Executive summary:

In the face of a rapidly increasing global population and the subsequent rise in demand for foodstuffs, mounting pressure is being placed on the agricultural industry and associated supply and retail sectors. In order for growers, logistics companies and traders to cope with the exigencies of a globalised economy and growing world populace, they require access to increasingly accurate, detailed, and up-to-date data and information. At present, worldwide agri-business lacks the coordination and coherence for the exchange of this data to be executed smoothly, with no standardised measures or gauges in place to be used as universal points of reference. To combat these shortcomings and work towards a synthesised exchange of information, AGRIXCHANGE was set up as an EU-funded consortium, with participants as diverse as academic institutions, farmers and ICT companies. Through international dialogue and cooperation, AGRIXCHANGE has developed novel techniques for sharing and comparing data and knowledge, making agri-business more efficient, economical and sustainable.

The backbone of AGRIXCHANGE, has been an analysis of a variety of scenarios regarding the exchange of agricultural information in each of the EU's 27 Member States and Switzerland. Despite expected differences between levels of organisation and communication amongst the countries being studied, several identifiable trends emerged. These included an ageing population of farmers, and consequent lack of adaptation to, and investment in, ICT, including: the need for better broadband internet in rural areas; the need for better mobile telephone infrastructures if mobile devises and smart phones are to fulfill their potential; and the potential for rapidly developing countries to skip outdated infrastructures and opt for advanced systems straight away.

To support the setup of the AGRIXCHANGE community, a web-based platform was developed. The platform provides information about the project and information exchange in general, but mainly functions as a community of practice in which stakeholders currently collaborate in 9 use cases, 24 interface descriptions and 20 standards. It has over 400 registered users, mostly from Europe, but also other countries. A LinkedIn group 'AGRIXCHANGE' (600 members) was supportive to the platform and contains many active discussion topics.

A central activity of AGRIXCHANGE has been the development of a Reference Framework. The Reference Framework's functions have been introduced in the form of a work flow, using the novel aXTool, specially designed to incorporate the Reference Framework design into the existing AGRIXCHANGE platform. The principle behind the aXTool is that it strictly guides the contributing of solutions and information, but makes the finding of information easy and efficient. The AGRIXCHANGE Reference Framework and aXTool are used to update the number of use cases and interfaces, and to improve the standards of the platform; together with relevant stakeholders, work has been done to make practical implementation available.

AGRIXCHANGE organized four workshops that were embedded in larger conferences, collaborating with other EU projects and organizations, such as ICT-AGRI ERA-NET, FutureFarm and SmartAgriFood.

The conferences were attended by an impressive number of delegates from various countries (also outside the EU), from areas including software

and hardware development, farming, consultancy, agri-food business, governmental organisations and research institutes. Most participants are members of the European Federation for Information Technologies in Agriculture, Food and the Environment (EFITA), but, increasingly, organisations from outside EFITA are also being incorporated into the debate – particularly partners from the software industry. The conferences were used for dissemination and to test concepts and ideas against current practice and resulted in the establishment of a great deal of new networks and contacts. In addition to this work, AGRIXCHANGE is also collaborating with a variety of European standardisation organisations, through which contact with GS1, the global standards organisation and Global GAP has been made. Further afield, AGRIXCHANGE is in contact with projects both in the US and New Zealand, positioning AGRIXCHANGE within a global effort, further increasing the opportunities for knowledge to be shared.

Collaborating closely with the AGRIXCHANGE community, this work has been supported by the establishment of a Strategic Research Agenda (SRA). In addition to its primary focus on standardisation, this SRA also provides recommendations for prioritising research within the agri-food sector.

Overall, these advances constitute significant steps in the right direction, aiding the exchange of information and working towards a standardised system.

Project Context and Objectives:
In the face of a rapidly increasing global population and the subsequent rise in demand for foodstuffs, mounting pressure is being placed on the agricultural industry and associated supply and retail sectors. In order for growers, logistics companies and traders to cope with the exigencies of a globalised economy and growing world populace, they require access to increasingly accurate, detailed, and up-to-date data and information. At present, worldwide agri-business lacks the coordination and coherence for the exchange of this data to be executed smoothly, with no standardised measures or gauges in place to be used as universal points of reference.

To combat these shortcomings and work towards a synthesised exchange of information, AGRIXCHANGE was set up as an EU-funded consortium of 15 partners from 11 countries, with participants as diverse as academic institutions, farmers and ICT companies:

- Wageningen University & Research Center (LEI, LSR, Alterra) - The Netherlands
- Kuratorium für Technik und Bauwesen in der Landwirtschaft (KTBL) - Germany
- MTT Agrifood Research - Finland
- Wireless Info (WRLS) - Czech Republic
- Institut de l'Elevage (ELEV) - France
- Institut de Recerca i Tecnologia Agroalimentàries (IRTA) - Spain
- Teagasc - Ireland
- Universität Rostock -Germany
- Forschungsinstitut für Biologischen Landbau (FIBL) - Switzerland
- Altavia - Italy
- Poznan University of Life Sciences (PULS) - Poland
- ACTA Informatique - France
- Progis software - Austria

Through international dialogue and cooperation, AGRIXCHANGE has developed novel techniques for sharing and comparing data and knowledge, making agri-business more efficient, economical and sustainable. The overall objective of this project is to coordinate and support the setting up of sustainable network for developing a system for common data exchange in agriculture. This will be achieved by the following three objectives:

1. establish a platform on data exchange in agriculture in the EU
The main target group of the platform are developers of tools (hard- and software) for farmers in which data exchange plays a role. The platform should provide a framework (see objective 2) and guidelines that can be used for national implementation by these developers. Additionally, the platform should function as a community of practice where experiences, use cases and examples can be exchanged. The platform should be supported by scientific research to supply the state of the art scientific insights on which to base solutions on. The platform must be 'open access'. The platform will be gradually setup through several activities. Full functionality is expected to be reached in M20. The success of the platform can be measured by the number of relevant users that are involved and the activities that take place by the platform. Its success is verified by getting feedback from workshops and through the platform itself.

