Building **R**adio frequency **ID**entification for the **G**lobal **E**nvironment

Innovation Report – first issue

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About the BRIDGE Project:

BRIDGE (**B**uilding **R**adio frequency **ID**entification for the **G**lobal **E**nvironment) is a 13 million Euro RFID project running over 3 years and partly funded (€7,5 million) by the European Union. The objective of the BRIDGE project is to research, develop and implement tools to enable the deployment of EPCglobal applications in Europe. Thirty interdisciplinary partners from 12 countries (Europe and Asia) are working together on : Hardware development, Serial Look-up Service, Serial-Level Supply Chain Control, Security; Anti-counterfeiting, Drug Pedigree, Supply Chain Management, Manufacturing Process, Reusable Asset Management, Products in Service, Item Level Tagging for non-food items as well as Dissemination tools, Education material and Policy recommendations.

For more information on the BRIDGE project: www.bridge-project.eu

This document:

In a number of its policy communications, ranging from the i2010 agenda to the first calls for Framework Programme 7 and including the Communication COM(2007) 96 on *RFID in Europe: Steps towards a policy framework,* the European Commission has stressed the importance of innovation in research to European competitiveness. The successful implementation of RFID and the move towards '*The Internet of Things'* is seen as an important part of this innovation. The BRIDGE project with its innovation in technical, business and dissemination activities is an important contributor to this research arena.

Disclaimer:

This document results from work being done in the framework of the BRIDGE project. It does not represent an official deliverable formally approved by the European Commission.

Contents

Preface – some quotes

Innovation – the successful exploitation of new ideas

– is the key business process that enables … businesses to compete effectively in the increasingly competitive global environment.
……
It explains current policy goals, such as the transfer of knowledge between the science and business communities, and support for small businesses as key sources of innovation.
http://www.dti.gov.uk/innovation/index.html

COM(2006) 502 final

Putting knowledge into practice:
A broad-based innovation strategy for the EU

1. OUR FUTURE DEPENDS ON INNOVATION
In a remarkably short period of time, economic globalisation has changed the world economic order, bringing new opportunities and new challenges. In this new economic order, Europe cannot compete unless it becomes more inventive, reacts better to consumer needs and preferences and innovates more.
http://ec.europa.eu/enterprise/innovation/doc/com_2006_502_en.pdf

COM(2006) 589 final

An innovation-friendly, modern Europe

There are many facets to promoting innovation. The success of some countries and regions in creating a genuinely favourable environment to innovation is largely due to a conscious political decision to take a strategic approach to innovation, by focusing policy on a key set of framework conditions and ensuring that its implementation is a matter followed up at the highest political level.
http://ec.europa.eu/growthandjobs/pdf/COM2006_589_en.pdf

Supply chain innovation

Supply Chain Innovation, Strategy and Management - Supply chains coordinated on a global scale for producing and marketing goods and services are a fascinating and important area for study. They are reshaping contemporary business, technological and socio-economic development. They impact on everyone's lives and conditions – in both industrialised and developing countries. They are central to environmental change and to sustainable business practice.

Open University, Post Graduate Course
http://www3.open.ac.uk/courses/bin/p12.dll?C01T882

COM(2007) 146 final

i2010 - Annual Information Society Report 2007

Boosting research and innovation is at the centre of the Commission's strategy for growth and jobs.
……
European research and innovation receive a major boost with the launch of the **Seventh Framework Programme for Research (FP7)** that will run from 2007-2013. The EU will invest over €9 billion in ICT, the largest single item in FP7.

The Commission will continue to cooperate with the nine European ICT Technology Platforms set up to strengthen partnership with industry and achieve a critical mass of research in strategic fields.
……
The EU is also committed to improving the framework conditions for innovation, and has identified 10 key actions to this end.
……
The ICT policy support programme (ICT PSP) in the **Competitiveness and Innovation Programme (CIP)** stimulates innovation and competitiveness through promoting wider uptake and best use of ICT by citizens, governments and businesses, in particular SMEs
…….
A new wave of innovation in networks and the Internet
The information society is becoming a reality. Low cost networks, extended by mobile or wireless networks, allow seamless connection and use of applications and services integrated in the network and these are becoming more widely used in society.
This move is supported by emerging technological trends such as the migration towards very high-speed networks, ubiquitous wireless technologies, web 2.0, the Internet of Things, Grids, new network architectures, web-based services, user interfaces, user-created content and social networking. These trends will affect the business and working environment, providing new industrial opportunities and new solutions for eBusiness and employment, thus improving the work-life balance. They will also extend the role of users as innovators. This is already visible in the explosion of user-created content.
…..
A user's perspective on innovation
With the emergence of new services, the next challenge is the user. The rise of user-created content is opening further perspectives for a more creative and innovative Information Society.
……
Investment in information and communication technology (ICT) is bearing fruit, finds the Commission's latest annual progress report on the i2010 initiative. Technology is fuelling innovation and productivity, and there are signs of fundamental change in markets and user behaviour, as Europe moves towards a knowledge-based economy.
http://ec.europa.eu/information_society/eeurope/i2010/docs/annual_report/2007/comm_final_version_sg/com_2007_0146_en.pdf

Summary

A simple definition of innovation is being used – the successful exploitation of new ideas.

In a number of its policy communications, ranging from the i2010 agenda to the first calls for Framework Programme 7 and including the Communication COM(2007) 96 on *RFID in Europe: Steps towards a policy framework,* the European Commission has stressed the importance of innovation in research to European competitiveness. The successful implementation of RFID and the move towards '*The Internet of Things'* is seen as an important part of this innovation. The BRIDGE project with its innovation in technical, business and dissemination activities is an important contributor to this research arena.

The BRIDGE project has a very strong representation of twelve University and industry based research organisations contributing to the development of hardware and software innovations in RFID and developing innovations in the design, manufacture and programming of RFID tags and associated equipment.

Strong involvement from RFID users is also a key part of the innovation process in the business development work packages. The consortium companies involved range from a global retailer, an independent cold sauces manufacturer to part of the worlds largest food and beverage manufacturer.

This report, being produced at the end of the first year of a three year project, is very much an interim report. However, there are already good signs of innovative developments, as shown by the following examples:

- Small tags, by design of small antenna and low cost readers
- Development of the EPCglobal network concepts and Discovery Service
- Development of probabilistic track and trace algorithms for serial level item identification
- A comprehensive security model for RFID tags

- Business models for anti-counterfeiting
- Business model for the tracking and tracing in the pharmaceutical supply chain
- Business models for global textile supply chains
- Improvement in manufacturing processes within a factory due to us of RFID for tracking and tracing
- Return on Investment (ROI) models for use of returnable assets (eg pallets)
- Examining ways in which item-level information acquired during a product's lifecycle could enhance its in-service use
- Improving speed and efficiency in the retail supply chain for non-food culture items (CDs, DVDs etc.)

The Commission's Communication about RFID (COM(2007) 96), and the German Presidency's draft document on *'European Policy Outlook RFID',* which can be found at http://www.nextgenerationmedia.de/Nextgenerationmedia/Redaktion/en/PDF/european-policy-outlook-rfid,property=pdf,bereich=nextgenerationmedia,sprache=en,rwb=true.pdf , also make clear the importance of the need for good training and dissemination in this area, especially so that SMEs can take up the advantages of using RFID in their supply chain activities. There are significant work packages in the BRIDGE project dedicated to producing suitable on-line learning materials for this purpose.

We believe that innovation and ongoing dissemination of the developments of the move 'Towards the Internet of Things' should be lead through a European Technology Platform (ETP) which would develop a strategic research agenda (SRA) around auto-identification, traceability and supply chain networks and be known as Ambient Intelligence Supply Chains (AmISC). In focussing on auto-identification and supply chains that contain 'intelligent products' the ETP moves us towards the' Internet of things' and would aim to fuse the issues of supply chain product flow and information flow, information sharing, consumer behaviour, sustainability, culture and governance.

