Final report
Work package 2

Recommendations for a Future European RFID Research & Development Policy

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Executive Summary

The subject of work package 2 is to define a detailed RFID research agenda, based on an analysis of the status quo of national and European subsidy programme lines, taking into account the requirements of various stakeholders, executing a gap analysis, and see to it that the European Research policy should take the end users' view and necessities more into account.

Research policy in general about the "what" and the "how", specifically the content part of technological and societal research, and the creation of tools, measures and infrastructure to implement , plus ways and means to transfer research findings into economic benefits for the widest possible selection of stakeholders (companies, customers, consumers, governments etc.)

As we started with the assumption that programmes and measures to support RFID are few and far between, our analysis started with a survey of existing projects and programmes focusing on RFID in the broadest sense, supported by national, regional/transnational and European authorities and agencies.

For a meaningful appreciation of RFID R&D, we started developing a yardstick against which we wanted to check the subsidy programme and projects.

For this we used several inputs:

First, we made a literature research on recent publications, focusing on analyses of the current status and on extrapolations 5–10 years ahead.

Secondly, we collected the internal views of partners in CE-RFID and selected additional contributors as to strengths and shortcomings of existing programme lines, both on national and European level in order to find subsidy programmes and projects.

Taking a cross-section (or the common denominator) of opinions voiced in the literature as to which challenges (or bottlenecks) have to be addressed to come to a full implementation of RFID in the various use cases, there is agreement on the following points:

a) Technological challenges in the tag/reader system, amongst others the required additional functionality for novel applications (e.g. smart systems), the cost issue, and reliability/dependability issue necessitating a case by case optimisation of the application

b) The lack of business models, mainly for the SMEs in the RFID value chain, whose access to using RFID is hampered by the unavailability of

generic architectures (building blocks) and lack of a fair sharing of costs and benefits in the value chain.

c) The reluctance of the consumer to embrace the technology and its services, due to unsolved or inadequately addressed data security and privacy issues as well as patchy information and customer involvement policy.

d) Lack of uniform standards and guidelines across Europe and across the applications.

For our analysis we retained the issues a) trough c) (in c) mainly the technological aspects of privacy by design); the standard issue is exhaustively covered in WP3, the guidelines issue in WP4.

In addition to these criteria we checked the existing RFID-related R&D subsidy programmes against more general programme related topics, amongst others:

- Are there any dedicated programmes?
- Are they easily accessible?
- Hit rate (chance to get subsidies)
- Focused on RFID or generic, thematic calls or open programmes etc.
- Do they support cooperative & industrial R&D?
- Do they go all the way to market introduction?

The basis of our recommendations for a future R&D policy is the analysis of the national and European R&D subsidy status quo for RFID.

As to the countries selected for the analysis, we identified a core group consisting of Germany, UK, France, Italy, and the Netherlands from the number of live business cases and economic importance attributed to RFID.

In this group, public financial support for R&D projects with industrial participation in general and RFID in particular differs widely. While Germany and France have a considerable number of subsidy programme lines for R&D, UK and Italy do not fund industrial R&D, while the Netherlands concentrate on funding for cooperative and industrial R&D and SMEs, and approach RFID-related funding via publicly financed research institutions.

Smaller countries like Austria and Finland support industrial R&D; the main difference here lies in the fact that Finland exhibits an RFID focus in present programmes, whereas Austria's new future programmes will open this opportunity.

The Nordic region (Sweden, Finland, Norway) give an interesting example of cross border cooperation with RFID focus on its NORDITE initiative, a benchmark example for the issue of bottom-up transnational cooperation.

Ideally, there should be earmarked money and dedicated calls for RFID. The lack of earmarked money has a negative influence on transnational programmes, such as EUREKA (bottom-up projects and clusters).

EU FP projects in the past (FP5, early FP6) only had little focus on RFID, and they also suffer from a lack of coherence between projects and project consortia, thus losing essential synergy effects. This coherence problem has only been addressed recently by the (temporary) CERP cluster of RFID projects from FP 6.

Concluding from all programmes analysed, RFID topics are certainly not over-represented (perhaps with the exception of Germany and France with their numerous RFID programmes).

In terms of coverage of the thematic "challenges" above, there are only few programmes addressing privacy explicitly. Business cases and ROI aspects of RFID introduction are also few, the focus generally is on tag/reader and system technology aspects.

Application programmes are frequently specific in nature, and contribute little to a generic re-usable system architecture that would enable easy access to RFID technology for SMEs.

In parallel to this R&D programme analysis, we collected ideas and suggestions from CE-RFID project partners and additional contributors on research topics for future R&D programmes; again, there are a number of similar research topic listings in the literature we consulted, differing perhaps in the level of detail, but agreeing with our findings on the main topics and challenges to address.

We used both input streams to come to the following recommendations for a future RFID R&D policy:

The present European R&D policy, as deployed for the preparation of FP7, solicits structural bottom-up initiatives of all stakeholders to co-define focal areas for collaborative R&D (European Research Agenda) and the technology

platforms for implementation. This in our view is a unique chance to agree on RFID centric R&D and synchronise European and national efforts. ETPs with explicit RFID focus should be supported.

Europe and the national authorities should act as enablers, supporting research into an RFID system architecture and its innovative HW and SW components allowing predictive design and implementation. This means also support for technology research into topics that seemingly are close to the market, but will allow rapid design — in and avoid case — by case optimisations leading to time delay and excessive cost.

National authorities tend to do so, but may be restricted by European state aid rules. Here, policies of national authorities and the commission need to be aligned.

Societal effects of RFID introduction were not a focal point of past research. This should be addressed adequately; we think that in addition a sound set of communication guidelines requiring industry to communicate and informing openly about their plans and motivation regarding RFID will help.

Next to the "what" there is an important supportive role in "how to implement":

Local/regional clusters tend to be a very effective way to foster cooperation along the value chain, with the added benefit, that such clusters represent critical mass and continuity (as the collaborative projects mirror image business relationships in the value chain). Support of such clusters and regions should be high on the agenda.

The EU also should play a significant role in creating a level playground across national frontiers for the implementation of RFID technology. Implementations, especially in SCM and logistics, will not stop at national borders. National rules should not prevail.

Finally, next to direct support the (national and European) authorities can play an important enabling role in their public procurement allocation: Support for novel RFID-based applications will have a tremendous stimulation effect.

Table of Contents

List of Figures

List of Tables

1 Approach

1.1 Definition of work package topic

RFID is a core technology in the fields of ICT and communication for the European industry. Although no more an emerging technology, the breath of its potential applications, and the number of open issues on its way to full implementation and market acceptance still requires substantial R&D effort in many domains.

The topic of this work package is to assess the present RFID R&D policy in Europe via its present implementation, the European and national RFID R&D programmes, compare this status quo with the requirements as perceived by the stakeholders of this technology, and make recommendations as to the content and the way of implementation of an optimised RFID R&D policy.

1.2 Structure of work package topic

The work package topic is structured in the following way:

Broadly speaking, the recommendations on a European RFID R&D policy are based on the analysis of the current status of R&D programmes and projects, starting with a survey of the present national subsidy programme lines of key countries and of the transnational programmes of EUREKA and the EU (EUREKA is a European research initiative aiming at cross-border cooperation between industry and technological research institutions, www.eureka.be). Alongside this analysis, and taking into account the content of the subsidy programmes and projects analysed, ideas and proposals for specific R&D topics were collected via interviews in this research project, and via literature research ([1], [2], [3], [4], [5], [6], [8], [10], [11]). Only documents dated between 2000 and June 2007 were used in the analysis.

This assessment and analysis was done against a set of criteria, outlined in chapter 2.2 (Methodology).

Survey and analysis of current R&D programmes are covered in chapter 3.

Parallel to this analysis, and taking into account the content of the subsidy programmes and projects analysed, we collected ideas and proposals for specific R&D topics, via interviews with our additional contributors and literature research, both in close cooperation with Work package 1. The survey of these

R&D topic proposals is given in Appendix 1, as reference for the content related proposals in the next chapter.

Finally, in the chapter 4 "Conclusions", we want to give suggestions as to:

- Which R&D topics should be addressed with priority
- How the EU could set the scene to optimise the return on subsidy money spent (both national and European)
- In which way the EU could act as sponsor / enabler / lead customer to support the adoption of RFID in areas of public interest.

1.3 Relevant stakeholders

Stakeholders are firstly the partners in subsidy projects, that is:

- research institutions
- companies in the value chain of RFID
- authorities defining programme lines and granting subsidies

and secondly, the "end users", such as

- the companies and institutions intending to introduce / apply RFID-based processes and solutions
- consumers, who are confronted with the results of these programmes

Research institutions and companies in the value chain were involved during the execution of this work package, partly as additional contributors, partly via direct contacts via phone or e-mail.

Some national authorities were addressed in the context of subsidy programme investigations; in addition, the EUREKA network (national delegates) helped obtaining an overview of past and current EUREKA projects.