2. develop a reference framework for interoperability of data exchange in agriculture in the EU

Because each specific field of data exchange (e.g. business transactions, geographical processes) has already its own developed standards and systems and the implementation will always be subject to local-specific conditions, it is unrealistic to suppose that one universal standard model for agricultural data exchange could be developed and used. However, there is a need for a reference framework for interoperability between various subsystems. This framework should also prevent the re-invention of the wheel in each member state. The framework will be an integral part of the platform and is gradually developed by implementation of several use cases. A mature reference framework is expected to be ready in M24. It will be tested by implementing a new use case and validated by user groups. An integral validation of the framework and platform takes place by feedback from a workshop and advisory board meeting in M30 and continuously through the platform itself. Developing the framework is part of this project, but specific implementation and actual coding of standards, etc, should take place in other (national and regional) projects. The framework should be open to public through the platform (objective 1).

3. identify the main challenges for harmonizing data exchange in agriculture in the EU
This should lead to a list of recommendations in the form of a strategic research agenda that should lead to activities that sustain the platform and reference framework. A draft report will be ready at M30 so that it can be validated and discussed during the workshop and advisory board meeting and continuously through the platform. The feedback will be processed resulting in a final report in M36. In this way, a European network is formed that facilitates common data exchange for systems in the agri-food sector.

First, an in-depth analysis and investigation of the state-of-the art in EU member states will be carried out. A platform is built up that facilitates communication and collaborative working groups, that work on several, representative use cases, guided by an integrative reference framework. The framework consists of a sound architecture and infrastructure based on a business process modelling approach integrating existing standards and services. The development is done in close interaction with relevant stakeholders through the platform and international workshops. The results converge into a strategic research agenda that contains a roadmap for future developments.

The AGRIXCHANGE project includes the following Work Packages:

- WP1 Project coordination and management: addresses the project management and scientific co-ordination tasks, including internal communication, quality management, time planning, reporting and financial control. WP leader: Sjaak Wolfert, sjaak.wolfert@wur.nl (LEI Wageningen UR)

- WP2 Analysis of current situation in EU-27 and Switzerland: analyses the situation concerning data exchange in agriculture in EU member states (incl. Switzerland). Together with input from WP4 on specific topics, it results in specific recommendations at a national level. Additionally, general recommendations are defined, which are input for WP5. The analysis uses existing networks such as EFITA, and is supported by WP6. Results are disseminated through the platform of WP3. WP leader: Henri Holster, henri.holster@wur.nl (ASG Wageningen UR).

- WP3 Set-up of AGRIXCHANGE platform: supporting the AGRIXCHANGE community to share knowledge and standards during and after the project. It is based on criteria that are taken from desk research, but also on results from the analysis of WP2. The platform is internet-based and it is used to carry the framework that is being developed in WP4. WP leader: Daniel Martini, d.martini@ktbl.de (KTBL).

- WP4 Development of a reference framework for interoperability: develops the basic design of the integrative framework and continues with the iterative development of the architecture and infrastructure. Criteria, derived from the analysis of WP2 are used. Implementation is done according to a living lab approach in which three representative use cases are elaborated. The platform of WP3 functions as a collaborative working environment. A fourth use case will be used to verify the framework. WP leader: Liisa Pesonen, liisa.pesonen@mtt.fi (MTT).

- WP5 Synthesis, recommendations and defining of the SRA: synthesizes the results from WP2, WP3 and WP4 and defines a strategic research agenda for follow-up activities of this project. It is important that the SRA is supported by all stakeholders. WP leader: Karel Charvat, charvat@ccss.cz (Wireless Info)

- WP6 Stakeholder integration and dissemination: coordinating stakeholder involvement and obtaining broad support from the user's community. This is done in close cooperation with the other WPs and in this way functions as a kind of integrating work package. A series of workshops, where the work and all relevant stakeholders come together, forms an important basis. Existing networks (e.g. EFITA) and contacts of all consortium partners are used for as well receiving input as dissemination of the project results. An advisory committee is set-up for getting explicit advice on project plans and strengthening ties for future support. WP leader: Sylvie Masselin-Silvin, sylvie.masselin-silvin@acta-informatique.fr (ACTAInformatique).

Project Results:

The main Science and Technology (S&T) results/foregrounds from the AGRIXCHANGE project concern three main results:

- Outcome of the Analysis of current situation in EU-27 and Switzerland (WP2)
- The developed platform as a community of practice and web portal (WP3)
- The Reference Framework that was implemented as the aXTool (WP4)

The results from WP6, stakeholder integration and dissemination, can be considered as supportive to these results. The SRA, as a result of WP5, is considered as a policy document.

The three main results as listed above are described in detail in the following sections.

Results from the analysis of the current situation in EU-27 and Switzerland

At the kick off meeting in January 2010, WP2 started with setting up the WP2 team. Common instructions and planning were made for the 6 focus groups and their leaders. The focus groups were responsible for collecting country data, for connecting external experts to the AGRIXCHANGE analysis work. As researchers and authors, the team members also played a major role in the elaboration of the area specific issues which all later came together in the reports.

For the literature review (task 2.1, D2.2), a template for gathering (meta)data has been set up, which later was used for importing all literature sources into the AGRIXCHANGE portal. The core WP2 team members (the focus group leaders) gathered over 400 literature sources (which took more time than planned) and put them into the template. Afterwards, these filled templates were uploaded into the literature database in the portal (see: http://www.agrixchange.eu/knowledge/literature-list). The team went through the large amount of literature, around and during the 2nd Project Meeting in Darmstadt (June 30 - July 2, 2010). Although good progress was made, the objective of getting a good analysis of the current status was not yet achieved at that time.

In the meantime, a template for inquiring the countries (task 2.3.) was set up and tested in Italy and France. In the test it appeared that not all parts of the template (questioning guideline) could easily be filled with the appropriate data. This was caused by differences between the countries, e.g. in some countries no relevant data were available. The test also proved that the choice for having a helping guideline (rather than a structured inquiry list) was right. Some changes were made for the final template, including data inquiry about the use cases which are of importance for WP4. The tested template was discussed and approved at the 2nd Project Meeting in Darmstadt.

The focus group leaders already started to build their expert teams per country. Some of them were struggling to find the right experts. After involving other partners and using the EFITA network most of the expert teams were formed around October 2010. Investigating the state of the art was done mainly in the last months of 2010, parallel to this also the analysis started.

In November 2010, at the GeoFARMatics conference in Cologne the first results of the investigations were presented at a workshop with approx. 30 participants. It was intended to get feedback, corrections and approval from the audience which worked out in a good way. In general, the first results were accepted quite well. In the Advisory Committee the results were judged as very promising and on the right track, but also some good advices and tracks were provided (see D6.5).