The BRIDGE project has been represented at meetings of CERP (Cluster of European RFID Projects) which aims to maximise the exchange of information about RFID developments taking place in the fourteen projects supported by the Commission under Framework Programme 6. Aspects of these projects, which involve RFID to varying degrees, could contribute very positively to the Ambient Intelligence Supply Chains work of a new European Technology Platform, together with relevant projects on RFID that may be supported under Framework Programme 7.

Finally, one patent, 11 papers and 12 articles have been published or are in press to date.

The policy environment

i2010

The Lisbon Agenda renewed

In March 2000 the European Council launched 'an ambitious agenda for reform'. Whilst all seem to recognise and concur with the concepts, it was agreed that delivery of those concepts is flagging. So half way through the decade of the Lisbon Agenda it has been reviewed and given a new start focussing on 'Working together for growth and jobs' (see http://ec.europa.eu/growthandjobs/pdf/COM2005_024_en.pdf). This identifies a new action programme to:

- Make Europe a more attractive place to invest and work
- Increase knowledge and innovation for growth
- Create more and better jobs

Important to this 'refreshed' programme is 'stronger investments *in* and use of Information and Communication Technologies' and a proposal to create a European Institute of Technology (see http://ec.europa.eu/education/policies/educ/eit/index_en.html) .

The renewed Lisbon Agenda is seen as a very strong mantra for improving European technological developments, enhancing the European Research Area (ERA – see http://ec.europa.eu/research/era/index_en.html) by significantly increasing EU investment in R&D and as part of that, strengthening our focus on ICTs.

i2010 – A European Information Society for growth and employment

The new start for the Lisbon Agenda stresses the need to build a fully inclusive information society based on the widespread use of ICTs in public services, SMEs and the household. This is expressed in three priorities under the i2010 banner (see http://europa.eu.int/information_society/eeurope/i2010/index_en.htm):

- A single European information space promoting an open internal market for the information society and media
- Strengthening innovation and investment in ICT research
- An inclusive European information society

The EU believes that we are at a turning point in the development of the Information Society where mass deployment of ICT, rich digital and media content and greatly improved network facilities can improve our technology, our services and our overall quality of life.

Industrial innovation and growth potential

There is significant emphasis on studying and developing the policy position over RFID and much effort from policy makers, users, solution providers and consumer groups is being devoted to the matter – the quotes in the preface to this document exemplify this activity. Plus draft paper from conference…

A first Commission Communication – COM(2007)96 -during the process of the consultation over RFID was issued in March this year. Entitled *'Radio Frequency Identification (RFID) in Europe: steps towards a policy framework'* it again states that:

> Further development and widespread RFID deployment could further strengthen the role of information and communication technologies (ICT) in driving innovation and promoting economic growth.
>
> Already today, Europe is a leading region in RFID-related research and development, not least thanks to the support of the European research programmes. Main research areas concern innovative applications, smart sensors and RFID-enabled actuators, as well as intelligent networks. Substantial effort is also spent on nano-electronics, which supplies the intelligence, memory, sensing, and Radio Frequency capability to RFID tags.
>
> On the industrial side, several large European enterprises, including technology companies and service providers, are at the forefront of bringing RFID solutions to the market and many small- and medium-sized enterprises (SMEs) have successfully introduced this technology. However, although the market for RFID systems in the EU is growing at about 45 % a year, it lags behind the almost 60 % growth in the global markets. Such a "growth gap" will hold back the contribution of the Information Society to growth and jobs.
>
> Quoted from http://ec.europa.eu/information_society/policy/rfid/doc/rfid_en.pdf

There is a tightrope to be walked between clearly encouraging RFID innovation and implementation for the good of European enterprise and the curtailing of this opportunity because of the concerns believed to be raised over personal privacy from some potential RFID applications.

Concerns over the curtailment of enterprise opportunities were most recently raised towards the end of the conference 'RFID: Towards the Internet of Things' held at the end of the German Presidency of the EU (see www.eu2007.de) in Berlin (see http://www.nextgenerationmedia.de/Nextgenerationmedia/Navigation/en/rfid-conference.html) where a speaker remarked that the

> *'Discussion about privacy and RFID is like worrying about traffic lights before we have worked out where to build the roads'*

The state of RFID innovation

This section is reproduced from the status review done for the BRIDGE project earlier in 2007. The full report can be found at http://www.bridge-project.eu/data/File/European%20Passive%20RFID%20Market%20Sizing%202007-2022-v1.pdf .

It is now three years since Wal-Mart and Metro announced ambitious plans to implement UHF RFID technology in their supply chains. These initiatives created a belief by many in the RFID industry that short-term growth would be driven by pallet- and case-level tagging.

Between November 2006 and February 2007 LogicaCMG conducted a study on behalf of GS1 to forecast the market for passive RFID in Europe for the next fifteen years. This study paints a very different picture for RFID adoption in Europe. Based on input from over 80 companies – including many European early adopters of RFID – we conclude that UHF RFID is still poised for significant growth in Europe. Most growth however, also in the short term, is coming from tagging of high-value items, instead of pallet-level or case-level tagging.

This study was conducted as part of the BRIDGE research project and focused on the use of passive RFID to track physical objects. Other applications for passive RFID, such as contact less smartcards and car clickers, are not included in our forecasts. We analysed the vertical markets that we believe to be most promising for passive RFID: retail & consumer goods, aviation, pharmaceutical & healthcare, automotive, and postal & express.

In this study we forecast the number of tags that will be purchased annually, the number of locations that will deploy RFID readers, and the total number of readers at these locations. Our forecast until 2022 is given below:

	2007	2012	2017	2022
Total number of tags purchased annually (in Millions)	144	3.220	22.400	86.700
Total number of locations with RFID readers	2.750	30.710	144.000	453.000
Total number of RFID readers deployed	7.630	176.280	1.161.800	6.268.500

Based on our analysis we predict that in five years more than 170,000 passive RFID readers will be deployed in Europe at 30,000 locations. These readers will process a total of 3 Billion tags. These numbers will grow significantly until 2022, when we expect more than 6 Million readers to be operating at 450,000 locations, with 86 Billion tags purchased annually.

We believe these numbers to be conservative, as they only represent a small percentage of the total potential number of objects that can be tagged. For example, our forecast is based on the estimation that in 2012 2% of all items in retail will be tagged. In 2022 we forecast that roughly 25% of all non-food items and 5% of all food items in retail will be tagged. If we experience a technology breakthrough in the next fifteen years that would reduce the cost of an RFID tag to less than one cent, these number could increase dramatically. In particular the number of tags on food items could grow to hundreds of Billions.

Other key findings of our research:

- European RFID implementations in supply chain management have been hindered by technical challenges. These include issues with the current European regulations, which make it difficult to use many readers in close proximity.

- High-value item-tagging will remain the largest opportunity for RFID tag and reader volumes. In the short term we expect to see significant growth in fashion and apparel, cultural goods (DVD's, books etc) and consumer electronics. In these categories RFID is helping to improve inventory management in the store, which may result in less stock outs.
- For many RFID applications it will probably take another two-three years before the market will really take off. This is due to technical issues, price levels that are prohibitive for the business case, or discussions on the distribution of costs and benefits in open supply chains.
- In the long term we expect hardware costs to come down dramatically. This is due to a combination of technical innovations and economies of scale. A passive RFID reader may cost 200 Euros, and tag prices may come down to a few Euro cents. A potential breakthrough in chipless technologies may even result in tag prices of less than 1 Euro cent (although our forecasts are more conservative and not based on this assumption).
- Retail & consumer goods will remain the largest market in terms of volumes for RFID tags and readers, accounting for approximately two-thirds of the total market volume, both short term and long term.
- After retail, the postal & express market provides the most potential. In the short term this market will focus on areas such as returnable transport items, but longer term it is likely to adopt RFID in its core processes on parcels and mail.
- In aviation RFID will be used for a wide range of applications. In 2007 we expect the first large-scale implementations in Europe in baggage tracking, and this will continue to grow in the future.
- In the next five years we do not expect RFID to be widely used in Europe against counterfeiting of drugs. Instead, we expect the pharmaceutical industry to focus on 2D barcode implementations in the near future. More longer term, the industry may change to RFID.
- UHF will be the dominant frequency for the tracking of physical objects, with HF being used in a number of niche markets such as library books.