2 Methodology

2.1 Work performed

We started work package 2 with two parallel actions:

- the inventory of RFID R&D subsidy programmes and projects on national and European level and
- the inventory of ideas and proposals concerning priority areas and specific topics for future RFID R&D programmes.

For both investigations, we involved additional contributors. We co-selected these with WP1, given the similarity of questions arising from the DoW of those two work packages.

Two joint workshops with WP1 were organised:

Workshop 1, 7 December 2006 in Gratkorn (Austria): In this workshop, first results of the WP1 survey of RFID-related R&D activities and the WP2 study on national and European RFID-related subsidy programmes were presented and discussed. Inputs for R&D topics were collected from the participants in a discussion.

Workshop 2, 2 March 2007, at the Tyco premises in Essen: The workshop aimed to collect and jointly discuss potential RFID-related R&D topics.

Based on the workshop results we started bilateral discussions (phone, E-Mail), both company-internal and with additional contributors, to check and underpin the proposals and findings.

Basic data collection concerning R&D subsidy programmes was done via web search (CORDIS, national Programmes sites etc).

A second major source for finding RFID subsidy programmes and their specific project content were the internal networks of the lead companies of WP2, in particular NXP and Tyco, plus networking via the programmes and organisations of the lead companies of WP2 themselves are involved in (EUREKA cluster Euripides, EUREKA advisory committee, French PdCs, Austrian and German RFID-related projects etc.)

For the cluster R&D topics there is a substantial body of recent publications covering status and future outlook of RFID in Europe, which we searched and used to corroborate our own findings.

2.2 Criteria for the assessment of current R&D subsidy programmes

In order to have a consistent method of work, we first had to define criteria to assess the present subsidy programme and projects. These criteria divide broadly into two categories.

Firstly, general programme characteristics were analysed, such as:

- Are there any programmes?
- Are they accessible for all potential participants (large companies, SMEs, academic institutions) or focusing on certain sectors (e.g. SMEs)
- What is the hit rate / probability of a successful application?
- Will it support single companies or are consortia required?
- Are these thematic programmes /call system or open for any topic?
- Does it cover all phases of innovation all the way to market introduction, or are there restrictions (e.g. only applied research etc)?

Specific criteria related to needs and necessities for RFID; the most important being: Does the programme (and consequently do the projects) address the main bottlenecks RFID faces on its way to full and profitable market acceptance? For this, we had first to make a brief analysis of those bottlenecks.

The main inputs for these specific criteria were the publications which were collected via desk research ([1], [2], [6], [7]). These publications also proved to be a valuable source of information on perceived bottlenecks (or challenges) that had to be addressed to achieve profitable implementation and a broad market acceptance of RFID technology.

By taking a cross-section of opinions voiced in the literature, as to which challenges have to be addressed to come to a full implementation of RFID in the various use cases, it seems that there is general agreement on the following points:

a) Technological challenges in the tag/reader system, amongst others the required additional functionality for novel applications (e.g. smart systems), the cost issue, and reliability /dependability issue necessitating a case by case optimisation of the application.

b) The lack of business models, mainly for the SMEs in the RFID value chain, whose access to using RFID is hampered by the unavailability of generic architectures (building blocks) and lack of a fair sharing of costs and benefits in the value chain.

c) The reluctance of the consumer to embrace the technology and its services, due to unsolved or inadequately addressed data security and privacy issues as well as patchy information and customer involvement policy.

d) Lack of uniform standards and guidelines across Europe and across the applications.

For our analysis we retained the issues a) to c) (in c) mainly the technological aspects of privacy by design); the standard issue is exhaustively covered in WP3, the guidelines issue in WP4.

2.3 Methodology used for the analysis

Initially, generic programme characteristics (see above) were investigated primarily via using available information sources (publications, homepages of funding agencies and ministries etc.), combined with interviews of responsible people in companies participating in relevant funding schemes. Also personal contacts with representatives of European programme lines have been used to collect information. This worked particularly well for the European programmes; however information on certain programmes at national level was quite difficult to collect, due to confidentiality rules which national funding agencies have to adhere to.

For the specific RFID-content related information we used a mapping technique based on the RFID Reference Model to determine the application focus of the individual programme or project. The model could then be extended with the following additional criteria, based on the issues a) through c) outlined above.

- Coverage of tag and reader technology aspects
- Coverage of systems aspects

- Coverage of business model and ROI aspects
- Coverage of privacy and data security aspects

An analysis was then carried out to establish to what extent the programmes covered the major challenges as perceived by the representatives of the RFID value chain. This was made for each programme line of the European projects, and also for each country when analysing the national programmes.

The results of this analysis are given in graphical form in each individual chapter covering specific countries or European R&D support programmes.

3 State-of-the-art and Analysis of the European RFID-related Subsidy Programmes

3.1 Overview of national and European RFID-related subsidy programmes

3.1.1 Introduction

This section gives an overview of the RFID-related funding programmes, both at national and European level in the period from 2000 to early 2007. This overview is certainly not exhaustive or complete, as access to programme and project information on national level was sometimes not easy to obtain.

We do believe however, that from the database created, conclusions and recommendations on EU R&D policy can be drawn.

All programmes supporting RFID and RFID-related technology and innovation were considered, from research to market introduction, and also programmes generating and supporting innovative infrastructures and cooperation models beneficial to RFID. Only such programmes were considered where we found proof of RFID-related activities and projects being executed in the context of these subsidy programmes. The following programme types were included in our assessment:

- All national programmes in the selected countries that either directly support RFID technology and applications or support infrastructural measures with significance for RFID
- European programmes with the same target setting; these include
- The EU Framework programmes FP5 and 6,
- EU regional programmes (e.g. Interreg)
- The EUREKA programmes (Clusters, Umbrellas and bottom-up projects)

For the selection of countries for this analysis we had several restrictions due to availability of information. We focused on the main European players based on the general activity level in RFID and the number of real business cases reported, as concluded from articles in the most important technical journals dedicated to RFID. Further we checked to the greatest extent possible, whether smaller countries or new Member States had a comparable activity level (as a means to measure the importance those countries attribute to RFID as a perceived core technology for Europe). The decision for analysing the research activities in these countries originates to a great extent to the availability of information. As stated above it was not possible to gather in-

formation for every European country. As a heuristic approach we decided to use the available information because drawing conclusions from this sample is still better then deciding without a sound basis.

3.1.2 National RFID–related funding/subsidy programmes

The candidates for the analysis actually come from 3 distinct groups:

1. Germany, France, UK, Italy, the Netherlands and Spain as representatives of large EU Member States with high visibility of the RFID topic, judged by the number of publications, projects and use cases

2. Austria and Finland, as representatives of the smaller Member States spending a relatively high percentage of the GDP on R&D

3. Poland, the Czech Republic and Hungary as representatives of the central European Member States

For these countries, a systematic overview was created, starting from the structure and content of the national subsidy programmes and then focusing on programme lines which support RFID. We further analysed the focus and impact of those programmes using the evaluation criteria outlined above.

3.1.3 Analysis of National Programmes

In this section we will give a brief summary for national R&D programmes related to RFID sorted by countries. Below is an overview of the selected countries and their respective R&D programmes.

	Funding agencies found involved in RFID R&D	**Number of dedicated RFID programme lines found**	**Number of RFID-related projects analysed**
Large Member States			
Germany	6	2	16
France	4	1	17
UK	1	none	1
The Netherlands	2	none	2
Italy	none	none	1
Spain	2	none	4
Small Member States			
Austria	3	1	17
Finland	1	none	10

Table 1 Overview of national programmes

3.1.3.1 Austria

National programmes

In Austria most national Research and Technology Development (RTD) subsidy programmes are financed, run and administered by two agencies:

- Fundamental Research oriented: FWF (Fonds zur Förderung der wissenschaftlichen Forschung = Scientific Research Fund)
- Applied /Industrial R&D and Transfer programmes: FFG (Forschungsförderungsgesellschaft mbH = industrial R&D Promotion Fund)

As almost all RFID-related activities fall within the scope of the FFG, we will focus on FFG programme lines in the remainder (please note that programme

line descriptions in this report are only summaries, details can be found on: www.ffg.at).

The main programme FFG programme lines (and their link to RFID subsidies) are:

Basic support programme

This programme line focuses on applied R&D and supports R&D projects of individual companies and Research Institutions as well as co-operations. It addresses large companies and SMEs alike, although there is an ongoing discussion whether positive discrimination of SMEs shouldn't prevail. Project results usually are one to maximum three years from market introduction. Eligibility criteria stipulate innovativeness and economic applicability. This is the main programme line within the FFG portfolio.

Within this programme line we find several programme types:

Basic promotion programme

This is an open programme (no thematic calls, continuous application, 10 evaluation / decision cycles per year). Cash value of subsidies range from 18 to max. 25 % of the accepted project costs, with the possibility of top ups from local authorities, mostly for SMEs; runtimes are between one to three years (typical).

Being an open programme, RFID-related applications from individual companies will mostly end up here.