Around the Helsinki project meeting (February 2011), WP2 faced some delay in writing down the information and finishing the literature and state of the art reports.

Finally in March 2011, WP2 delivered both reports (draft chapters of D2.2. en D2.3, according to the Description of Work), already including some basic recommendations (in preparation of task 2.4) and future based frameworks (task 2.2).

During 2011, discussions by means of the AGRIXCHANGE portal, social media (LinkedIn group AGRIXCHANGE) and the usage of the EFITA newsletter and the ICT-Agri ERANET network, started about the country reports. The country reports, each by each, where published (in batch by focus group) at the portal, in order to trigger the discussion and feed the world. Although the publishing of the individual reports were not on the deliverable list, this was done because of major value to regional actors. In this period some new experts were involved in the discussion, leading to enhancements of the country reports.

In the period autumn 2011 till February 2012 the team assembled the final report (D2.4 "Current situation on data exchange in agriculture in the EU27 & Switzerland") based on summary of the literature review, state of the art based on field research and analysis of regional differences. Regional differences (areas) were elaborated based on levels of maturity on data exchange but also a number of different regional views and specific recommendations are given. A table per country can give recommendations on a general level.

At the time of the Smart AgriMatics conference (June 13-14, 2012) all tasks of WP2 were done. Team members of WP2 assisted at that time by providing input for WP4 (through the right implementation of the use cases) and carrying in the major results in the Strategic Research Agenda (SRA) of WP5. From beginning of 2012, WP2 started to provide input to WP5 in building the SRA. Content of recommendations are inserted and further elaborated in the final SRA. In November 2012 this task was finished. Concerning the current status on information exchange in agriculture, Europe can be split up in 4 levels.

Level 1 - None or hardly any data integration (like BG, RO, MLT, CYP) No private initiatives, public (CAP) providing rather closed (registry-) databases.
Level 2 - Poor developed (mostly Southern and Eastern, Baltic States) A move towards data integration has been initiated by CAP/Governments through interfaces. Some shared databases and portals are showing up. But still hardly any integrated private systems.
Level 3 - Rather well developed (Scandinavian states, CZ, UK, IRL, BE, CH) Involvement by private organization is evolving. A few data dictionaries are showing up and used.
Level 4 - Quite well developed (FR, DE, NL, DK) System assessment and move towards open/shared communities. Existence of private

standardisation bodies. Usage of national, private owned and global standards. Infrastructure based on hub structures (communicating and transporting systems). Further developing towards integrated models.

Concerning data integration, currently even level 4 is far from perfect. Data integration at inter-enterprise level (between enterprises) is often well organised but from intra-enterprise (within enterprise) point-of-view there is hardly any efficient and structured infrastructure. Data exchanging processes are drawn like a spaghetti mess.

Future integrated models are evolving towards an infrastructure more or less made up of open hub systems where those hubs have the functionality not only to transport data in a highly efficient way but also to be the place to add value and distribute it through services and in markets.

The AGRIXCHANGE platform as a community of practice

Information has been collected and user demands analysed in desk research to be able to formulate platform requirements. Findings have been discussed at the project meetings. Feedback has been queried and provided through the AGRIXCHANGE mailing list. Other initiatives and toolsets for user communities have been examined. Target groups and different personas using the platform have been characterized and their anticipated usage patterns outlined. A list of possible functionalities and detailed descriptions of the purpose has been created and evaluated in their usefulness for the aim of the project. Ways of implementing the platform using existing web toolkits and content management systems have been analysed. Task 3.1 has been finished by delivering D3.1.

As a bridging solution for the first months of the project, a preliminary website serving only the most important information on the AGRIXCHANGE project as static content has been setup. After the require-ments analysis and evaluation of software tools, a first prototype of the interactive platform has been developed demonstrating ideas of what could be done. This prototype has been presented to the project partners and discussed at the 2nd project meeting in Darmstadt end of June 2010. After some final modifications according to feedback provided by the partners, the platform website has been released on 3rd of September 2010 to the general public at the URLs http://www.agrixchange.org and http://www.agrixchange.eu. Since then, a number of additional functionalities have been implemented according to new requirements from other work packages. Especially the section for description of use cases has undergone heavy modification and evolved into what is now known as the aXTool (see WP4). Apart from use cases only, it now provides means to also edit and publish information on interfaces, (data) standards and implementations. On the other hand, forum and discussion facilities offered in the original prototype have over time been moved more into the background. These functionalities have been taken over by social network groups on LinkedIn. The AGRIXCHANGE platform website will continue to exist after the end of the project. Moderation and administration will be continued by a small team consisting of people working at several project partners, namely KTBL, DLO and MTT.

WP6 has announced availability of the platform through the EFITA newsletter. Literature and references from WP2 have been incorporated and made available on the website. The aXTool, a framework for describing use cases, interfaces, standards and implementations at several levels of detail has been implemented. A number of stakeholders – for now mainly in

research – have been contacted and asked to provide use cases to be presented on the platform. Reports from other work packages have been managed and published using the platform. The platform also has been presented at the GeoFARMatics2010 conference in Cologne, the EFITA congress 2011 in Prague and the Smart AgriMatics 2012 in Paris connected with an invitation to participants to sign up. Out of the project, a small group has formed that advertises aXTool as a means to share information on agricultural data exchange use cases, existing interfaces and standards.

Within the last 12 months several new use cases beyond the ones already planned for the AGRIXCHANGE project as test cases have been recorded. On the other hand, discussion facilities that have been setup on the website have not been used much. Activities have therefore not been restricted to the AGRIXCHANGE website with its aXTool, but take place also in the real world and in social media platforms like LinkedIn within groups. Links have been setup manually from the AGRIXCHANGE website to the LinkedIn group and vice versa. At the beginning forming the community required active involvement of the AGRIXCHANGE team, but during the last few months mainly the AGRIXCHANGE group and the Open Data Working Group became self-sustainable. Real communities sharing ideas and supporting collaboration now exist. LinkedIn played an important role in the collection of ideas for the Strategic Research Agenda.