In conclusion, RFID is developing very differently from the way most people envisioned a few years ago. And in five years from now we may again discover that RFID adoption has not developed as we predicted in this study. However, this uncertainty only relates to the speed of adoption across the various RFID applications.

There is no doubt that performance will continue to improve and prices will continue to come down. It seems certain that in the future passive RFID will become an integral part of doing business in Europe, resulting in Millions of readers that read Billions of tags each year.

The view from the BRIDGE project

The strong research focus

The BRIDGE project has a very strong representation of University and industry based research organisations contributing to the development of hardware and software innovations in RFID and developing innovations in the design, manufacture and programming of RFID tags and associated equipment. Short summaries of the twelve organisations are given below.

Auto-id labs - architecting the Internet of Things

The Auto-ID Labs are the leading global network of academic research laboratories in the field of networked RFID. The labs comprise seven of the world's renowned research universities located on four different continents. These institutions were chosen by the Auto-

ID Center to architect the Internet of Things together with EPCglobal (see http://www.autoidlabs.org/).

The following diagram shows the world-wide distribution of these laboratories and identifies their Research Directors.

Mission of the Auto-id laboratories

- The common goal is to build a business driven, truly global, sustainable, robust, cost efficient, and future-proof EPC Network Infrastructure that is flexible enough to support future technologies, applications and industries.
- EPCglobal is the commercial successor of the Auto-ID Center, a global business initiative and academic research program with its roots at MIT. The Auto-ID Center focused its work on (a) simple and thus inexpensive RFID tags to (b) enhance supply chain and store management processes in (c) the fast moving consumer goods industry. The Auto-ID Center ended its work in 2003, licensing its research results to the newly born EPCglobal, Inc.
- However, a sustainable and future-proof EPC Network needs – as the Internet itself – to support many different applications in many different industries leveraging a variety of emerging and future technologies.
- To make sure the EPC Network meets these challenges during the next decades, EPCglobal and the Auto-ID Labs teamed up to research and shape (a) new technologies such as active tags and sensors, (b) new applications such as anti-counterfeiting, and (c) new industries such as automotive and aerospace.

Cambridge (CAM)

Auto-ID Labs at Cambridge is a part of the Centre for Distributed Automation and Control, which is based within the Institute for Manufacturing at the Cambridge University Engineering

Department. The lab focuses on the integration of RFID and other ID technologies into industrial environments. Specific research themes include:

- Reduction in the uncertainty of RFID deployment
- Methodologies for tracking and tracing objects
- Management of product information networks
- Quantification of the impact of RFID introduction
- RFID integration with sensing and automation systems

ETH/St Gallen (ETH)

The Auto-ID Lab St.Gallen combines the strength of a leading business school (University St.Gallen) with those of a leading technical institution (Swiss Federal Institute of Technology, ETH Zurich). It devotes its research to the business impacts (processes, products and services), applications and infrastructure of the "Internet of things". Together with EPCglobal and other Auto-ID Labs it develops the next generation of the EPC-Network. The main research topics of the St.Gallen Lab are:

- Active Tags and Sensors,
- Addressing Uncertainty in RFID,
- Smart Products and Services,
- New Industries - Automotive and Health Care,
- Managing the EPC-Network, *and*
- Business Impact.

Fudan University, Shanghai (FUDAN)

The research area of Auto-ID Lab covers RFID hardware research, network research, and RFID application reEventssearch. The laboratory joined in the Auto-ID center in the year 2002.

Mission

- Research on RFID core technology: Hardware: tags and readers; Software: EPCIS middleware; Network: framework, security. Perform fundamental research and development of key technologies of IC design that would make the RFID system cheaper and more efficient.
- Educate people in China on the capabilities, limitations, and applicability of RFID technology.
- Perform research and development of knowledge, technologies, and systems that enable the application of RFID technology in China.
- Provide experimental results to the international standard organization and the government and Standard Committee in China. Promote the internationalisation of the Chinese standard.

The following universities and company research centres are also involved in the BRIDGE project:

University of Technology, Graz (TUG)

The Institute for Applied Information Processing and Communications (IAIK) is one of the eight institutes of the computer science faculty of Graz, University of Technology (TU Graz). The research group VLSI and Security at IAIK has been active in the field of RIFD security for several years. One of their main research interests is to enhance passive RFID

technology with functionality of standardized crypto algorithms to allow secure authentication of tags and to enable privacy protection in RFID systems.

The institute organized summer & spring schools on RFID security topics in 2006 and 2007 in Graz, arranged a workshop for RFID technology for the Article 29 Data Protection group in Graz in 2006 and is the local organizer of the conference CHES2007 in Vienna. There main interest in BRIDGE is the development of secure RFID-tags that support standardized crypto functionality. Additionally the group works on protocol extension for the tag-reader link so that the RF communication can be protected by using the crypto functionality of the secure tag.

Universitat Politècnica de Catalunya (UPC)

The Technical University of Catalonia is one of the leading technical universities in Europe. It enrols more than 30.000 students and a faculty of over 2.600 professors and lecturers. In the context of the BRIDGE project, the UPC will participate through the Ambient Intelligent Lab (AIL) and a part of the Signal Theory and Communications Department (www-tsc.upc.es). The AIL has many years experience in RFID, Wireless Sensor Networks, ubiquitous computing and ambient intelligence technologies in general. The department has an advanced antenna design group and many radio frequency design, fabrication and testing facilities. The group belongs to the Antenna Centre of Excellence (ACE) network, and it has received several international awards, such as the 1998 European Information Technology Grand Prize for its work in fractal antennas. Some of the other lines of research of the department are remote sensing, MEMs (Micro Electromechanical IC's), and digital communications.

BT

BT is one of Europe's leading providers of telecommunications and ICT solutions. Its principal activities include local, national and international telecommunications services, higher-value broadband and Internet products and services. Our global networked IT services business is growing strongly and our global capabilities have been strengthened by successes in the European market. Our research division, under BT GCTO, headquartered at Adastral Park (Martlesham Heath) in Suffolk (UK), offers the services of IT professionals woth knowledge of leading-edge network design and IT systems and application development. In the 2005 financial year, BT group has invested £257 million in research and development. We provide research, development and consulting services for BT - developing innovative technological ideas and solutions that translate into practical and marketable solutions for businesses.

SAP Research (SAP)

SAP is the world's leading provider of business software solutions and the world's third-largest independent software supplier overall. SAP solutions help enterprises of all sizes around the world to improve customer relationships, enhance partner collaboration and create efficiencies across their supply chains and business operations. SAP industry solutions support the unique business processes of more than 25 industry segments, including high tech, retail, public sector and financial services. As an integral part of SAP's R&D activities, SAP Research is SAP's worldwide corporate research organization responsible for identifying and evaluating emerging technologies that may impact the future of SAP's products. With a focus on applied research, SAP Research bridges the gap between open, collaborative research with external partners and exploitation into new or existing SAP product lines through SAP's development groups.

AIDA Centre (AIDA)

The AIDA Centre is the Spanish leader in UHF RFID installations, it researches and develops RFID technology and products for specific sectors, with the support of the Ambience Intelligence Lab and Electromagnetism and Photonics Engineering Group of the Technical University of Catalonia, the Telecommunications Technology Centre of Catalonia, the Auto ID labs, the Catalan Foundation for Research and Innovation, and the IESE and ESADE Business Schools. AIDA Centre will act in very close coordination with the Technical University of Catalonia (UPC), acting effectively as its "industrial branch". As a result it will also participate in the Hardware Technical Development Cluster and the Global Supply Chain Management in the Textile Industry Business Application Cluster. AIDA will focus on reflecting market requirements in technical specifications, prototypes and the design and management of the fabrication process.