Due to secrecy/confidentiality rules, no surveys of projects and/or participating companies are published or otherwise available.

We therefore can only give project examples from Philips/NXP that were supported by this programme type:

Acronym/Title	Runtime	Short description
Tyre pressure monitoring	2004–2005	Design and development of pressure sensor and RFID send-receive functionality
RFID Reference Design Centre	2006–2007	Integrated project; design of UHF EPC Gen2 Ics, plus setup of complete test lab infrastructure for integrated application evaluation

Table 2 Project examples of the basic promotion programme

Strengths	Weaknesses
Little bureaucracy, short decision cycle (8-10 weeks), relatively high hit rate, open for all technologies / themes	Relatively low subsidy percentage (cash value).

Table 3 Strengths & weaknesses of the basic promotion programme

Headquarter strategy programme

This programme type supports the transfer of core company R&D (and related company functions) to Austria, and addresses specifically internationally operating companies.

Next to the standard eligibility criteria, value creation for Austria (e.g. through creation of networks with local SMEs and co-operation with national / regional Research Institutions and Universities) is a criterion.

Again, this programme type is not linked to specific technologies; subsidy percentages are higher than in the basis promotion programme.

In the RFID field, Philips/NXP and (according to our knowledge) also Infineon have used this programme type to allocate company R&D to their Austrian subsidiaries.

Acronym/Title	Runtime	Short description
NFC Headquarter	2005–2007	NFC chip design, integration with SIM functionality, Data security / encryption studies, field testing & business case studies

Table 4 Project example of the headquarter strategy programme

Structure programmes

This programme line supports the structural co-operation between research institutions and industry.

Of the various programme types in this programme line, a very successful programme type in the past was the Competence Centre/Competence Network programme. (This programme type is presently under revision, and an upgraded programme has been drafted; details see on the FFG homepage).

The programme type supports consortia of Industry and Academia; run times were four years, with a possible prolongation of another three years. R&D topics are selected by the consortia, and evaluated by an international expert panel.

Research topics are open in principle, and range from environmental technologies to software, automotive technologies, medical R&D, speech recognition etc.

RFID topics are all but non-existent in the running centres/networks. In the new follow–up programme (called COMET), presently in the submission/preselection phase, RFID is a major topic in one of the proposals (ARGE-IKT), with NXP and Infineon, plus a number of smaller companies, as main "RFID-sponsors".
(www.bmvit.gv.at/innovation/strukturprogramme/comet/cometprogrammem.html)

Thematic programme line

This programme line focuses on selected national thematic areas; selection and definition of these themes is frequently done by joint industry-academia panels under the guidance of the sponsoring ministry.

Of the various programme types within this programme line, the programme FIT-IT (acronym for "Forschung, Innovation und Technologie für Informationstechnologien"/Research, Innovation and Technology for IT) has supported (and still supports) a number of projects of high relevance for RFID.

Thematic areas relevant for RFID-related projects are:

- systems on a chip
- embedded systems
- trust in IT systems

The programme issues calls within the thematic areas and supports projects "with a radical innovation potential", 3–9 years from market introduction. It only supports co-operations between universities/research institutions and companies.

In practice, existing co-operations between companies and academia in the RFID technology (e.g. NXP–TU Graz) have benefited from this programme line.

Typical examples of RFID-related projects are:

Acronym/Title	Runtime	Short description
SNAP	2006–2008	Security enabled NFC systems: investigation on data encryption
TOPAS	2007–2008	Trust oriented platform for advanced security: application for mobile computing, including RFID /NFC applications
PURE NFC	2006–2007	High-performance, usable, reliable embedded NFC systems
ART	2003-2005	Long range authentication of RFID in logistics applications
POWERSIM	2005–2006	Methodologies for designing power aware smart card systems
LOWSOM	2004–2005	Power profile software optimisation for mobile devices and smart card systems
CTS	2006-2007	Comprehensive (multi-standard)transponder system
ReadRF	2007-2008	Contactless reader technology for logistic and data management challenges

Table 5 Project examples of the programme FIT-IT

Specific ("Impulse") programme lines

Occasionally, ministries in Austria support special programmes focusing on specific economic categories (e.g. SMEs) in combination with a technology focus.

One of the examples with full RFID relevance is the programme "Development and market introduction of RFID technology applications" run by the Ministry of labour and economy under the heading "Action programme for the digital economy/ICT". It addressed SMEs exclusively, and most likely is/was a one-off initiative.

Examples of projects subsidised under this scheme are:

Acronym/Title	Company	Short description
Shipment localisation kit	Identec Solutions	SW platform to enable tracking of goods based on an intelligent long range RFID system using GSM for data transfer
RFID Application optimiser	CISC	Design and development of a tag-emulator for control and optimisation of RFID applications
DIMA	Internic Data communications	RFID application for theft prevention and anti counterfeiting
SmartCare	EOSS innov. Mgt	RFID-based asset tracking & logistic Mgt system for hospitals
Follow Me	Follow me	Access control person tracking system with escape route indicator in case of emergency
Tag Trans	Datatronic	Wireless uplink of RFID-based system components to central database via Bluetooth

Table 6 Examples of projects subsidised under this scheme

Regional programmes

As a mirror-image of the federal structure of Austria, the Austrian states have their own regional subsidy/R&D promotion organisations.

There is a multitude of programmes, frequently not focusing on specific technologies, but supporting regional development and infrastructure programmes.

Although no RFID relevant regional programmes were found, their general way of working (supporting the creation of local/regional clusters and cooperation models) is quite successful in other areas (e.g. automotive cluster in Styria) and could serve as role model for future RFID-related structures. (http://www.innovation-steiermark.at/de/programmem/pdf/operationelles_programmem.pdf)

Conclusions

The structure of subsidy programme lines in Austria is in principle quite supportive to RFID-related projects, as the major subsidy lines support both single companies and co-operations, are open regarding to the technological themes, and cover the whole range from applied research to "close to market introduction".

We only found a focus on RFID–centric programmes in one call concentrating on SMEs. A larger and concerted action on RFID will require industry and industry/academia initiatives in defining projects within the programme lines, and cooperating with ministries and agencies in creating and defining specific programmes in support of the RFID value chain. The new COMET competence

centre programme can offer the possibility; to our knowledge at least one RFID-related proposal for such a competence centre has been filed.

Strengths	**Weaknesses**
Flexible, little bureaucratic overhead; High hit rate for applications; e-card and e–government initiative supportive for implementation of RFID (government as lead customer)	Low subsidy percentages, no real coherence between RFID subsidy projects, little focus on RIFD
Opportunities	**Threats**
New COMET programme offers opportunity for support of RFID-centric cluster around major players in Austria	Danger that RFID-related cooperative ICT R&D in COMET may lose out against other R&D priorities.

Table 7 SWOT analysis R&D subsidy programmes Austria

Country	Austria	Tyre pressure monitoring	RFID reference design centre	NFC Headquarter	Shipment localisation kit	RFID Application Optimiser	DIMA	SmartCare	Follow me	Tag Trans	SNAP	TOPAS	PURE NFC	ART	LOWSOM
Application fields	A. Logistical Tracking & Tracing		■		■	■				■				■	
	B. Production, Monitoring and Maintenance							■	■					■	
	C. Product Safety, Quality and Information						■								
	D. Access Control and Tracking & Tracing of Individuals			■					■				■		
	E. Loyalty, Membership and Payment										■	■	■		■
	F. eHealth Care							■							
	G. Sport Leisure and Household														
	H. Public Services														
Project focus	1. Tag/Reader technology	■	■	■									■		■
	2. Systems aspects		■	■	■	■	■	■	■	■					
	3. Business model/ROI		■												
	4. Privacy/Data security			■			■				■	■		■	

Table 8 Project mapping on the extended RFID Reference Model Austria

3.1.3.2 Germany

Funding for R&D projects on national level mainly come from the following four organisations:

- BMBF (Bundesministerium für Bildung und Forschung): German Federal Ministry of Education and Research)
- BMWi (Bundesministerium für Wirtschaft und Technologie): German Federal Ministry of Economics and Technology),
- DFG (Deutsche Forschungsgesellschaft): German Research Foundation
- FhG (Fraunhofer Gesellschaft): Fraunhofer Society

In addition, there are some regional programmes.

The search for current and past RFID Projects and programmes gave the following results:

BMBF programmes

Project Call "Smart labels in Logistics"

This call was launched in 2004/2005 as part of the "Mikrosystemtechnik" (microsystems, MEMS) programme and specifies the programme focus as "support for industrial cooperative projects which deal with open issues of micro systems technology in smart labels/transponders and mobile readers, and for projects which want to test these smart label prototypes in field application tests". A total of 11 projects were identified within this call.

A project survey table is given in Table 9.

Other Programmes:

Two other calls within the "Mikrosystemtechnik" programme deal with technologies and applications that may have some significance for RFID from the technology and applications point of view:

Smart Technical Textiles

The cooperation of sophisticated technologies of the micro system technology and textile technology opens huge chances for the textile industry in Germany. Already today, German enterprises take an international leading position in the area of technical textiles. To hold the top of technology or to develop even further, these enterprises depend on the continuous development of innovative products. Promising application fields are the health service and

the security area. Here, the BMBF promotes the development of new micro-system-technical solutions.