In the feasibility study, desk research and analysis of working methods of existing communities provided an overview about possible models for the continuation of the platform including financial issues taking into account maintenance costs for different options (basic maintenance vs. extended maintenance). Details can be found in deliverable 3.4. After evaluating all possibilities, the maintenance of the platform and support for the AGRIXCHANGE community is now planned to be continued within the EU funded project SmartAgriFood. Additionally, discussions on merging activities of the ICT Agri ERANET project with AGRIXCHANGE activities have been initiated. This is currently an on-going process. Involvement of the European Federation for Information Technology in Agriculture (EFITA) is an option as well.

Potential feature classes of the platform included user, document, task and source code management, discussion and communication and knowledge bases. The knowledge base aspect has been considered to be important in discussions with project partners. Standard meta databases providing information about standards and specifications in use in IT in agriculture, literature references and a use case catalogue have been evaluated as potentially being useful tools for future work on the topic of data exchange. Not considered in implementation of the platform have been features that can be realized by using other, standard tools like e.g. teleconferencing and chats.

Evaluation of several content management systems with regard to necessary functionalities has led to the conclusion, that the Drupal system fulfils requirements best for now as it provides a rich set of ex-tensions and can easily be managed and adapted. The platform was implemented using that system and is available at http://www.agrixchange.org and http://www.agrixchange.eu.

The platform now provides information on the project itself both for the general public and for the project partners and makes the project results available. It hosts also the aXTool, the implementation of the reference

framework for interoperability and data exchange in the agri-food sector, as outcome of WP4. The aXTool currently shows 9 use cases, 24 interface descriptions and 20 descriptions of relevant standards. It therefore constitutes a relevant source for information on common data exchange in agriculture. This fact is mirrored in high rankings in common internet search engines.

The platform has now over 400 registered users, 46 of them are community members in the narrower sense, e.g. members of partner institutions, who can add content to the platform independent of the administrators. About 20 of them already have made use of this permission. Users originate mainly from European countries, but there are a number of users from overseas, e. g. from the United States and Peru or from states east of Europe like Russia or India. In total, the website served 1,2 million requests during the time from 1st of January 2012 until 14th of November 2012, of which roughly two thirds were generated by regular users, whereas the other third was issued by search engine robots. Referrers from search engines, i.e. people coming across the AGRIXCHANGE platform website through a search at one of the major search engines, occur quite frequently. The search for the terms 'data exchange agriculture' for example will give hits on AGRIXCHANGE.org on the first page of the search results, the website can therefore be considered highly visible.

The AGRIXCHANGE LinkedIn group currently has 584 users (at 21 Jan.2013) and serves very well as an informal discussion place. There are also two active subgroups within the LinkedIn community – the Open Agricultural Data Working Group (with 175 members) and the sensors working group (with 74 members).

The Reference Framework, implemented as the aXTool

The methodology to develop the reference framework was specified containing detailed work plan, scheduling and cooperation with other work packages and stakeholders, and also the requirements for use case documentations and analysis. The elaborated methodology was reported in D4.1.

Use cases and their analysis were utilized to lead us to the core problem area of interoperability. Three cases were selected as example use cases:
- Updating of LPIS (Land Parcel Identification System)
- Geo-farmer and fertilizing
- Animal registration

First, the use case template was defined. This template is used to describe the use cases in detail following the same structure. It was agreed that to the analysis chosen use cases should be based on existing real use cases but the technical platforms are based on Service Oriented Architecture (SOA) thinking as described in the WP4 methodology. The WP4 work group had two face-to-face meetings (Darmstadt 30.6.-1.7.2010, Helsinki 5.-6.8.2010) where use case templates were discussed and defined and actual work with use case analysis was carried on. The criteria for use-case specification and documentation for data exchange harmonization was reported in D4.2. The work with three selected use cases was presented to the public during the GeoFARMatics conference in Cologne on the 25th of Nov. 2010, both in WP4 session as oral presentations and in the Open Space workshop dedicated meetings. The use cases raised a lot of interest among the audience, and the approach was found to be useful. The use case descriptions including information models are published in the

AGRIXCHANGE platform (aXTool). A use case modelling approach plays a key role in the design of the reference framework for systems interoperability.

Information models of the use cases play an important role in data exchange harmonisation indicating the purpose and data content of a particular data exchange. As a collection of common use cases in the sector, they are also useful to identify the central vocabulary needed in the data exchange in the sector. A face-to-face meeting was arranged in connection of the JIAC2011 conference in Prague (13.07.2011) within the WP4 members to discuss about the meaning, content and format of the information models. The outcome is reported in the D4.4. Since the focus of AGRIXCHANGE project is more on inter-organization level data exchange problems, the information models of the use cases represent rather the information flow models of the problems considered, describing the information content of the data exchange between the actors. The information model of a use case consists of the Business process Model Notation (BPMN) diagram with message IDs and a table listing the information content of each data exchange message shown in the BPMN diagram.

The reference framework supports information gathering and information sharing to enhance data exchange harmonizing and systems interoperability. The aim was to implement the reference framework into the AGRIXCHANGE platform in cooperation with WP3, where it functions as a data exchange harmonizing tool for the community. Information produced by WP2, about the situation of data exchange and information management in EU countries, provided background knowledge about the environment where harmonization work will take place and the challenges the work will face. Created use case descriptions and their cross-examinations gave a good ground for defining the main structure of the basic design of the framework. It was agreed that the harmonization work will concentrate on inter-enterprise data exchange, which are defined as data exchange interfaces between the actors in the use case models. The functionalities of the framework and its design were discussed and planned on the base of use case analysis during the third project meeting in Helsinki (02.-03.2. 2011). A follow-up face-to-face meeting was arranged in The Hague (10.03.2011). The key functionalities to share information and to create common awareness of existing solutions, and a classification of the information (aXRIM) to be shared by the support of the reference framework were agreed in this meeting. The first design of the Reference Framework was made in May-June 2011, paying attention especially to information presentation hierarchy and workflow when using the functionalities of the design. The main components of the design were implemented in the AGRIXCHANGE platform. The implementation got the name aXTool. The design was discussed and evaluated by the AGRIXCHANGE community members during the Open Space AGRIXCHANGE workshop in JIAC2011 conference (12.07.2011). Especially, the quality management of the aXTool content was considered as one of the critical issues for the success of the aXTool. The gained feedback led to iterative modifications to the design. The implementation of the Reference Framework in the AGRIXCHANGE platform in the connection to the whole platform development was discussed in a WP3 and WP4 face-to face meeting in Darmstadt (12.-13.09.2011). The Reference Framework, Information models and further development of aXTool were discussed during the WP4 workshop in the Project Meeting in Paris (19.-21.10.2011). The aXTool was introduced to a wider audience and AGRIXCHANGE community in a dedicated session in the Smart AgriMatics 2012 conference in Paris (13.06.2012). The gained

feedback was positive in nature, and remarks from the audience were taken into account in the next modifications of the aXTool during the summer 2012.