CAEN

CAEN is recognised as being one of the most advanced European hardware manufacturers for RFID UHF technology, mainly focusing on readers and tags. The R&D division is a specialist in the design of Radio Frequency circuitry, both at the reader level and the tag antennae designs. The robust firmware and software team is capable of implementing new functionality and "edgeware" connectivity in our readers. All the experience acquired in the past through pilot projects and real RFID installations allows CAEN to address and resolve specific problems in vertical applications such as transportation, security access and control, supply chain management, container tracking, airport baggage management, management of "cold chain", train composition management, drug and vaccine tracking by using specific readers and tags developed "ad-hoc" for such applications.

Confidex

Confidex's core competence is on RF-/RFID product and application design, reel to reel process and equipment design and application engineering. Confidex offers RFID solutions and services for the packaging and printing industries as well for the RFID physical layer system integrators. Confidex is a fast growing and internationally operating company, established by Nokia, Finland in August 2005. Confidex brings an expertise on issues related to HF- and UHF tag designing, manufacturing and testing. It is also experienced in optimising the physical link functionality (RF link between tag and reader). This optimisation includes application analyses, application specific tag designing and field tests, debugging of physical link problems and reader antenna optimisation. Confidex's own product offering will consist of special tags, manufacturing, converting and testing equipment, tag and process designing services, factory design and ramp up services and training services.

AT4Wireless

Centro de Tecnología de las Comunicaciones, S.A. (AT4WIRELESS), was established in 1991 as a Test House Laboratory for the Telecommunications terminal equipments and electronic equipment markets. AT4WIRELESS is now a Private Technology Centre and a leader in global solutions in the industrial, technological and services fields. AT4WIRELESS provides testing solutions in wireless technologies such as Bluetooth, WLAN, GSM, GPRS, UMTS, and RFID. AT4WIRELESS has provided the first conformance test system for RFID EPCglobal Generation 2 hardware certification. It has a team of more than 50 experienced staff coming from different branches of engineering and has strong development experience in the following fields: RF hardware, radio software, communication protocol stacks, protocols for intelligent transport systems, automation of measurement and processes, internet, CTI (computer telephony integration), web development, etc.

UPM Raflatac (UPM)

UPM Raflatac is a world leading RFID tag manufacturer, specialized in low-cost and high-volume production. The company's expertise spans across both RF technology and the aspect of materials such as paper, plastics, adhesives and different lamination processes. Among the first supporters of the Auto ID Center and EPCglobal, working in close collaboration with IC suppliers, UPM Raflatac has always been involved in the standardization processes aimed at fostering the adoption of RFID technology. The company has been the first to test and introduce EPC compliant UHF and HF tags in the market. UPM Raflatac offers the broadest portfolio of RFID tag products and addresses the rapidly emerging demand for EPC tags and labels. With its multidisciplinary expertise, the company is able to determine the most cost effective application in the value chain for its products. This warrants RFID tag cost optimization for the end user.

Involvement of RFID users

Strong involvement from RFID users is also a key part of the innovation process in the business development work packages. The companies involved are Carrefour, the global retailer; Benedicta, an independent cold sauces manufacturer; Kaufhof, a department store, part of the Metro group; Gardeur, a brand name fashion manufacturer; Nestle UK, part of the worlds largest food and beverage manufacturer; and Sony Europe, part of the Sony global group that manufactures audio, video, communications and information technology products.

Cluster of European RFID Projects – CERP

Objectives

RFID has the potential to enhance Europe's competitiveness and is an important driver for the development of an information based economy and society. A wide range of research and application projects in Europe have been set up with funding support from the European Commission in different application fields. Communication between these projects is an essential requirement for a competitive industry and for a secure, safe and privacy-preserving deployment of RFID in Europe. To promote this exchange of information the "Cluster of European RFID Projects" has been founded in January 2007. The objectives of the cluster are:

- Facilitate networking of different projects in Europe
- Coordinate research activities
- Assure coherence of work in Europe
- Leverage expertise, talents, and resources and maximize impact
- Establish synergies between projects

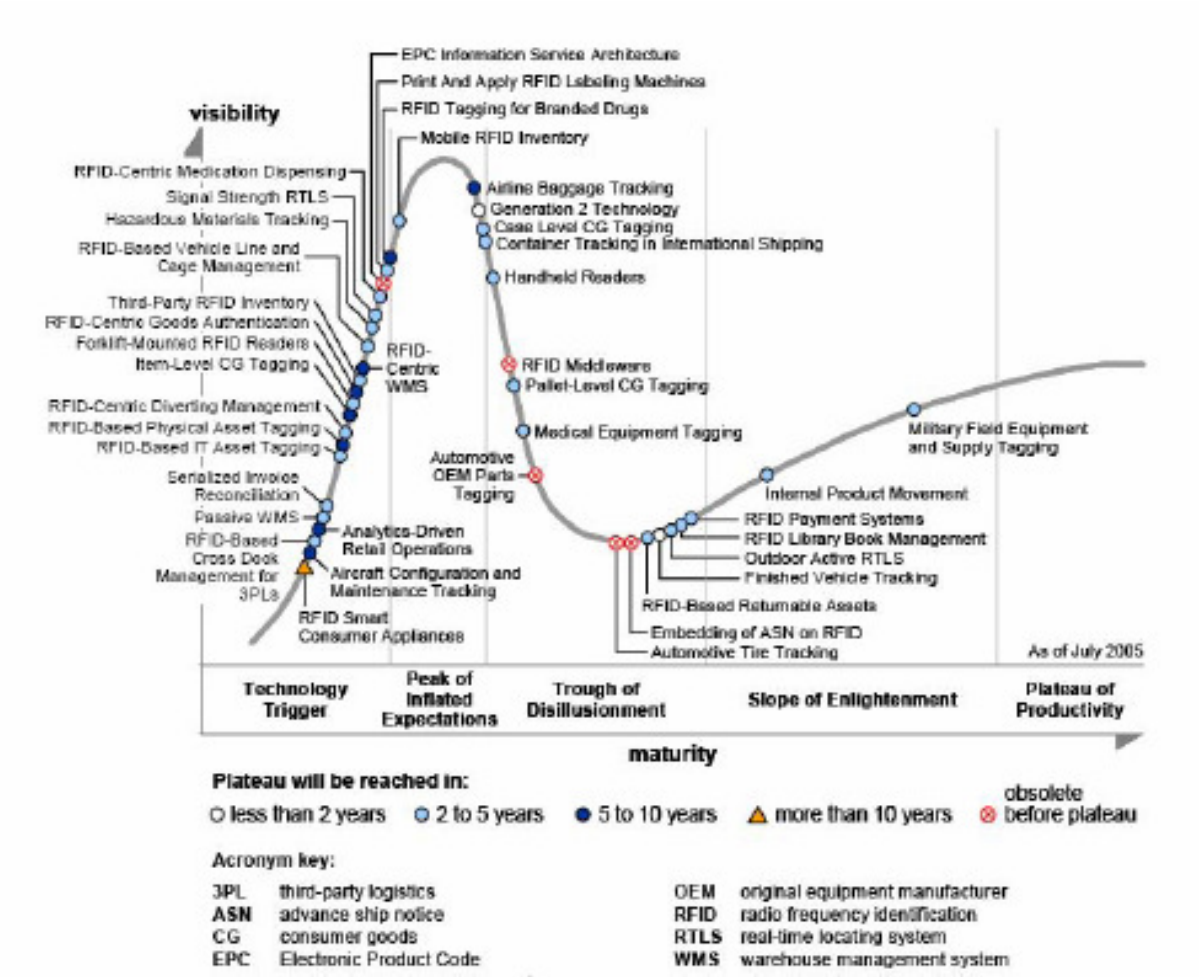
Participating Projects

Project Acronym	Name of Project
AMI-4-SME	Ambient Intelligence Technology for Systemic Innovation in Manufacturing SMEs
BRIDGE	Building Radio Frequency Identification in the Global Environment
CE-RFID	Coordinating European Efforts for Promoting the European Value Chain
CoBIs	Collaborative Business Items
Dynamite	Dynamic Decisions in Maintenance
INDISPUTABLE KEY	Intelligent distributed process utilization and blazing environmental key
PRIME	Privacy and Identity Management for Europe
PROMISE	Product orientated manufacturing systems including RFID technology
SMART	Intelligent Integration of Supply Chain Processes and Consumer Services based on Unique Product Identification in a Networked Business Environment
SMMART	System for Mobile Maintanance Accessible in Real Time
StoLPaN	Store Logistics and Payment with NFC
SToP	Stop tampering of products
TraSer	Identity-based Tracking and Web-Services for SMEs

The BRIDGE project is represented in the Cluster and is actively involved. Aspects of all the CERP cluster projects are involved with RFID and could contribute actively to the European Technology Platform proposed in a following section.

