burnhouse Mains, Scotland
3. Workshop with Partners, 13 March 2013 at Roxan, Selkirk, Scotland
4. UHF Livestock technical conference hosted by ScotEID, 19-20 April 2013, Dingwall, Mart, Scotlan
5. Presentation Meeting with Psion by NMBU, 3 June 2013, Ås, Norway
6. Technical & business discussion by NMBU with Dutch software developer and retailer of animal ID equipment, 20 August 2013, Nijmegen, Netherlands
7. Technical & business discussion by NMBU with software developer in charge of NL national sheep ID database on 21st August 2013, Deventer, Netherlands
8. Workshop with partners on 23 September 2013 at Page-Up, Dijon, France
9. Workshop with partners on 31 October 2013 at ISRI, Melton Mowbray
10. Meeting with Spanish research institution (NEIKER) on 21 February 2014 in Spain. A presentation was given by NMBU.
11. Meeting with French research Institution (INRA) on 24th February 2014 in Corsica. A presentation was given by NMBU.
12. Meeting with Italian research Institution (Agris) on 28th February 2014 in Sardinia. A presentation was given by NMBU.
13. Meeting with Greek research Institution (NAGREF) on 6th March 2014 in Thessalonica, Greece. A presentation was given by NMBU.
14. Meeting with Romanian researcher into RFID equipment on 13th March 2014 in Timisoara, Romania. A presentation was given by NMBU.
15. Meeting with ROSEI partners in Ireland on 15th June 2014 where demo of the tag & reader capability was demonstrated at Michael McHugh's farm.
16. Conference: 65th Annual Meeting of the European Federation of Animal Science, NMBU attended on 25th-29th August 2014 to promote ROSEI
17. Meeting with Nortura in Norway to promote ROSEI on 3rd September 2014, presentations given by NMBU, Agrident, TLR & Roxan
18. Field Trails in Ireland on 30th September 2014 where the capability of the system was demonstrated to all ROSEI partners at Michael McHugh's farm

In addition to these activities Roxan have promoted ROSEI at a large number of agricultural shows that they have attended. This includes the Royal Welsh show 2014, National Sheep Association Event 2014, Builth Wells Ram Sales 2014, Great Yorkshire show 2014 and the NSA Winter show 2014.

A press release was made on February 14th 2014 regarding the ROSEI project. This appeared in Farmers weekly and the meat trades journal.
A further release was made in September 2014, part of which appeared in the food safety supplement of the meat trades journal.

Main Exploitation Results

The following exploitable results have been achieved from the project:

1. EID tag requirements specification
2. Auto tuned dual band LF/UHF antenna
3. Advanced Livestock Management Platform
4. Dual Band LF/UHF reader
5. Integrated robust LF/UHF EID tag

An exploitation strategy and plan has been developed to enable commercialisation of the ROSEI technology. The project has demonstrated that the technology is ripe for exploitation and must now be demonstrated in trials large enough to quantify benefits that would result from its application to an industrial organisation or national herd.

As well as independent exploitation by each consortium SME member, the members also consider it equally important to exploit the ROSEI results as a collective group.

The members of the consortium have agreed to offer major meat producers along with the sheep industries in particular countries, a project that demonstrates and evaluates the ROSEI system on their sheep, in their country under their operating conditions.

A project would run in parallel, and be evaluated with, the methods that a specific country or industry currently uses to record, trace, monitor and identify animals. The work would be to compare and contrast the methods and technologies, to identify efficiency savings, quality improvements and any system shortcomings.

The business plan for ROSEI provides a forecast of income from the development and operation of a customer base in UHF sheep tagging systems. The plan includes forecasts for tags, readers, user applications and cloud computing services. The business plan neglects any possible income from markets outside sheep, however it is recognised that the system could easily be adapted to offer solutions to other markets, and these other areas are expected to be targeted in the future.

Address of project public website and relevant contact details

Please see www.rosei.eu