Energieautarke Mikrosysteme (energy self-sufficient Microsystems)

The areas of intelligent textiles, medicine, car, aviation and astronautics, house technology, measuring technology, information technology, production or logistics prove to be promising application fields. Before the industrial manufacturing of energy-self-sufficient microsystems can begin, however, still some basic questions have to be answered. The BMBF promotes the development of new ideas for energy scavenging principles to be used, energy management, miniaturisation and system integration of the single components as well as manufacturing.

Acronym	Participants	Project budget	Short description
PRISMA (printed smart RFID Labels)	Bundesdruckerei, PolyIC, Siemens, Kurz, Höft & Wessel	8,2 m €	Development of low cost, polymer based RFID transponders, incl. validation in pilots
ASIL (active smart ID Label)	KSW Microtec; ELMOS, TU Chemnitz, Schenker AG	2,0 m €	Active smart ID label for transport surveillance of valuable goods, with integrated micro mechanical sensor for tilt/shock loading
EISTH_LOAW	RAKO Security Label, Sentronik, BeKa Eng, OFFIS e.V., Modehaus GmbH	2,1 m €	Development and implementation of specific transponders for the Textile logistics chain; process optimisation
UHF-Label	KSW Microtec, ZMD AG, ASEm GmbH, MGI, FhG IPMS, AT-MEL Germany	3,6 m €	Development of a semi-active smart label with integrated temperature sensor, incl. IC and assembly technology development
PESEL	FhG ISIT, ADT Peter Schmidt, PAV card, Melzer GmbH	3,6 m €	Pan.-mobile data capture with optimised smart labels for efficiency optimisation of logistic processes
PARIFLEX	Deutsche Post, SHK, FHG IZM, Uni Paderborn, ISPIRE AG, Funkwerk ITk	5,3 m €	Realisation of a novel passive RFID tag with integrated bistable display to replace the present paper based product info carriers. Integration into the logistics flow of the Deutsche Post

Acronym	Participants	Project budget	Short description
TRACK (tractability of consumer goods via autonomous microsystems)	FhG IPM, EADS, Schreiner group, Südelbe Logistik, Uni Tübingen	2,6 m €	Development of semi active labels with integrated sensors for temperature, humidity etc. Application to monitor past temperature /humidity history of containers etc.
LoCostix	SAP, NSP, MAN, PDS, TU Chemnitz, Uni Karlsruhe, DM-Drogeriemarkt	5,3 m €	Development of low cost labels for logistic tics in retail applications
TexTraLOG	FHG IZM, deister electronic, SKA Sitze SABIC Polyolefine	3,3 m €	Integration of RFID transponders into textiles, e.g. large textile transport bags or seat covers
RFIDrecycl	Uni Dortmund	0,1 m €	Study of existing recycling processes and systems when used for future RFID tag disposal; development of initial recommendations for the label disposal logistics
SmartPack	NXP, SMI Itzehoe, ALCAN Packaging	2,5 m €	This project aims at integration of the RFID tag functionality with the packaging, thus reducing cost, and explores the integration of extra functionality in the RFID IC, opening the possibility of using this integrated "intelligence" for novel tasks beyond pure logistics tracking.

Table 9 BMBF projects

BMWi programmes

Within the programme line "Next Generation Media", with a total call volume of 80 m € (funded volume: 40 m €), one of the four thematic clusters focuses on RFID. The theme cluster "Logistics networks — everything on track" supports four projects.

In the introduction to the programme launch, the BMWi pays special attention to the issue of involving SMEs into the rollout of the technology across all kinds of logistics applications and the bottlenecks encountered:

- Open technical issues (e.g. harsh environments/metals/liquid)
- Software/middleware architectures
- ROI/business case
- Security issues
- Standardisation

4 projects with RFID-related content were identified. In addition, the BMWI supports the: "Netzwerk elektronischer Geschäftsverkehr (electronic commerce competence network) initiative, which offers RFID-related support (information and consultancy) to SMEs planning to introduce RFID in their business processes.

Acronym	participants	Project budget	Short description
Ko-RFID	DaimlerChrysler, Gerry Weber, SAP, Humboldt Uni Berlin, Wellmann	n/a	Aim of the project is the use of modern RFID technologies to optimise logistics processes and improve the process transparency and communication of the participants. FID logistic systems of various businesses (textile, automotive, kitchen manufacture) are analysed to define standards and application concepts for a trust based trading system.
LAENDmarKS	DaimlerChrysler, IBS, Keiper GmbH, ITM /Ruhr Uni, Volkswagen AG	n/a	Development of technical solution for complete tractability of components through the supply chain; focus on safety relevant parts, possibility of complete transparency in case of defects /safety related recalls
Log Net Assist	BSH, Daimler-Chrysler, ebp GmbH, Fraunhofer-IML, PSI AG, SAP	n/a	Real time tracing and capturing of all logistically relevant along the supply and production chain. Use of innovative wireless technologies to support multimedia based visualisation for an event-based decision-making. Trials in white good manufacturing and in Truck production
Sm@rt logistics	Simcron, Tedrive Germany, TU Dresden, WZL RWTH Aachen	n/a	Kanban implementation with RFID and WLAN, with specific optimised SW implementation; application in car manufacture; technological focus on solutions for harsh environments (metals, oil etc)

Table 10 Overview of the subsidised BMWi projects

Deutsche Forschungsgemeinschaft

The DFG funds seven fields of research. For all fields there is 363 m € available. One of the special research areas with significance for RFID is "Selbststeuerung logistischer Prozesse" (self steering logistic processes). In this programme, which consists of a total of 14 projects, RFID is addressed as one of the main enabling technologies for the ICT aspects of this research area.

Fraunhofer Gesellschaft

In recent years, no projects with a focus on RFID were funded; the last project dates back to 1999: The project "assist" (personal shopping assistant).

Regional programmes

From several regional programmes existing in Germany, the Stiftung Industrieforschung supports RFID-related projects.

For 2007 they have formulated a programme around topics like:

- new concepts for high reliability applications of RFID
- development of methods to validate the cost/benefit trade-off of RFID applications.

These programmes are mainly aimed at small und medium sized companies considering RFID.

A typical example is the project WIRELESS, executed by the Institute for telematics of the University of Freiburg, dealing with various aspects of the implementation of RFID /EPC Global for SMEs integrated in the value chain of large companies.

The programme focuses on aspects of the business case for SMEs and ROI aspects of this novel technology.

Another initiative, the "Netzwerk elektronischer Geschäftsverkehr (electronic commerce competence network, www.ec-net.de), supported by the BMWI, offers RFID-related support (information and consultancy) to SMEs planning to introduce RFID in their business processes.

Also the Bayrische Forschungsstiftung (Bavarian Research Foundation) supports RFID-related projects. An example is the project CMOS-RFID-S, executed by the Institute of Electronics Engineering of the University of Erlangen. This project deals with passive, locatable multi-standard CMOS RFIDs with sensor functionality for mass applications

Conclusions

Germany exhibits a multitude of subsidy programme lines; most are based on a competitive call system. There seems to be a reasonable match between RFID-related technologies and applications, and the past and present thematic priorities of the largest funding bodies, the BMBF and BMWI.

On the other hand, this thematic call system has its drawbacks, e.g. for EUREKA programmes (relying on national funding): the "right" project at the wrong moment (no fitting call open) will jeopardise funding, and thus the consortium.

RFID is in the focus (or at least an important part) of a number of programme lines. Examples are the NextGenerationMedia and Microsystems programme lines of BMWI and BMBF respectively.

High political awareness of the potential impact of RFID and the economic benefits are supportive to RFID-related subsidy programmes.

Furthermore, the strong position of research institutions and University institutes in the RFID field, and their good contacts to funding agencies helps to generate a sizable RFID project portfolio.

On the downside there is little coherence between the separate projects, to the extent of redundancy/overlap between projects, no central repository for the experience and information gained (especially when no academic institutions with an RFID centric research programme are involved).

This is well recognised in a number of recent policy papers on medium-term R&D policy, and also specifically for RFID; suggestions range from support for structural support for RFID-relevant technologies to support of regional /thematic clusters.