The Internet of Things

The Gartner Group diagram, known as the RFID Hype Cycle and shown below, nicely characterises the development curve for RFID applications. Having passed through the 'Inflated Expectations' and the pilgrim's progress-like 'Trough of Disillusionment' we are now moving towards enlightenment. This certainly involves a wide range of RFID applications and technology developments as reviewed in the European Commission's JRC (Joint Research Centre) report on *'RFID Technologies: Emerging Issues, Challenges and Policy Options',* EUR 22770 EN, published this year and found at: http://www.jrc.es/publications/pub.cfm?id=1476):



Gartner's RFID Hype Cycle

The next stage of RFID developments in supply chains foresees a world where supply chains consist of items that are tagged, and probably have sensors attached, so that they can be seen and identified wherever they are in a supply chain. This will require a large number of information service networks to be linked so that the goods, which will be tagged at the item level, can be tracked and traced as they move along a global supply chain. This innovation requires orders of magnitude larger networks with more sophisticated security frameworks and more sophisticated hardware and software. It is this step forward that the BRIDGE project seeks to begin.

What is the Internet of Things?

The definition of the 'Internet of things' is best comprehended by reading some of the scenarios that have been produced. The GCI (Global Commerce Initiative) report on '2016: The future value chain' (visit www.gci-net.org) is recommended. This presents the future ambient intelligent supply chains from the point of view of a family and their interactions with the various consumer oriented applications.

Two further attempts at definitions follow.

> In the technical trade literature, definitions of the Internet of Things remain surprisingly vague. Most approaches reflect the vision of Mark Weiser – "Everywhere, always, everything" – for Ubiquitous Computing. The concept of Ubiquitous Computing – as well as Pervasive Computing or Ambient Intelligence – represents a new form of invisible computing. Computers will be integrated into "smart" everyday objects that can communicate and interact autonomously and provide numerous services to their users. The Internet of Things refers to the networks and services that enable communication among these objects. Ubiquitous Computing considers objects as smart agents that act on their own behalf. This striking paradigm shift provides objects with their own digital identity and is a critical component of both Ubiquitous Computing and the Internet of Things.

The Internet of Things is the technical vision for the integration of any kind of object into a universal digital network.

> The Internet of Things is a metaphor for the universality of communication processes, for the integration of any kind of digital data and content, for the unique identification of real or virtual objects and for architectures that provide the "communicative glue" among these components. RFID serves as a means to uniquely identify objects. Via RFID, the Internet of Things connects real world items with further data and digital "brains", and, *vice versa,* it supports software systems with sensor and context information accessed by the RFID tags. In the weakest version of the Internet of Things, these objects can be identified but do not "do" anything actively; in the strongest version, objects communicate with each other so that the Internet of Things and Ubiquitous Computing complement each other.

These quotes are taken from the German Presidency's draft document entitled 'European Policy Outlook RFID' which is found at
http://www.nextgenerationmedia.de/Nextgenerationmedia/Redaktion/en/PDF/european-policy-outlook-rfid,property=pdf,bereich=nextgenerationmedia,sprache=en,rwb=true.pdf

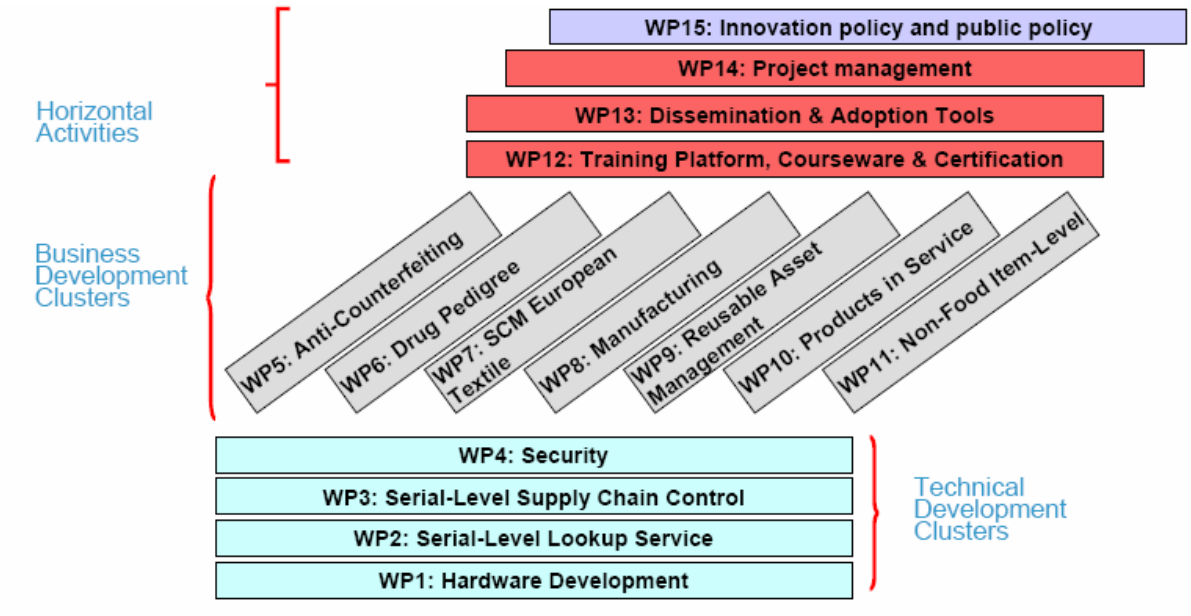
Innovation in the BRIDGE project

This deliverable is very much a report of work in progress, being submitted at the end of the first year of a three year project. So the status and degree of innovation developed to date varies from work package to work package. For example, a patent has been lodged for the prototype of a small tag antenna (very important for tagging small items); a comprehensive security model, covering many scenarios has been developed; improved business models have been piloted which create great improvements in speed and accuracy in typical supply chains and innovative new eLearning modules are being developed for use by GS1's very large SME community.

The diagram below characterises the three different types of work package in the BRIDGE project. The first group, looking at hardware, serial level services and security are developing innovations in the technical arena. These range from tag and antenna innovations, to new security services based on a thorough analysis of security risk scenarios.

The second group, looking at business developments in the use of RFID in a variety of sectors, again involve innovation *per se* . Here the innovation is in the new ideas developed to improve existing, or create new, business practices using RFID.

Finally, we have a number of work packages, referred to as 'Horizontal Activities' which cover the management of the project, production of this report on innovation and two very important packages on training and dissemination. These do not involve innovation in the sense that the other packages do. However, they are of great importance because of the development of training and dissemination modules, based on the GS1 public web-based LEARN platform.



WP1

This package is involved with the development of the RFID hardware and also looks at the ambient intelligence promise of the RFID systems. The package is divided into following subtasks:-

Sensor enabled tags - Until now the sensor integrated tags are still in their infancy. Here we define the sensor needs for the RFID tags, research the state of the art, specify the technical requirements, define air interface protocol extension for sensor enabled tags, research means for managing sensor data and sensor configuration and develop prototypes which allow us to verify and test concepts that are developed.

Miniature tags - Here we research the current state of the art in miniature tags, analyze different techniques commonly used in compact antennas, develop prototypes stretching the read range and size to the limit.