The three selected example use cases: 'Updating of LPIS (Land Parcel Identification System) ', 'Geo-farmer and fertilizing' and 'Animal registration' were utilized in the design process of the Reference Framework as to give understanding of concrete requirements of information structure and needed level of details for the information to share. Three end-users outside the project were involved in the early phase of the design process by giving their opinion and view of needed functionalities in the Reference Framework. Two of the interviewees represented software companies and one the government point of view. They all were dealing with both wide scope use cases and narrow scope interface implementations in their profession. These interviews took place before implementing the aXTool, and the gained answers and opinions were taken into account in the design.

To confirm the appropriateness of the design of the Reference Framework to its purpose to enhance interoperability and data exchange in agri-food sector, the initial verification of the design was carried out subjectively by the project members (L'Elevage, KTBL and MTT assisting) as a kind of a transparent self-checking procedure during spring 2012. The aim of this early stage verification was to evaluate the basic functional model behind the Reference Framework design, and therefore attention was paid to the functional targets and evaluation criteria derived from the collective project workshop discussions (Helsinki, The Hague, Prague, Darmstadt, Paris).

The fourth use case concerning animal identification named 'European Bovine Identification and Traceability within one EU country' was utilised in the verification work. The wide scope use case and its information model were described using prepared templates in the aXTool. The template for narrow scope interface description for data exchange between two actors and aXRIM classification functionality of the aXTool were tested, however, using interface description of spatial data exchange named 'Request for Weather Nowcast (GeoTIFF to XML conversion)'. The verification cases provided information which was linked to the earlier three use cases in the aXTool providing material for testing the search functionalities. The information contained also new items like food industry or weather service provider as actors and spatial images as data to test the adequacy of the templates and aXRIM classification.

The evaluation indicated that the Reference Framework design fulfils the main objectives, and its implementation will have good potential to evolve as an efficient tool for the AGRIXCHANGE community to enhance interoperability and data exchange in agri-food sector. The evaluation was an initial test to verify the main functionalities of the AGRIXCHANGE Reference Framework, and to expose the major functional shortages and needs to adjust the design. More comprehensive testing including the evaluation of usability of the aXTool should take place later, when more material is available in the aXTool. The AGRIXCHANGE community has an important role in this further evaluation and development of the Reference Framework design and the aXTool.

The community shall pay attention to following three main properties:
1) functionalities for information sharing,
2) functionalities for the data exchange harmonizing process and

3) functionalities for quality management.

The actual data exchange harmonizing work of the AGRIXCHANGE community begun with this task. The results of the other WP4 tasks were taken to the discussions and further development work in the community platform and workshops in a form of the aXTool. The aXTool supports the Living Lab approach for implementing the practical pilots in Europe and to gain feedback and awareness of data exchange harmonizing solutions. The solutions for interoperability and related feedback is gathered to the aXTool in the AGRIXCHANGE platform, from where it is shared for further discussions and development work in the community.

The harmonization of the selected use-cases was the main focus during the project, and the main problem points, concerning e.g. business process interfaces of the systems, data formats and schema, vocabularies, quality assurance needed in the data exchange, were identified and brought to the community discussion using aXTool in its different development phases. The task collaborated intensively with the WP3, especially with task 3.3 'Building contents and community', and also with the stakeholders. The WP2 reports have given the insight which topics would be interesting and important in different countries and different parts of the Europe.

So far, the work of this task has included discussions with potential community members around the use cases in connection to data and information collection for use case analyses, discussion about the use case variants and AGRIXCHANGE activities. The use cases and further development of the Reference Framework design has been available to the community in the AGRIXCHANGE platform. Discussions and feedback collection with a wider audience took place during to the use cases dedicated meetings in the Open Space workshops in the GeoFARMatics conference in Cologne in November 2010, in the JIAC2011 conference in July 2011. In the discussions with the community (including advisory board members), it has been indicated clearly, that the focus of the data exchange harmonizing is in the data exchange interfaces between the actors and enterprises and not in harmonizing the processes. In Service Oriented Architecture (SOA) this means that we harmonize the process service layer, not the process management layer. This is due to diversity in process management in different countries and existing process management systems. Process management is also area where companies compete in business with each other. The almost final version of aXTool to support data exchange harmonizing work and interoperability was presented to community members in the Smart AgriMatics conference in Paris (13.06.2012), and it gained positive feedback.

The aXTool shares information about possible solutions. The information gives understanding on what can be changed and in what timespan, and what is needed to change in order to utilize and to take benefit of existing solutions, good practices and standards, and to create interoperability. Due to diversity of business ecosystems and their technology level and information needs in different countries, regions and production branches the organisations involved and their role in the information systems vary. Novel technologies provide generic, often standardised, interoperable solutions for technical system structures and communication protocols designs. It seems that instead of defining typical systems for data transfer to be unified in Europe, it is important to create awareness of existing use cases showing the need and also solutions for systems integration, and to share and (re)use open communication interfaces between the actors in the information management networks. In

this kind of networked systems, the vocabularies and ontology become important issues to harmonise and unify. Advanced semantics enable creation of intelligent integrated system networks which serve the business in the agri-food sector efficiently.

The work to harmonise vocabulary in the agri-food sector can be enhanced utilizing the material that is collected in connection of contributing Information models to the AGRIXCHANGE database. The list of collected attributes/data items could be reused when creating a new information model for a solution and/or contributing one to the aXTool. Indication of the commonness of the used word in the attribute list could guide the reuse of it. To enhance the utilization of existing standards, the standardization bodies could contribute their standards to the aXTool collection, where they can be easily found by system developers.