Strengths	**Weaknesses**
Substantial and explicit support of RFID through thematic calls; Importance of RFID for national economy is well recognised; Clear and explicit formulation of long-term vision regarding RFID applications and technologies	Little coherence between individual projects; No central RFID competence repository, Organisation of access to project results for the SME community is not clear
Opportunities	**Threats**
Chance to turn the long-term vision expressed in policy papers into action	No substantial threat given

Table 11 SWOT analysis R&D subsidy programmes Germany

Country	Germany	PRISMA	ASIL	EISTH_LOAW	UHF-LABEL	PESEL	PARIFLEX	TRACK	LoCostix	TextraLog	RFIDReCycl	Smartpack	Ko-RFID	LAENDmarKS	Log Net Assist	Smart Logistics	Wireless
Application fields	A. Logistical Tracking & Tracing	■	■	■	■	■	■		■	■	■		■	■	■	■	■
	B. Production, Monitoring and Maintenance										■			■			
	C. Product Safety, Quality and Information		■	■				■			■	■					
	D. Access Control and Tracking & Tracing of Individuals	■															
	E. Loyalty, Membership and Payment																
	F. eHealth Care																
	G. Sport Leisure and Household																
	H. Public Services																
Project focus	1. Tag/Reader technology	■	■		■		■	■	■	■		■				■	
	2. Systems aspects			■		■	■				■	■	■	■	■	■	
	3. Business model/ROI										■		■				■
	4. Privacy/Data security																

Table 12 Project mapping on the extended RFID Reference Model Germany

3.1.3.3 France

General subsidy landscape

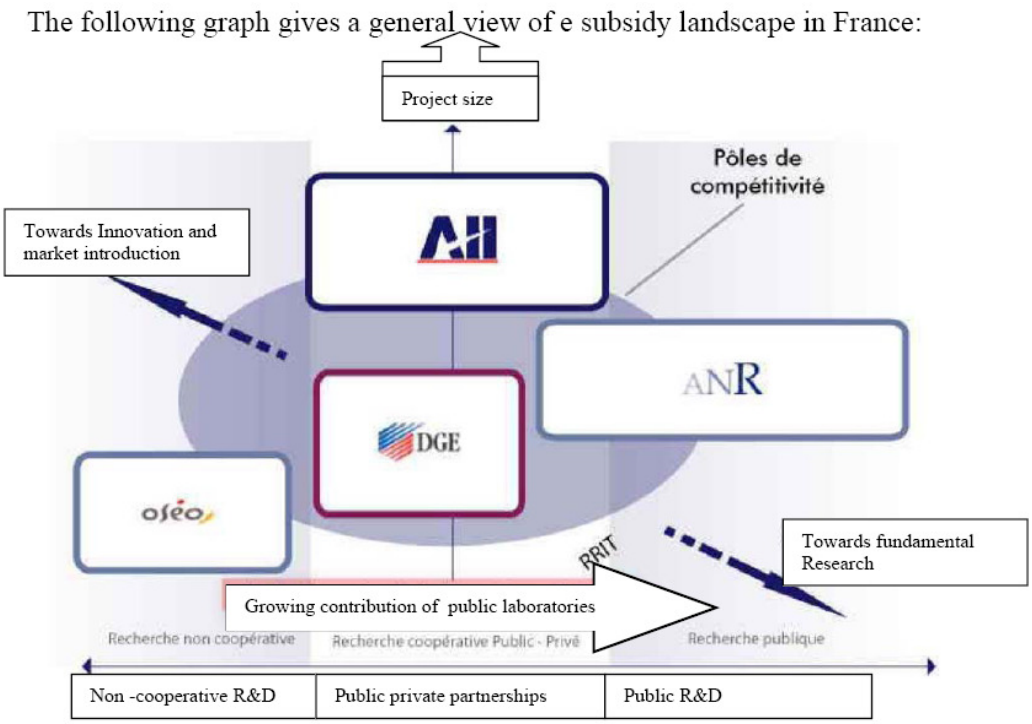

Figure 1 General view of the subsidy landscape in France

The following ministries and governmental agencies are involved in RFID-related R&D support programmes:

- **OSEO Anvar** focuses on the support of SMEs, specifically innovation & technology programmes.
- **The Ministry of Industry (DGE**) harbours the "Enterprise Competitively Fund" of the Ministry of Finance, and finances industrial R&D programmes, especially in the context of EUREKA and its clusters.
- **ANR (National Research Agency)** supports fundamental and applied research, and technological transfer from research institutions to industry.
- **AII (Industrial Innovation Agency)** supports large cooperative projects of large enterprises, which surpass their usual R&D effort and aim at global markets, creating highly qualified employment and export revenues.

Pôles de Compétitivité

Pôles de Compétitivité (PdC) are specific regional forms of cooperation on various fields, which usually have a selection procedure for cooperative projects in their respective fields of operation. They may receive government subsidies from all sources mentioned above (plus regional subsidy programmes and funds), depending on the character and scope of selected projects.

This form of cooperation combines the advantages of regional clustering with thematic focus(ses) in their programmes; there are concise guidelines from the French authorities/government concerning the labelling of a PdC; financing is considered long-term. Average subsidies amount to one third of total project costs.

The subsidy money comes from the above-named agencies (approx. 60 %) with the remaining 40 % from a specific government fund bundling the budgets of all ministries concerned. Regional top up is foreseen.

RFID-related projects

As we are specifically looking for RFID, PdCs with explicit relations to RFID thematic areas are most probable sources for projects. Furthermore, a second support line for RFID exists along the EUREKA axis. This support line can especially be found in EUREKA clusters concentrating on relevant technologies and system integration aspects. This will be covered under the transnational programme survey.

The following summary shall display such RFID-related PdCs in brief review:

PdC SCS (Solutions Communicantes Securisées)

This PdC with its subordinate thematic groups

- Identity
- Convergence
- Connectivity
- Mobility

contains the thematic areas, and associates industrial and scientific partners in order to cover a majority of RFID use cases.

Presently, the following projects within the PdC SCS receive state subsidies:

Acronym	Participants	Short description
Alpha Sante	Neopost DIVS, SPS, MS Conseil, Llab. d'informatique d'Avignon	Usage of RFID technology to improve the traceability of medical documents and data storage
Clic&go	Mobeo, SRID, Agevia, INRIA	Development of a search engine to check available products in stores, stock info based on RFID tagging
RFID trace Aero	Eurocopter, ST Micro, CNRS	Development of an RFID-based system for stock control and authentication of aeronautic spare parts
RFID authentication and Privacy	CEA Leti, Euredom, INRIA	Development of HW & SW solutions to prevent traceability in RFID-tag based systems
RFID trace Agro	STid, ST Microelectronics, Université d'Avignon	Replace one way packaging by re-usable packaging, reducing waste; traceability as factor in food safety, based on RFID
Mostra	Amadeus s.a.s, Philips, Université de Nice	Application of NFC for arrival / departure registration of travellers; personalisation of travel services, business case study
Pac ID grande distribution	STM, France telecom, IBM, Carrefour, Tagsys, Malongo	EPC Global Gen 2 implementation of SCM based on RFID
Pac ID Sante	ST Microelectronics, IBM, Tagsys, CHU Nice	Replacement of barcodes by RFID tags for traceability of tissue samples; Patient tracking; Tracking and authentication of pharmaceuticals
Sacose (Secure contactless)	CEA LETI, ST Microelectronics, Gemalto, ISEN	Identification of attacks on the air interface, development of countermeasures, and validation of proposed solutions in typical application scenarios
Vinetag	ST Microelectronics, SPS, Shaktiware, Caves de Lambesc	Traceability of products and assets in vineries, using RFID and mobile communication

Table 13 Project examples of PdC SCS

PdC TES (Transactions electroniques securisées)

TES is a regional PdC (located in Basse Normandie/Caen) and unites 16 large companies, 38 SMEs and three research institutions and concentrates on aspects of secure data transfer (technology, IT, services, etc.) that use case electronic payment.

By investigation we found the following RFID projects:

Acronym	Participants	Short description
ALBATROS	n/a	Development of a banking card allowing to display business requirements and field trials.
MOTE pay	NXP, Caisse d'épargne	Development of a system architecture for payment by using an NFC mobile (near field communication)
PEGASUS	NXP, France telecom, major French banks	Standardisation of NFC transactions

Table 14 Project examples of PdC TES

PdC Logistique Seine-Normandie

This PdC concentrates on logistic solutions, especially for containers and maritime transport.

Three RFID-related projects were found within this PdC:

Acronym	Participants	Short description
DOL 21	LHD, Toshiba, Transports Buffard, Université du Havre, Aircelle	Development of an cooperative industrial logistics system involving subcontractors, and covering the whole production and transportation chain for the end customer
CIT	CMNP, MAR-FRET, Hub telecom	Container identification. Tracking: localisation in container ports, development of a logistics system for the optimisation of container usage
GOST	SNCF, JP Geo, Soget SA, Université du Havre	Geo-localisation, optimisation and security aspects of container transport based on RFID

Table 15 Project examples of PdC Logistique Seine-Normandie

PdC MINALOGIC

In this programme, located in Grenoble, the cluster combines micro-nano technology with software competence in order to foster innovation in intelligent miniaturised products and solutions for industry.

One RFID-related project was found:

Acronym	Participants	Short description
Papier RFID		Realisation of very low cost RFID labels based on paper

Table 16 Project examples of PdC MINALOGIC

Conclusions

In summary, awareness of RFID on national level is high (Roure et al. 2005). Both the structure and the size of the subsidy infrastructure in France are

very beneficial for thematic clustering. Strong national support exists for industrial and application-oriented R&D, the amount of money available is considerable, and there is a strong focus on technology implementation; while still pre-competitive in nature, the programmes support activities quite close to final validation and market introduction.