Metal and glass object tags - Here we research techniques that make tags suitable for metal and dielectric objects, study the state of the art available and develop prototypes to verify and test concepts developed.

Low cost reader - Here we research the state of the art in compact reader designs, formulate the perfect functionality versus size characteristics and develop prototypes which allow to verify and test the concepts that are developed.

High read rate antenna for reader - Here we analyse various tag, reader usage scenarios, research the state of the art and develop prototypes to test and verify the concepts.
Ambient Intelligent RFID system - Here we formulate the specifications for the smart object, study various ambient intelligence scenario possibilities and develop one such scenario.

So far one Patent has been submitted (listed in the Appendix with the publications) for the *self-resonant electrically small antenna* that is being developed.

WP2

The Discovery Service (also named EPCIS Discovery or Serial level Lookup Service) is a key element for information sharing in the EPCglobal Network. Its main role is to provide a means to locate all EPCIS services that may have information about a specific EPC. However, EPCglobal has not yet chartered a work group to standardize the interfaces to Discovery Services. In this situation, the BRIDGE project is taking a step forward, developing an innovative proposal for a Discovery Service, taking into account the requirements extracted from different industry sectors. WP2 aims to specify and design a Discovery Service concept, implementing and deploying also a prototype to validate the functionalities and architecture proposed.

The proposed Discovery Service is not intended to host too much detailed information or even to be a replica of what is held on EPCIS. Its design is oriented to collect valuable information from an EPCIS and to provide this to a client making queries about a certain EPC with a list of links to all EPCIS that have the required information. Afterwards, the client would be able to query directly to the EPCIS's owning the information.

The main challenges for the development of a Discovery Service are: to be autonomous from the EPCIS, provide synchronisation to queries, support the standing queries, support aggregation/disaggregation of items to others (e.g a tagged components inserted on a

tagged computer), have a scalable and efficient storage architecture, and for the most comply with privacy and security policies on terms of data integrity and protection. This final point makes WP2 to work on cooperation with WP4. Also, WP2 works together with WP3 and can potentially contribute to others business oriented WPs activities.

In a second step of research, initially not being covered by the BRIDGE project, the organic growth of Discovery Services could be addressed. These services will need to grow rapidly as the information about an item changes as it moves through a global supply chain which may encompass different regions, countries or even continents.

Finally, WP2 intends to share its results with other working groups on the field and to address its results to standardisation bodies including EPCglobal, IETF (the Internet Engineering Task Force) and ETSI (European Telecommunications Standards Institute).

WP3

Tracking and tracing of objects across the supply chain is a key enabler for effective and efficient business operations and decisions. High quality information about the past, present and potentially the future state of an object is the cornerstone for effective decision making in business applications such as inventory control, distribution planning, manufacturing control and maintenance operations. The emergence of the new generation product information networks, based on serial-level information, provides a new potential for enabling enhanced tracking and tracing applications.

This work package which is researching serial-level supply chain controls has begun its work by developing a model which proposes a track and trace information layer which sits between the EPC network and the business applications, providing enriched tracking and tracing information to the latter, based on serial-level product information retrieved from the former. The novelty of the proposed model stems not only from the fact that it is based on serial-level information, but also from the use of probabilistic tracking and tracing algorithms which provide high quality object state information, enabling intelligence that was not feasible with the traditional track and trace applications.

WP4

WP4 is, among other areas, performing research to make the application of standardised cryptography available on RFID tags. To date provision of this functionality was assumed to be infeasible due to technological and cost requirements and some wrong assumptions about dedicated implementations of symmetric cryptography.

The work so far has analysed a broad variety of security scenarios and developed a comprehensive suite of risk scenarios.

The treatment of possible implementation attacks on RFID tags is also not neglected, and is investigated by using semi-passive prototypes. A protocol extension for the EPC Generation 2 standard is suggested that provides a security layer to allow authentication and anti-eavesdropping measures to be implemented for the tag-reader communication.

WP5

Here innovative business models are being developed for effective anti-counterfeiting applications by:

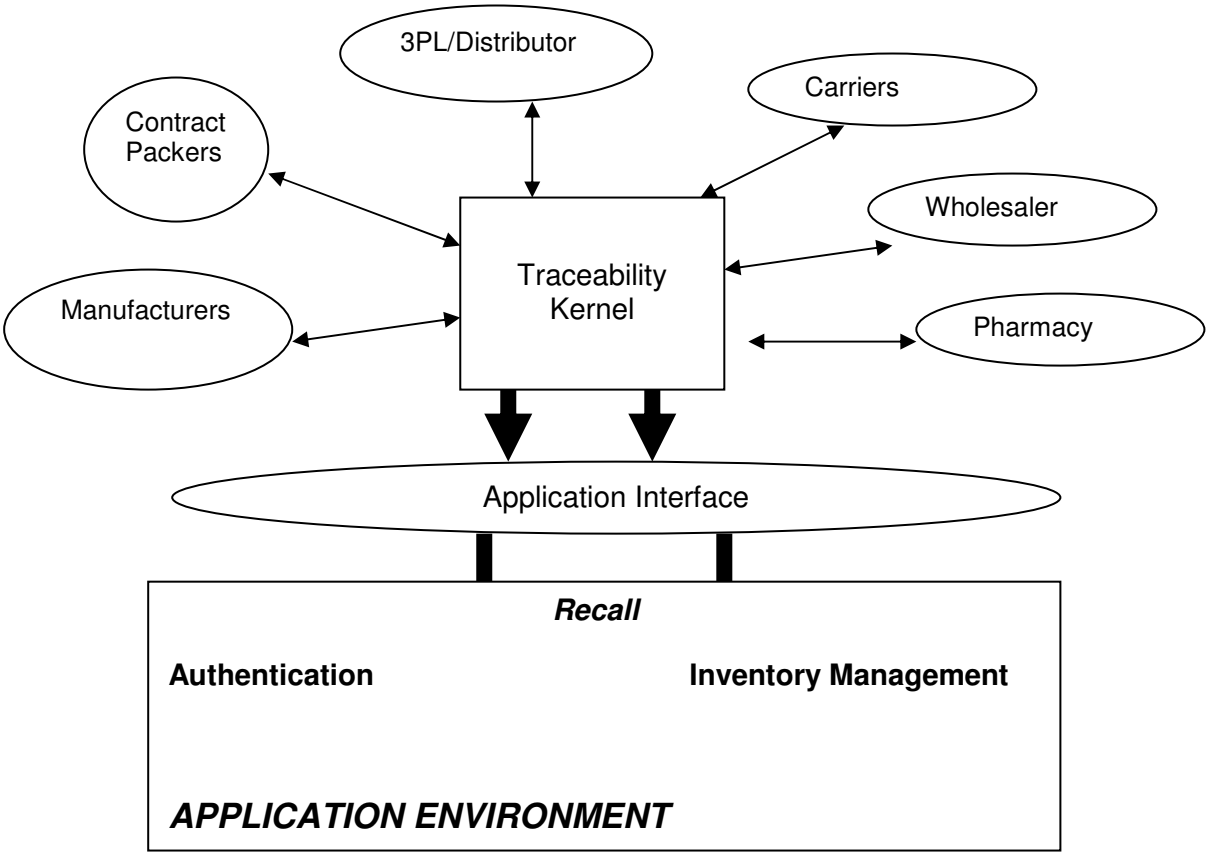
- Analysis of counterfeits in various industries (IT, Aerospace, Consumer Goods, Retail, Life Science, Pharmaceutical and Customs)
- Elicitation of industry requirements for anti-counterfeiting measures
- Development of an Anti-Counterfeiting System based on the EPCglobal network (ongoing)

WP6

Innovation incorporated by the Pharma Traceability Pilot (previously referred to as Drug Pedigree) comes from the business application philosophy being applied in the medical supply chain.