The AGRIXCHANGE community has an important role in further evaluation and development of the Reference Framework design and its implementation aXTool to mature to a usable and efficient tool for interoperability. The community shall pay attention to the constant development of the functionalities for information sharing, data exchange harmonizing process and quality management, to which the present design gives an appropriate framework. The future challenge is whether the aXTool will receive use case, interface, standards and implementation contributions. Thus, one way to promote the data exchange harmonizing for interoperability is to encourage AGRIXCHANGE community members to disseminate resulting solutions from research and development projects by contributing them to the aXTool collection. Projects like SmartAgriFood, ICT-AGRI EraNet, UASI and several new project initiatives have shown interest to utilize aXTool to disseminate project results and to further develop them to generic or common solutions. To conclude, the aXTool is the tool for those actors who need and want to develop and create interoperability between the systems they have influence on.

Potential Impact:

Potential impact (including socio-economic impact and wider societal implications)

The potential impact of the AGRIXCHANGE project, including socio-economic impact and wider societal implications, was mostly covered by the Strategic Research Agenda that was defined. The SRA goes beyond the general scope of the AGRIXCHANGE initiative. It is focused not only on standardisation of data exchange but also on the definition of research priorities for ICT in the agri-food sector and for future sustainability of ICT agriculture research and standardisation.

The SRA introduces basic problems of agriculture interoperability, the problems of management and interoperability of data, information and knowledge in agriculture. It gives a short overview of current standardisation initiatives, which are relevant to the problems of AGRIXCHANGE. It also describes current AGRIXCHANGE activities in the area of standardisation.

The AGRIXCHANGE work was focused on two topics:
- the structure of the framework model serves information on sharing and harmonisation development for data exchange, and
- the implementation of the practical model tool (aXTool) in the AGRIXCHANGE platform to be user-friendly.

The SRA also gives an overview of previous activities. We analysed only those projects and documents that were focused on a vision of future ICT for agri-food or eventually ICT for rural development. The analyses conclude that the progress in the deployment of ICT infrastructure for (standardised) data exchange in Europe is changing very fast and changes from one year to the other. In principle, a large part of the population in Europe has the possibility to access broadband or has permanent access to the Internet (the bandwidth is usually lower for rural regions than for cities). This potential access to the Internet is not really used: real use of Internet access is lower in rural regions and the uptake of new solutions into practice and also research in agri-food and rural applications is slower than the deployment of the general infrastructure. In many cases application priorities are the same as 10 years ago. The big problem is the data, information and knowledge exchange and interoperability.

From the overview we come to the following conclusions, important for building of AGRIXCHANGE SRA:
- The uptake of new ICT interoperable technologies in primary production, which will be accepted by farming sector
- The analysis of documents from the last decade demonstrates that there is low sustainability of ICT for agri-food research and little exchange of experiences among projects. Often similar analyses with similar results are provided, but overall progress is slow. To overcome this problem, it is necessary to support a long-term suitability of ICT research and to support a long-time vision for RTD development in the agri-food sector.
- Better and faster implementation of RTD results of ICT in practice with appropriate business model thinking.
- A strong professional (international) organisation which will unify different efforts of different ICT research and development groups, but which will be also able to protect interests of communities. The

candidate for such an organisation could be the European Federation for Information Technology in Agriculture, Food and the Environment (EFITA,) but it will be necessary to change its organisational structure.
- It is important to renew dialogues for politicians to focus on ICT for rural regions as part of Horizon 2020 activities. It is not only important to support standardisation awareness, but also deployment of new solutions necessary for rural regions. Currently, ICT for agri-food is not covered on a large scale, neither in DG Connect research nor in KBBE calls.
- Due to the global character of agriculture and food production and also because agriculture production influences and is influenced by the environment, it is important to improve dialogue and transfer of ICT knowledge between developed and developing countries.

Following the latest ICT research trends, three aspects are relevant:
- Future Internet;
- Open Source Software;
- Open Data.

The relation between Future Internet (mainly cloud computing) and Open Source Software could be in some way considered as competitive approaches, but at the same time they could be in synergy. There are two important aspects:
1. Interoperability and service-oriented architecture, which allows easy replacement of one component or service by another one. This concept is already currently broadly used in geographic information systems.
2. Support for large-scale use of Open Sources by Future Internet. Currently, Open Source generates business for companies which customise solutions into final applications. Such web-based solutions could generate profit for SMEs developers.

Open data initiatives and Public Sector Information are also considered important for the agri-food sector. Until now, mainly farmers have been limited by restricted access to data, information and knowledge. Linked Data introduces new semantic principles into Web resources and could be useful to the agri-food sector.

Concerning future challenges two types of challenges can be distinguished:
- Political-organisational challenges
- Technological, innovation and research challenges

The following flow chart explains how both types of challenges affect the SRA.

The following political and organisational challenges have been identified:
- To improve the representation of ICT agriculture specialists and users in European activities
- To include ICT and knowledge management for agri-food and rural communities generally as a vital part of the ICT policies and initiatives
- To support a better transfer of RTD results and innovation to the everyday life of farmers, food industry and other rural communities
- To accelerate bottom-up activities as a driver for local and regional development
- To support discussion and transfer of knowledge between developed and developing countries

And the following technological, innovation and research challenges:
- To find a better balance between food safety and security, energy production and environmentally and socially sound production
- To support better adoption of agriculture on climatic changes
- To make rural regions an attractive place to live, invest and work, promoting knowledge and innovation for growth and creating more and better jobs
- To support the farming community and rural education, training and awareness building in ICT
- To build new ICT models for sharing and use of knowledge by the agri-food community and in rural regions in general.

The following research priorities for the Applications domain are identified:
- Collaborative environments and trusted sharing of knowledge and supporting innovations in agri-food and rural areas, especially supporting food quality and security.
- New (ICT) structures to serve sustainable animal farming, especially regarding animal and human health and animal welfare.
- ICT applications for the complete traceability of production, products and services throughout a networked value chain including logistics.
- A new generation of applications supporting better and more effective management of sustainable agriculture production and decision making in agriculture ICT applications supporting the management of natural resources.
- An ICT application supporting adoption of farming practices adapted to climatic changes.
- An ICT application supporting energy efficiency on farm level.
- An ICT application supporting rural development and local businesses.
- An ICT application for education, training and awareness raising.
- ICT applications reducing administrative burdens in rural areas.