Strengths	**Weaknesses**
Strong national support for industrial and application oriented R&D; Substantial funds, funding authorities are well-coordinated; Strong support for regional clusters (PdC) (some of them with explicit world wide scope); Relatively high hit rate	RFID (to our opinion) is not an explicit key focus area
Opportunities	**Threats**
Support for PdC model also for cross border cooperation	Over-subscription to PdCs can lead to financial cuts

Table 17 SWOT analysis R&D subsidy programmes France

Country	France	ALFA Sante	Click&go	RFID Trace Aero	RFID Authentication & Privacy	RFID Trace Agro	Mostra	PAC ID grande distribution	PAC ID Sante	SAcose	Vinetag	Albatros	Mote pay	PEGASUS	Dol 21	CI T	GOST	Paper RFID
Application fields	A. Logistical Tracking & Tracing																	
	B. Production, Monitoring and Maintenance																	
	C. Product Safety, Quality and Information																	
	D. Access Control and Tracking & Tracing of Individuals																	
	E. Loyalty, Membership and Payment																	
	F. eHealth Care																	
	G. Sport Leisure and Household																	
	H. Public Services																	
Project focus	1. Tag/Reader technology																	
	2. Systems aspects																	
	3. Business model/ROI																	
	4. Privacy/Data security																	

Table 18 Project mapping on the extended RFID Reference Model France

3.1.3.4 Spain

Subsidy programme lines

In Spain most subsidy programmes are handled by one central agency, the CDTI (Centre for the development of industrial technology). It is a public organisation under the Ministry of Industry, Commerce and Tourism, and acts as intermediary between the ministry on one side, companies and R&D organisations on the other side.

Financial support is granted by funds and loans of the government.

Supported programmes come from all industrial sectors. While theoretically companies of all sizes are supported by these programmes, in practice there is a tendency to concentrate on SMEs.

Programmes are usually divided in:

- cooperative industrial research projects
- technological Development projects
- technological innovation projects

There are no specific programme lines or themes that will be supported preferably, so that there is no specific RFID-related programme line. Only 3 RFID-related projects in the CDTI portfolio (OMEDIS, NEPTUNO II, and RFID in traceability) could be identified; access to projects data is restricted.

Acronym	Participants	Short description
OMEDIS	SEMARK AC GROUP, S.A.	Integrated Information system for operations and goods in distribution chains using RFID technology
NEPTUNO II	BSH ELECTRODOMESTICOS ESPAÑA SA	New IT platform for introducing online e-Learning, RFID in warehouses and on line shops for employees and end-users
APLICACIÓN DE LA RFID A LOS PROCESOS DE TRAZABILIDAD	DISEÑO CODIGO BARRAS SA	Application of RFID in traceability processes

Table 19 Project examples Spain

More detailed information on these projects is not available.

Given the accentuated regional structure of Spain, there are also regional agencies active in industrial R&D subsidies.

An example: the Basque government sponsors the project KIROLTEK, which, amongst other things, tests the use of RFID for registration and timing in sporting events. (http://www.kifer.es/producto/rfid.htm)

On the other hand, there is a number of interesting larger scale application projects financed by companies. However, there seems to be no public support for these projects.

Objectives	Funded by	Fund	Target Market	Time Schedule	Internet
Trace envelop through different steps for quality purposes in delivery	Correos	1 m €	Public Sector	June–December 2006	www.correos.es/comun/informacionCorporativa/desarrolloNoticias.asp?id=325&idNodo=desarrolloNoticias
Trace product in production plant	KHLloreda	100,000 €	FMCG	January–March 2006	www.khlloreda.com/idioma/es/noticias.html
Trace egg production from farm to production plant	Leche Pascual	120,000 €	FMCG	January–June 2006	www.rfidjournal.com/article/articleview/2786/
Shipment controls	Renault	200,000 €	Automotive	2005	www.mylogistics.net/de/news/themen/key/news504702/jsp
Improve maintenance tasks	Estrella de galicia	100,000 €	FMCG	2005	www.vieiros.com/publicacions/nova.php?Ed=42&id=55669
Trace product in production plant	Quesos García Baquero	50,000 €	FMCG	2006	eventos.idtrack.org/rfid06/prensa.html

Table 20 Application projects financed by companies

Conclusions

The basic subsidy structure in Spain supports companies and research institutions alike (including single company projects such as OMEDIS and NEPTUNO II), but according to our investigation there are no specific support programmes for RFID.

There is too little information to execute a full SWOT analysis. One of the apparent weaknesses is the regional fragmentation of subsidy programme lines, and the lack of focus on RFID.

3.1.3.5 The Netherlands

Subsidy programme lines

Judging from the high number of official publications and papers from (regional and national) government agencies and ministries, RFID is one of the top innovation themes. Certainly, this is also triggered by the importance of the logistics and transport sector in the Netherlands.

The SenterNovem Agency is the central institution for the coordination and the administration of the major part of national subsidy programmes. The agency reports to the Dutch Ministry of Finance.

There is a multitude of programme lines, but none with a direct focus on the topic RFID, i.e. there is no thematic programme for "RFID".

One of their major subsidy programmes supporting the cooperation of research institutions and companies is the so-called BSIK (Besluit subsidies investeringen kennisinfrastruktuur = Decision on subsidies for investments into competence infrastructure): within this programme line, two major projects include some aspects of RFID technology and application:

a) Smart Surroundings, a multi-year programme, with major players as Philips, OCE, TU Delft, TNO, TU Twente and others in the consortium, and the following vision statement: The overall mission of the Smart Surroundings project is to investigate, define, develop, and demonstrate the core architectures and frameworks for future ambient systems. The project started in April 2004, will run for four and a half years, and has a budget of 13 Million Euro. The Smart Surroundings research programme is investigating a new paradigm for bringing the flexibility of information technology to bear to every aspect of daily life.

b) Freeband, focusing on ambient intelligence in communication. Here, Marcopolog, one of the demonstrator projects within the Personal network Pilot Programme line integrates RFID sensing into a location sensitive communication system for the tourist industry.

A second subsidy line containing RFID-related topics focuses on the SME community; the subsidies are available in the form of tax reductions for R&D/innovation related labour cost. Although a rather large number of SMEs have used this programme for (mostly service related) projects containing some aspects of RFID, the cash value of those subsidies is rather small (less than 1 % of the project cost).

A third "indirect" subsidy/support line for RFID in general are centrally, from ministerial side financed investigations and study reports, such as "RFID in healthcare", done in cooperation with medical institutions and market research companies.

Looking at plans for new programme lines, there seems to be a consensus that support for applications' investigations and prototyping could fill a gap on the way to a more rapid adoption of novel, RFID-based services.

Interesting enough, the Dutch government also recognises the leading role state procurement can play in supporting the adoption of RFID applications: several publications point at the importance of e-passport and e-transport card project for this technology, and suggest more initiatives in the future.

Additionally, the Ministry of Economic Affairs participates in industry/research institutions platforms, such as the RFID platform Nederland (www.rfidnederland.nl) and eNederland (www.ecp.nl) aimed at the dissemination of RFID application information and investigations of privacy and data security aspects.

Conclusions

In spite of the high interest in RFID and the potential importance of RFID for the key economic sector transport & logistics, there are surprisingly few subsidised projects in this area. Presently there seems to be an awareness that more should be done, and especially the "last mile", i.e. the support of real size testing and validation should have more and bundled support.

Strengths	**Weaknesses**
Strong position of government as lead customer for novel applications; Many RFID implementations in public transport, health, logistics etc.	No dedicated RFID subsidy programme lines; focus on non-thematic SME support with tax credits
Opportunities	**Threats**
Concrete plans to support application research (partly publicly financed test-lab for validation of technology and business cases)	No substantial threat given

Table 21 SWOT analysis R&D subsidy programmes France

3.1.3.6 Italy

From our search we conclude that in Italy national programmes in RFID technology (and RFID projects in general) are currently not subsidised.

Nevertheless, Italian companies do participate in regional (EU funded) and transnational (EUREKA) projects.

One example is a recent project in Varese (North-West of Italy), named REGINS-RFID, partly sponsored and subsidised by the European Community and a several Italian Local Public Administrations (such as Lombardy Region, the Chamber of Commerce/Industry/Handicraft/Farming of Varese, the University of Castellanza-Varese and other local entities). REGINS-RFID aims to

promote a new key technology for logistics to improve the transparency and quality of the logistics supply chain.

However, the RFID technology is strongly promoted both in private and in public environment. From the private point of view, the main sponsors are the University of Milan, School of Management of the Politecnico di Milano, and the Sapienza University of Rome. From the public point of view, the main sponsor for RFID-related research is the FUB (Fondazione Ugo Bordoni: partly privately financed research centre affiliated to the Ministry of Communication).