The application adopts an innovative philosophy insofar as the traceability data captured by the system serves a multiple application environment – see the illustration below. For example, receipt data can feed inventory management systems in the back-office as well as accounting data for automated invoice/receipt matching – a major issue for the hospital and the wholesaler trading model. Recall data (the trace of products flowing downstream) can be created in seconds, on demand, as required; as can the ***electronic pedigree*** including details of product movements and their custodianship as they flow downstream, from one trading partner to the next.

We are not aware of any other similar applications in Europe today – and certainly not one that enables electronic pedigree of medicines in the supply chain.



RFID and 2-D Data Matrix barcodes

There is much industry discussion about the merits and demerits of the various auto-identification carrier technologies (specifically bar code or RFID tag).available today. This project will utilise these two carrier types to further the discussion and clarify the business case for RFID.

WP7

This package is developing innovative business practices for the global textile supply chain and to date has established that:

- "Human errors" during the picking process can be eliminated as picked items are identified and verified via RFID before dispatch.
- Read rates of nearly 100 % achieved in tests carried out with garments labelled with UHF Class 1 Gen 2 tags for the textile sector, for different applications (on conveyer belts, on fixed Read Points, on Smart Shelves, etc.)
- The EPCIS data exchange between the manufacturer and the retailer based on the ratified EPCIS standard and on terminology of FMCG (FMCGDataExchgVocabFinal42006) will provide both companies with real time information about "events" along the supply chain. This enables them to track and trace garments without any time delay of data transmission.
- The reporting functionality for manufacturers and retailers based on data of EPCIS-events will lead to a better and faster information flow.
- New insights derived from pilots, e.g. store relevant processes and identification points based on UHF-technology Gen2 (also for some supply chain processes) will be achieved.
- Smart shelves and rails in the front and back store provide service staff with information about item localisation and permanent inventory. Therefore the staff can provide faster and better customer service.
- RFID readers can be linked to information displays. These displays offer customers with cross selling or additional garment information such as different sizes/colours and their availability while picking garments from the shelf or the rail.
- The "magic mirror" in the fitting room enables customers to look for the availability of other sizes and colours or cross selling information in the front and back store without leaving the fitting room. Thus shopping will be much more convenient and less time consuming.

WP8

The WP8 'Business Application Manufacturing Process' work package is examining ways in which the role of RFID can provide accurate and complete batch level information in a timely manner to enhance the management of production processes within the walls of a factory from raw materials to finished product. The fundamental capability of the networked RFID-based automated product identification systems enabled by the EPCglobal Network is the ability to connect products tagged with RFID to a network.

Some twenty five different manufacturing processes were studied and classified into five process groups which are now being analysed for the opportunities they offer for improvement in processes by using RFID.

WP9

The objective of WP9 is to use radio-frequency technologies (RFID), to bring a better visibility and traceability to reusable transport items (RTIs such as pallets) as well as to their contents.

The contribution of the use of RFID has been studied for two different actors in the supply chain:

1. **RTI Pool Providers** : Who wish to identify individual RTIs for a more efficient asset management of their whole collection of RTIs
2. **Manufacturer, LSPs and Retailers** : For tracking the flow of goods on or in an RTI for better supply chain visibility and also for more efficient processes in RTI handling

The goal and stakes of this project are to allow all RTI users to reduce stocks and costs of rented reusable assets for manufacturers and retailers, improve exchange of information between trading partners about the rented park of reusable assets, decrease the time of inventory, etc…

The other objective of this project is to tag the reusable asset and link it to embedded information about reusable asset (GRAI – the Global Re-usable Asset Identifier of the GS1 System) and about goods on it (SSCC – the Serial Shipping Container Code of the GS1 System). By this process, we're able to track and trace both the RTIs themselves and the flow of goods (which are on the RTIs) across the supply chain.

Another key challenge is to find a business models that produces good, acceptable Return On Investment [ROI] for all the actors in the supply chain and in particularly the RTI pool providers. In effect the cost of embedded tags on reusable assets, and the costs inferred in information systems by RFID, must not be too high for RTI pool providers' economic model.

Another key challenge is how to distinguish, in the business process management, specific RFID-tagged reusable assets from reusable assets that are not RFID-tagged as they move through the supply chain logistics.

WP10

WP10 the 'Products-in-Service' work-package, is examining ways in which item-level information acquired during a product's lifecycle could enhance its in-service use. The "in-service use" applications could range from warranty or maintenance management to enhancing customer's experience when using the product.

Having presented the supply chain operation in detail in a first deliverable, five problem areas that have the potential to provide a positive impact to existing processes have been identified. Although the work is focused on RFID and EPC Network as the primary tool to provide unique identification and networked product-lifecycle management, other technologies such as the barcode are being considered as complementary technologies.

Further work has highlighted a broad range of requirements that need to be satisfied in order to create an infrastructure, and applications, to support these 'products in service' applications. It is clear that many of these requirements have been well-anticipated by the EPCglobal network architecture, and indeed that is re-assuring. Further requirements should be met by the developments taking place in WP2 and WP4.

WP11

This work package is looking at item level tagging for non-food items (such as CD's DVD's and retail software products) and is examining many aspects of retail operations, including improving customer value, company efficiency, and practical issues involved in changing business practices.

Early stages in the in-store pilots are showing significant improvement in speed and accuracy in receiving goods, in store inventory and picking items for return to manufacturers.

A video showing the changes in in-store and supply chain processes engendered by RFID has been produced as part of the pilot activity.

WP12 – WP14

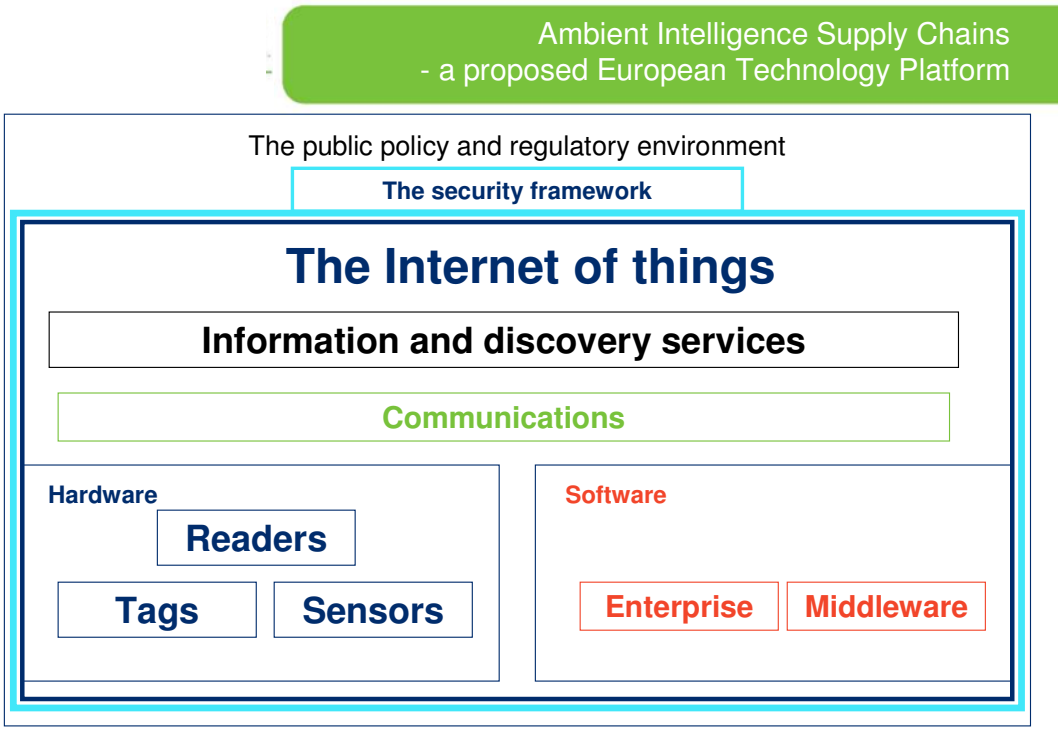
Work packages 12 and 13 involve development of new training and dissemination products to present the results of the BRIDGE project and to explain the business opportunities to potential users, especially SMEs across Europe. GS1 is uniquely placed to do this by implementing new modules on its LEARN platform (visit http://learn.gs1.org/portal3/index.asp) and through its indigenous presence in all twenty seven EU states – and beyond.