The priorities for ICT research domains were based on the needs from application areas, but also on the analysis of results from chapters 2, 3, 4 and 5. The future development has to be supported by ICT focusing on:
- Future Internet and Internet-based applications such as sensor technology, cloud computing and machine-to-machine communication.
- Mobile applications.
- Improving of positioning systems.
- Service Oriented Architecture.
- Methods of knowledge management.
- Semantic models, multilingualism, vocabularies and automatic translation.
- New Earth observation methods.
- Management and accessibility of geospatial information.
- Open data access.
- Open Source development.
- New modelling.
- The power of social networks and social media.
- New e-educational and training methods.

The relation between agri-food related applications and ICT research topics.

Recommendations for a necessary future standardisation effort related to ICT and agriculture applications priorities emphasize the following important facts:

- On the level of data standardisation, the agri-food community will mainly be the consumer of standards coming from other domains or activities. For example activities related to Future Internet, where it is the intention to design low-level standards allowing developers to access data through standardised API. A similar situation, for example, can be found with geospatial data, where access is solved through OGC standards. Also questions like security are mainly solved outside of the agri-food community. It is important to follow this initiative, and eventually participate in other initiatives including the SmartAgrifood project in Future Internet.

There are two areas where further development is necessary inside of the community:
- ISOBUS for access to information to agriculture machinery;
- Special agriculture sensors or RFID activities.
- More important seems to be the effort on an information level.

In accordance with work which was provided in WP4, it is necessary to be focused on protocols (Web services), API and data models for exchange of information in different areas such as traceability, precision farming, live transport, welfare regulations, subsidies systems (for example LPIS), weather information, market information, logistic information. It seems that for the next period the key focus will be in this area. The work could be partly related to activities such as agroXML.
- In the future with the expansion of Web-based technologies, more effort will be necessary in the area of knowledge level. Access to knowledge is the goal of many information systems. It is necessary to build knowledge based tools, which will help user in orientation and right decision. It could be ontologies, RDF schemas for open linked data, thesaurus or vocabularies. Such activities already exist, for example under FAO (AgroVoc thesaurus) and different tools of knowledge management. This effort is partly covered by the new project agINFRA.

The strategy to define long-term strategic goals for sustainability of AGRIXCHANGE follows the previously defined political organisational challenges for the following reasons:
- In any area there are two types of standardisation efforts:
- Community or industry driven effort. For these it is necessary to have structure inside the community, which will take leadership in this area.
- Politically driven standardisation – in the agri-food area it could include standards for animals welfare, food security etc. For implementation in practice, it is necessary to support related policy. Also, it is good for policy makers to have partners on the community level.
- For any standard it is important to transfer it to the community. It is necessary to support communication between researchers, politicians, industry and also final users. It is necessary to transfer all knowledge to the users.
- It is important that the requirements for standards are not defined only by politicians or by large industry. Standards have to cover needs of users like farmers and regional and local IST developers. Involvement of these communities is crucial.
- The food market is international and for example information about food traceability has to be shared worldwide. It is important in this area to support standards worldwide.

As a reaction on single challenges there are the following recommendations:

- It is necessary to have a better coordination of different activities related to ICT for agriculture, but also related to standardisation. On the basis of the performed analysis, it seems not realistic to establish a new platform initiative. It is not only a question of financing, but it is also a question of building infrastructure, human resources, etc. For this reason, the project team recommends to move AGRIXCHANGE under the umbrella of an existing organisation. It will increase the chances for financing of future activities. As an umbrella organisation, the European Federation for Information Technology in Agriculture (EFITA) would be most suitable. The advantage to have a European body, representing the ICT Agri-food sector, which could be an interesting partner for the European Commission and other policy actors.., in particular for Initiatives such as the European Innovation Partnership.
- Currently ICT for agri-food sector is not covered by any policies and also there is no direct support for such activities. The topic is addressed by different Directorate Generals (DGs), but no DG covers this issue fully. It is important to include these topics as part of the European priorities and also as part of Horizon 2020. From this reason, it is important to have strong representative of a community, which will provide the necessary lobbing. On the worldwide level, part of these activities is covered by FAO. But there are gaps between FAO and the worldwide community. It is necessary to improve cooperation.
- Any RTD results and also results of standardisation have to be transferred into practice to local and regional users. In the future, the agINFRA project could be of help. The project has an objective to build infrastructure for sharing agriculture information.
- It is necessary to support open innovation initiatives in rural regions. It will be good to introduce concept of 'Smart Rural Regions' similar to Smart Cities.
- It is necessary to support standardisation cooperation also worldwide. FAO or the International Network for Information Technology in Agriculture (INFITA) could play an important role.

Main dissemination activities and exploitation of results

Dissemination and exploitation of results were mainly done in WP6 on stakeholder integration and dissemination, although it was very much using and amplifying the results of the other work packages. The most important activities were the organized workshops. Besides some other relevant external communication took place.

Three workshops were planned to present and discuss the AGRIXCHANGE results and plans for follow-up activities, with external stakeholders. It was decided to organize the workshops as much as possible together with other projects or networks to increase the potential impact. The following workshops were held:

GeoFARMatics 2010 - International Conference on Geo-Information and Information Management for Farms, Agribusiness and Administration (24-26 November 2010 in Cologne, Germany).

This was a joint conference with the FutureFarm project and the CAPIGI network. The first results of WP2, WP3 and WP4 were presented discussed, which led to adjustments to the follow-up activities of these work packages. A preliminary exercise was done to get input for the SRA (WP5) which resulted in the Cologne Declaration.

The conference was a real success. With the alternation of plenary sessions and group specific sessions, together with AGRIXCHANGE open space and CAPIGI exhibition market, nearly 150 people from 15 countries found opportunities to learn on on-going works, to meet and discuss. Participants mainly represent public research (2/3 of the attendees and speakers). But other organizations (e.g. ANELA and ARVALIS-Institut du Végétal, France; CRV, The Netherlands; Danish cattle federation, Denmark) as well as industry (e.g. John Deere, Claas) were also there. The European Commission sent people working in DG-Agri and DG-Research. Information about the presentations and results can still be found at http://www.geofarmatics2010.org and the AGRIXCHANGE website.

2nd AGRIXCHANGE workshop as a side-event of the EFITA/WCCA 2011 conference on the Digital Agenda for 2020, ICT-technologies, and knowledge management for integrated and sustainable farm management in the whole world, in conjunction with the 8th ECPA, and 5th ECPLF conferences, held in Prague (Czech Republic, 12 July 2011).