Conclusion

National funding of R&D projects in general exists on a very low level, no focus on direct RFID support. Indirectly, government–funded research institutions execute cooperative projects with the RFID industry.

3.1.3.7 UK

Subsidy programme lines

In the UK the R&D priorities, and possibly linked subsidy lines are determined by the Technology Strategy Board, which defines relevant technology areas. These are delivered by the Department of Trade and Industry (DTI) and come along in two support lines:

- Collaborative Research & Development
- Knowledge Transfer Networks.

The total sum available over the period 2005-2008 involves about 400 m €.

Calls within the Collaborative R&D framework are usually twice per year including an updated list of technological themes and addressing cooperation between companies and research institutions.

A typical technological priorities list can be seen in the following (taken from a call in fall 2006):

- network security
- moving towards a zero emission enterprise
- emerging energy technologies

- bioscience and healthcare
- sensors and imaging for medical, security and environmental applications
- plastic electronics

From a scan of the projects database, no projects with focus on RFID were found.

Though, an example for an RFID-related materials science project from 2004 can be given:

Materials, Process and Device Development in Plastic Electronics for Displays, RFID and Logic Applications (HIPPO)

Project lead: Avecia Ltd

Total project size: 2.24 m £

This project will deliver potentially significant developments in Printed Plastic Electronics by combining novel High Mobility Materials and Device Architectures for Fast Transistors to provide performance equal or greater than that of amorphous Si. This will enable a considerably wider range of Plastic Electronic applications to be addressed than it is possible with the current status. This industrially lead project will capitalise on recent developments within the UK academic and industrial research community and develop them towards industrial application, and will be delivered by a close collaboration between developers of Materials, Processes and Device Physics with the guidance of Industrial End Users.

Conclusions

The UK subsidy scheme does not support larger companies outside cooperative (research-company cooperation) programmes. There is little evidence for a targeted support for RFID-related topics, be it in national or transnational programmes (such as Eureka). On the other hand, the importance of support for "the last mile" in RFID introduction is clearly recognised. The Department of Trade and Industry supports the RFID Centre (www.rfidc.com), a public-private organisation focusing on advice and guidance in RFID matters such as business case development, technology testing training and technical trials.

3.1.3.8 Finland

Government funding

The structure of R&D subsidies and the executing agencies in Finland have some similarity to the Austrian situation.

The central agency dealing with subsidies for Academic institutions and companies alike is TEKES, the Finnish funding agency for Technology and Innovation.

TEKES's funds come from the national budget through the Ministry of Trade and Industry; their annual budget is around 500 m €, and they fund close to 2000 projects annually.

Funding is done by low interest rate loans and/or grants, depending on the nature of the proposed project and the stage of its innovation.

Percentages for grants range from 50–100 % for research institutions, and 15–50 % for industries; additional loans are possible.

The scope of TEKES project support covers both national and transnational and European programmes (e.g. EUREKA).

The programme structure is twofold:

An "open" system, similar to the Austrian base programme, with no thematic priority and open to submission throughout the year. About 60 % of the TEKES grants fit into this "open" funding line.

A more focused "technology programme" line, where (defined via regular reviews) the most promising technology areas are identified, and project submissions fitting those areas (and specific topics within these areas) are solicited. Ideas for new technology programmes are based on initiatives by the "customer base" and on the focused areas regarding to the TEKES's strategy.

Examples of present technology focuses areas are:

- ICT
- biotechnology
- materials
- nanotechnology

Within those Technology Focus Areas multi-year technology programmes are defined.

Scanning this wide array of already finished and running technology programmes we found a number of RFID-related projects. The survey certainly is not complete, as (due to confidentiality clauses) the accessibility of the project databases is limited.

Examples of RFID projects:

Acronym	Participants	Short description
Mini RFID	University of Tampere	Research project: Development of methods and models for miniaturisation of RF antennas and readers
Idesco UHF reader family	Idesco OY	Enterprise project: development of novel tag antenna solutions, development of HW and SW modules for advanced UHF readers
RF remote reading technology	VTT	Research project: study of remote readout technology for capacitive and resistive sensors on RFID tags
WIRSU	NOKIA	Enterprise project: wireless sensors for ubiquitous communication

Table 22 Project examples ELMO

Acronym	Participants	Short description
NFC (RFID)solution & tag development	ToP identification Ltd	Enterprise project: development of customer specific NFC /RFID tags, incl. study of the business model

Table 23 Project examples VAMOS

Acronym	Participants	Short description
CYCLOG	Helsinki University of technology, BIT Research	Development of effective logistics management practices and logistics information services for service and maintenance /product lifecycle applications
eSCID	Tampere University of Technology, VTT	Research project: electronic supply chain Identification with passive RFID for spare part logistics and paper reel logistics in the paper industry, incl. testing
RFTUNLOG		Enterprise project: study of potential benefits of RFID systems for automated product and transport unit level identification
RFID technology in inbound logistics	ABB group	Enterprise project: RFID-based identification platform for Kanban containers between final assembly factory and supply chain
Logistics improvement programme	Finnmirror OY	Enterprise project: improvement of reliability and speed of the entire logistics process based on RFID

Table 24 Project examples ELO

Partly publicly financed Contract Research Organisations

A typical example is VTT (www.vtt.fi/vtt), which does cooperative R&D with Finnish and international companies, and receives about 20 % of its funds from the government (via TEKES).

In its strategy paper, this organisation lists a technology focus on area RFID/interactive ICT.

In the project database we found 20 RFID-related projects, demonstrating that RFID is one of the larger topics in VTT's contract research portfolio

Public-private partnership model: the RFID Lab

The recently opened RFID Lab in Helsinki (www.rfidlab.fi) is an interesting example of cooperation between companies active in the field of RFID (e.g. Nokia, UPM, and HP) and local/regional governments and their technology agencies.

The Lab will provide consultancy services for system specifications, implementation and testing. It will run a demonstration and testing facility to support the validation and market introduction phase of RFID technology and solutions.

Conclusions

The Finnish subsidy model is very pragmatic, in principle open to all technologies and companies and research institutions alike. Technological focus areas are defined in close alignment with industry. Judging from the themes and topics, plus the presence of major players in RFID within these programmes, the Finnish subsidy model is rather supportive for RFID-related programmes and technologies.

Strengths	**Weaknesses**
Flexible open system, all topics; Technology programme lines defined in close alignment with "customer base"; RFID Lab cooperation model	Average subsidy level low
Opportunities	**Threats**
Cross border cooperation models with Norway & Sweden	–

Table 25 SWOT analysis R&D subsidy programmes Finland

Country	Finland	Mini RFID	UHF Reader Family	RFID remote reading technology & sensors	WIRSU	NFC Solution & Tag dev.	CYCLOG	ESCID	RFTUNLOG	Logistics improvement project	RFID technology in inbound Logistics
ca tio n	A. Logistical Tracking & Tracing										
	B. Production, Monitoring and Maintenance										
	C. Product Safety, Quality and Information										
	D. Access Control and Tracking & Tracing of Individuals										
	E. Loyalty, Membership and Payment										
	F. eHealth Care										
	G. Sport Leisure and Household										
	H. Public Services										
Project focus	1. Tag/Reader technology										
	2. Systems aspects										
	3. Business model/ROI										
	4. Privacy/Data security										

Table 26 Project mapping on the extended RFID Reference Model Finland

3.1.3.9 New Member States

For our overview of new Member States, we selected the Czech Republic, Hungary and Poland. Our research showed that no national RFID R&D programmes exist in these Member States, however one Czech company participated in the EUREKA project and Hungary and Poland both participated in some FP6 programmes.

Czech Republic

Our search by contact with the Czech Eureka office and a member of the national scientific council was negative; (no national RFID subsidy programmes or projects). Only one Czech company has recently participated in a EUREKA project.

Hungary

According to our research no national RFID-related support programmes; two companies participate in the FP 6 project STOLPAN.

Poland

According to our research no national RFID-related support programmes; companies and institutions do participate in FP6 programmes with RFID relevance.

Conclusions

Although we only looked at those three countries, the lack of national programme focus on RFID and related technologies indicates a clear gap between the new member states and the other countries selected in this survey.

3.1.4 Transnational programmes with national funding

3.1.4.1 Cooperation between national subsidy authorities: the NORDITE programme

One of the best examples of transnational cooperation between national authorities and programmes relevant to or focussing on RFID is a cooperation between the Finnish (TEKES), Swedish (Vinnova) and Norwegian (Research Council of Norway) funding authorities, called NORDITE.

NORDITE aims to support research institutes and universities in their effort to develop state-of-the-art research in the fields of SW radio, wireless sensors, short range wireless networks and RFID.

The objectives of the programme are to:

- solicit project proposals from teams composed of Swedish, Norwegian and Finnish Universities and research institutes in areas relevant for these three countries
- create and support projects which should provide results in the form of technology development that can be used by companies in those three countries

In order to establish a link between the subsidised research institutions and future economic exploitation, the market potential of these projects has to be confirmed by at least two companies who have signed an agreement of participation

The programme runs from 2005–2010, the total subsidy volume is 16 m €; up to now 38 companies and approx. 20 research organisations are participating.