WP14 provides the Project Management activity for the BRIDGE project and though not involved in innovative research *per se*, certainly seeks to employ good practice.

Towards a European Technology Platform

We believe that innovation and ongoing dissemination of the developments of the move 'Towards the Internet of Things' should be lead through a European Technology Platform (ETP) which would develop a strategic research agenda (SRA) around auto-identification, traceability and supply chain networks (Ambient Intelligence Supply Chains). In focussing on auto-identification and supply chains that contain 'intelligent products' the ETP moves us towards the' Internet of things' and would aim to fuse the issues of supply chain product flow and information flow, information sharing, consumer behaviour, sustainability, culture and governance.

The diagram below identifies the modules, or areas of work that could be involved in the proposed ETP, ranging from developing hardware (eg small tags and sensors) to the management of the overall 'Internet of things' and the public policy interactions associated with these developments.



The work on the policy and regulatory environment must include consideration of the governance of the global, open 'Internet of Things'.

Some background – explaining an ETP

The first ETPs were developed in 2002-2003 during the Sixth Framework Programme (FP6) of EU research. Their aim is to improve EU competitiveness by uniting a group of stakeholders in defining, developing and implementing a Strategic Research Agenda (SRA) around the technologies concerned in the ETP (see http://cordis.europa.eu/technology-platforms/home_en.html).

Stakeholders typically include industry (often initiated by large companies, but ensuring a very positive involvement of SMEs), public bodies, research institutes and the academic

community, the financial community (as venture capital and investment bodies) and civil society at large (representing users and consumers).

After an initial flurry of proposals it seems that there are nine strong and well developed ETPs and these have made a significant input to the development of the Seventh Framework Programme (FP7 – see below). Two of them relate in part to the interests of the BRIDGE project and of GS1 too - ARTEMIS – the European Technology Platform for Embedded Intelligence Systems (see http://www.artemis-office.org/dotnetnuke/) – relates to embedded tags and readers as well as ubiquitous networks. EPoSS – the European Technology Platform on Smart System Integration (see http://www.smart-systems-integration.org/public) - has a working group on Smart Systems in Logistics/RFID.

The ETP concept was conceived to bring together public and private stakeholders to set up and implement common research agendas in fields of industrial relevance.

The Strategic Research Agenda developed outlines the evolution of the field from a medium to a long-term perspective and identifies a number of important technological changes that have to be met in order to allow Europe to implement the vision of the ETP.

Ambient Intelligence and the development of scenarios

During Framework Programme 6, the IST Advisory Group (ISTAG) wrote about 'Scenarios in Ambient Intelligence in 2010' which can be found at http://europa.eu.int/information_society/policy/rfid/doc/finalconferenceprogramme.pdf believing:

> *The concept of Ambient Intelligence (AmI) provides a vision of the Information Society where the emphasis is on greater user friendliness, more efficient services support, user empowerment, and support for human interactions. People are surrounded by intelligent intuitive interfaces that are embedded in all kinds of objects and an environment that is capable of recognising and responding to the presence of different individuals in a seamless, unobtrusive and often invisible way.*

These scenarios are essentially 'novellas' about how different people's lives can be enhanced by ambient intelligence systems – including 'Maria – road warrior' and 'Dimitrios – The Digital Me'. Back then in 2001 they realised that these scenarios were all at the human interface but they recognised that these technologies are also very important for industrial and commercial purposes.

More recently Lara Srivastava from ITU, who spoke at the EU RFID Conference on 16 October 2006, also edited the ITU report issued in November 2005 on 'The Internet of things' - http://www.itu.int/osg/spu/publications/internetofthings/ which developed the scenario ideas a little further with '2020: A day in the life of Rosa' which addresses the opportunities for the citizen to manage, and vary, their personal privacy domain.

Ambient Intelligence Supply Chains

In early 2007 the Global Commerce Initiative (GCI) has published its report '2016: The Future Value Chain', obtainable at http://www.gci-net.org/content/e29/e1525/e1610/item_d1910/2016_Future_Value_Chain_GCI_Report-06-11-01-ohne.pdf which beautifully fuses these issues (supply chain product flow and information flow, information sharing, consumer behaviour, sustainability and culture) in a series of scenarios in '2016: A day in the life of ….'.

The GCI report sees a number of key directions in global commerce:

- Economic shifts will affect consumption, production and logistics
- Ecological trends will lead to a more sustainable industry
- Demographic changes will drive population shifts and diversity
- New technologies will benefit businesses and consumers
- Regulatory interest will increase

…… where ubiquitous RFID use in a pervasive network ('The Internet of things') is the major new technology involved.

Now, as Research Framework Programme 7 (FP7) is in full swing, and the Commission has developed the concepts of European Technology Platforms, the BRIDGE project leads us naturally towards the development of a strategic research agenda around auto-identification, traceability and supply chain networks (Ambient Intelligence Supply Chains). This concept fits closely with the many scenarios being developed around ubiquitous computing, the Internet of things etc. and the work of this project.

Ambient Intelligent Supply Chains will constitute the 2010 supply chain environment in which all objects are tagged and known about. It is the obvious evolution of the coalescence of bar coding and electronic messaging into an RFID enabled environment, with EPC and the EPC network fully functional. So, rewriting with slight changes from the ISTAG paper:

> *The concept of Ambient Intelligence Supply Chains provides a vision of intelligent supply chains where the emphasis is on greater integration, faster supply chain processes, more efficient services support, commercial empowerment with improved competitiveness, and support for better human interactions. People managing the processes are surrounded by intelligent intuitive interfaces that are embedded in all kinds of objects and by environments that are capable of recognising and responding to the presence of different objects and differing customer requirements in a seamless, unobtrusive and completely efficient way.*

The BRIDGE project is starting to address these important ideas of ambient supply chain intelligence, and further development of these concepts will be very important to European business competitiveness.

In conclusion

Quoting from the work by the EU in document EU 22770 (referenced in a previous section and found at http://www.jrc.es/publications/pub.cfm?id=1476):

> Radio Frequency Identification (RFID) technology, an enabling technology for automatic identification based on radio waves, will impact the daily lives of European citizens in many different ways. Minuscule devices, called RFID tags are attached to objects and emit information which aptly positioned readers may capture wirelessly. Such tags and readers come in various shapes and forms, have technological capabilities that can open up new application areas and are already in use to improve efficiency and reliability. They also facilitate the coupling of the physical reality to the virtual world, infusing it with digital functionality and triggering the move towards the so called Knowledge Society.
> The technology is complex but mature enough for immediate deployment. However, due to its enabling character, it is still under constant evolution – as is evidenced by the increasing number of RFID related patents (65% increase in 2004). The RFID market is still in its infancy with most applications not being large-scale and the forecasted economic benefits (Return-on-Investment) still unclear. However, the technology providers' market for RFID is global and Europe houses a few of the world's strongest RFID suppliers. At the same time the end-user market is specialised in diverse application areas, mainly local and usually dependent on emerging opportunities in the public sector domain. Technology Consultants IDTechEx predict that in 2007 a total of 1.7 billion tags will be sold and that the global RFID market value (including all hardware, systems, integration etc) will be 3.8 billion Euros, rising to 21,3 billion Euros by 2017 – see the data published at:
> http://www.the-infoshop.com/study/ix49177-rfid.html

Just one year into the BRIDGE project we can see clear and exciting innovation in RFID technology growing and believe that the development of a European Technology Platform (ETP), that encapsulated both Ambient Intelligent Supply Chains and the development of what has become known as ‘The Internet of things’, would greatly increase the ability to develop and apply innovation in value chains, giving leadership to the European Community in this global arena.

Appendix – Publications and patents to date

One patent has been submitted for '*Self resonant electronically small antennae'* – reference number PCT/EP2007/000262.

Details of eleven articles and twelve papers published to date has been supplied to the Commission for this first year of the project.