The final results of WP2 were presented and the on-going activities in WP3 and WP4 were presented and discussed, also in 'open space' sessions. Several keynote speakers were invited to, amongst others FAO and JRC that provided external insights to the subject of AGRIXCHANGE. They also participated in a round-table session. The whole workshop was broadcasted via an interactive web video channel. Afterwards all presentations and discussions were made available as videos on the Internet. We also took the opportunity to make additional videos for each work package that were broadcasted through a YouTube channel. Beside the special AGRIXCHANGE workshop we had several presentations in a special session at the EFITA conference, dedicated to AGRIXCHANGE.

EFITA/WCCA2011 was an international conference where the key topic was Information and Communication Technology (ICT) in agriculture, food and the environment at European and global level. More than 300 registered people who were attending the joint conference; 47 persons, coming from

19 countries, attended the AGRIXCHANGE session, of which 28 were not AGRIXCHANGE project participants. This participation rate was a little deceiving but people attending the AGRIXCHANGE session have been really interested in the promotion of data exchange, standardisation and harmonisation, and by the AGRIXCHANGE platform being a rich documentation source as well as a living lab and a virtual meeting place where to learn and debate. Compared to the 1st workshop in Cologne (November 2010), the public profile was different. In Cologne, the public came from various origins, including the industry. In Prague, the public was more academic, with only a few ICT companies or service providers. The full workshop has been broadcasted as a webinar through http://wurtv.wur.nl/Presentations/Roadkit4/ during which it was possible to interact through Skype. Afterwards the broadcasted sessions and related presentations were published on the AGRIXCHANGE website. Additionally recordings were made from general presentations of WP1 to WP5. Which are broadcasted through a YouTube channel.

Smart AgriMatics 2012 on the future use of ICT and robotics in agriculture and agri-food (13-14 June 2012 in Paris, France).
This was a joint conference with the EU-FP7 projects SmartAgriFood and ICT-Agri ERAnet. The objective was to outreach for practitioners (e.g. software developers, agri-food business) to get them acquainted with the results from AGRIXCHANGE and get feedback from them. Therefore, workshops in small interactive groups formed the heart of the conference, in which presentations alternated with hands-on exercises or real programming sessions. Most sessions were a real mix between the targeted audiences of the three projects involved, but there were also several specific sessions that focused on AGRIXCHANGE activities. In this way we managed to involve a large group of people that were not included in AGRIXCHANGE before. It was also an important conference to test the draft SRA (WP5).

The Smart AgriMatics conference started with a plenary opening session to introduce the workshops and several key note speakers introduced some interesting topics on ICT and robotics in agri-food business. A plenary closing session concluded the conference and set the agenda for the future. For that purpose key persons from leading industries in agri-food/ICT business and policy makers have been invited. The organising committee benefited from the experience of earlier conferences (e.g. GeoFARMatics). So they achieved to catch a large public of 172 visitors, coming from software and hardware companies, farms, consultancy, agri-food business, governmental organisations and research institutes. Participants came mainly from The Netherlands (36) and from France (28), but also from 20 other countries, mainly European ones, although a few people came from outside Europe. All presentations and other materials are publicly available through http://www.smartagrimatics.eu and the AGRIXCHANGE website.

Beside these three planned workshops, an additional, extra workshop was organized:
Workshop 'The Future of Information Exchange and ICT in Agri-Food business' (5 Oct 2011, Munich, Germany).

This was a joint workshop with the SmartAgriFood project. For this workshop many relevant standardization organizations and agri-business platforms were invited such as: AgroXML, AgroEDI Europe, AgroConnect, FrugiCom, FloreCom, EDIbulb, UN\Cefact, AEF\ISOBUS, INSPIRE, GS1 and GlobalG.A.P. We also invited Rod Conner from AgGateway, a non-profit consortium of businesses serving the agriculture industry, with the

mission to promote, enable and expand eBusiness in agriculture from the USA. exchange of knowledge and experience on information exchange and standardization. The objective was to exchange knowledge and experience on information exchange and standardization and look for possible future cooperation between various standardization organizations and business platforms and the role of the currently established AGRIXCHANGE Platform in that.

In addition to the workshops, which were already focusing on external communication a lot, the following activities were carried out:
- The EFITA (European Federation of Information Technology in Agriculture) mailing list has been maintained and used to disseminate information about the AGRIXCHANGE project, to contact specialists involved in information exchanges in our respective countries, to announce various workshops that were held. The AGRIXCHANGE project and its web site were mentioned regularly in connection with publication of results or organization of all kind of stakeholder events. We published the 500th issue weekly EFITA newsletter in February 2011. Around 4500 contacts were receiving the weekly EFITA newsletter. The AGRIXCHANGE project and its web site were mentioned 39 times in the weekly EFITA newsletter since April 2010.
- The dissemination of information about project results already began through the EFITA newsletter with special emphasis on results obtained by each work group. The maintenance of the EFITA mailing list and the edition of the EFITA newsletter proved to be a key success factor for the organization of the workshops.
- EFITA web site: the EFITA web site has been maintained to support the EFITA community of in which AGRIXCHANGE was largely embedded.
- There was a good relationship with ICT-Agri ERAnet. We used their communication channel to disseminate about AGRIXCHANGE activities and vice versa.
- Two general project articles were written for the 'International Innovation' magazine, targeted at a general public to enlarge the impact of the project.
- A contribution in terms of an oral presentation and paper to the ICT-Ensure project.
- Presentations and contributions to discussions at several international conferences: IST Africa 2012, IFMA2011 (Methven, NZ), Internet as Innovation Eco-System Summit and Exhibition (Italy), ICE (Munich, DE), AgGateway (Las Vegas, US) and IAALD 2012 (Africa).
- The Czech partner WRLS explicitly disseminated AGRIXCHANGE in its network in the Baltic states.
- The project coordinator Sjaak Wolfert has given several presentations to different audiences during his half-year visit to New Zealand (farmers, policy makers, ICT developers, etc.).
- Finally, every partner was involved in various dissemination activities at national level.

The various activities to disseminate the project to external stakeholders has led to a number of publications in books, proceedings and magazines. Also various stakeholder groups (large and small) were reached through these activities at national and international level (also outside EU).

List of Websites:
http://www.agrixchange.eu