We found two examples of NORDITE-funded, RFID-related projects:

Acronym/Title	Partners	Short description
Printed RFID sensor solutions	Mid Sweden University, VTT; TagMaster, UPM,	Development and evaluation of technology to print RF rectifiers and modulators for fully printed RFID tags; development of printed sensors integrated with standard RFID platforms
IntelliSense RFID	Chalmers Univ, VTT, IMEGO, SINTEF	RFID platform with sensor integration capability, with following characteristics: dual frequency antennas, high data rates, temperature, pressure humidity and pH-sensor design and integration.

Table 27 Project examples of the NORDITE programme

The fact that RFID projects are part of the transnational initiative is based on the fact that RFID technology is recognised as important for the core industries (manufacture, automotive, transport and logistics) of those Nordic countries.

Conclusions

This Nordic initiative is an interesting example for transnational cooperation, initiated by national authorities and focussing on areas of common industrial and business interest.

Given the fact that RFID as technology and application will need concerted efforts across national boundaries, this initiative can serve as a reference model for implementation of a (regional) R&D policy beyond pure national priorities and interests.

3.1.4.2 EUREKA

The Eureka programme in its two forms, bottom up and cluster projects, addresses transnational cooperation, relies on national funding of individual participants. It will be most successful in countries that have either earmarked budgets for participation in EUREKA or a subsidy programme line that is neither stipulating specific technology priorities nor operating a competitive call system on national level.

In the following, a short survey of RFID in EUREKA programmes is given.

EUREKA clusters

EUREKA clusters closest to RFID-related technologies and applications are:

- CELTIC
- EURIPIDES (a merger of the cluster programmes EURIMUS and PIDEA)

CELTIC deals with integrated telecommunications systems, wherein RFID could play a major role in certain aspects. In contrast, EURIPDES focuses on smart systems integration, in which all packaging /Systems integration aspects of RFID applications come into play.

Scanning through available project files, no RFID-related projects were found in CELTIC calls up to now.

Within EURIPIDES and its predecessors (with their focus on smart systems integration), two packaging projects were found. They relate to specific, multi-layer/wafer level packaging designs for smart cards.

Acronym	Run time	Short description
SmartPack	2005–2007	Development of new packaging and die-stacking technologies for future smart card applications
WALPACK	2004–2007	The project aims at developing a packaging process at the wafer level, targeting on improved connectivity, higher reliability, lower costs, manufacturability and compact components for applications such as smart cards, system in package for automotive, mobile handset, optical network hubs.

Table 28 Project examples of EURIPIDES

Both projects have participants along the value chain of RFID applications, with a clear overweight of French and German project partners.

EUREKA's "bottom-up" and umbrella projects

There are a number of RFID-related projects to be found in the EUREKA project files:

Acronym	Run time	Short description
METATEC	2006–2009	The project is devoted to the development and application of meta materials in a new generation of high-performance, compact and cost effective RF and microwave modules for modern broadband wireless systems and RF identification.
FERROXTAG	2006–2007	Design and development of RFID transponder with the capability of identifying pharmaceutical products with metallic packaging in logistic stores
TIRAL	2005–2007	Development of very cheap RFID antennas. The principle is that a plastic film will be coated with a material that prevents the metal from sticking to the substrate in vacuum deposition. Coated in pre-designed shapes, we obtain kilometre-long rolls.
RFID UHF Encoder	2004–2006	To expand the market with an UHF reader geared towards industrial logistic solutions and compatible with the latest computer chip technology.
RF-DAT	2003–2005	Radio frequency technologies are used for contactless reading and writing of information in labels. The aim is to substantially improve the capacity of systems in this domain by research and development in reader and antenna technologies.
DELTA	1998–2001	The aim is to develop a radio-frequency system composed of a label form factor RF read-write tag and tag reader. Delta technology will support item level distribution and logistics through very low-cost, disposable RF tags.
ARTSAFE	2001–2006	The system is built around an RFID-device that is useful for protection of high value objects, data collection and communication as well as personal protection and monitoring in buildings like airports, offices and manufacturing areas
TRAPOLO	1999–2001	Development of a low frequency, RFID, battery-less tag/transponder, computer, radio communication, odometer/tachometer and satellite technology to enhance future train positioning/ operation; improve user accessibility of public info services
HISS	2005–2006	Innovative site security solution with localisation of people and objects simultaneously. Based on smart card, access control and surveillance elements integrated with an expert supervision system
Wireless-PSMS	In preparation	Development of a wireless patient site monitoring system for the prevention of incorrect medical treatment of patients through medical error checking.

Table 29 Project examples of EUREKA

Conclusions

Generally speaking, EUREKA is a bottom-up, low overhead programme and as such quite successful in stimulating trans-national R&D. Although there is no specific RFID-centric cluster within EUREKA, the existing cluster programmes EURIPDES and MEDEA could function as a home base for the microelectronics and systems integration aspects of RFID.

The main drawback is the reliance on national funds for financing, and the necessity of alignment of sometimes very differing national funding rules to start a project. One step to overcome this problem is the EUROSTARS programme, co- financed by the EU and requiring earmarked funds from the participating countries. EUROSTARS could, in the future, support RFID projects with SMEs as main participants.

Strengths	**Weaknesses**
Bottom up, low overhead programme line; EUREKA cluster MEDEA potential candidate for RFID–related microelectronics R&D; Cluster Euripides suitable environment for smart systems integration	Financing depends on national funds; Little alignment between countries, rarely earmarked funds for EUREKA
Opportunities	**Threats**
First step into Art 169 cooperative programmes via EUROSTARS can support RFID focus for research performing SMEs	Danger that EUREKA programmes, especially clusters, will lose out in the competition for national money from the new EU programme initiatives (e.g. JTI)

Table 30 SWOT analysis EUREKA

Country	EUREKA	Smartpack	WALPACK	METATEC	FERROXTAG	TIRAL	RFID UHF Encoder	RF-DAT	DELTA	ARTSAFE	TRAPOLO	HISS	Wireless PSMS
Application fields	A. Logistical Tracking & Tracing												
	B. Production, Monitoring and Maintenance												
	C. Product Safety, Quality and Information												
	D. Access Control and Tracking & Tracing of Individuals												
	E. Loyalty, Membership and Payment												
	F. eHealth Care												
	G. Sport Leisure and Household												
	H. Public Services												
Project focus	1. Tag/Reader technology												
	2. Systems aspects												
	3. Business model/ROI												
	4. Privacy/Data security												

Table 31 Project mapping on the extended RFID Reference Model EUREKA

3.1.4.3 Transnational programmes with joint national and EU funding

Interreg III

Some programmes funded by the EU to stimulate and support regional cooperation and development may create infrastructure for specific regional technology focus.

An example related to RFID is Regins, a regional framework operation project within the Interreg IIIc programme, focuses on cluster management and knowledge transfer to regional SMEs. Its thematic priorities are automotive, logistics and biotechnology.

Within this newly created infrastructure, the subproject REGINS-RFID (www.regins.org/en/content/project_sheet_reginsrfid.pdf) has been defined, with participants from Germany, Hungary, Austria and Italy, focusing on the promotion of RFID, an analysis of the current status, a development of guidelines for implementation, and especially on the needs of SMEs.

3.1.5 European programmes

The Framework Programme

Programmes we analysed	Number of dedicated RFID programme lines we found	Number of RFID-related projects we analysed	Total volume of RFID-related R&D support (Mio €)
FP5+6	none	20	168

At the EU RFID Conference "Heading for the Future" (Brussels, October 16, 2006), the DG for Information Society and Media published a concise overview of the RFID portfolio of European research (cf. Fig. 2) and a shortlist of RFID-related projects from FP4 to FP6 (cf. Fig. 3).

Two graphs taken from the overview give an interesting analysis of the distribution of those projects among research domains and among RFID application areas:

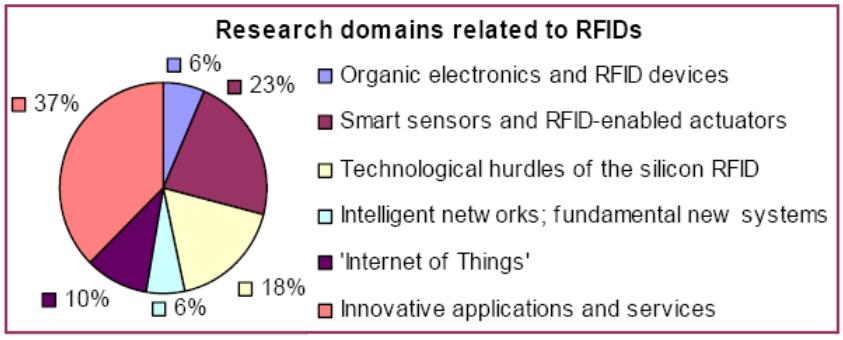

Figure 2 **Overview of research domains related to RFID**

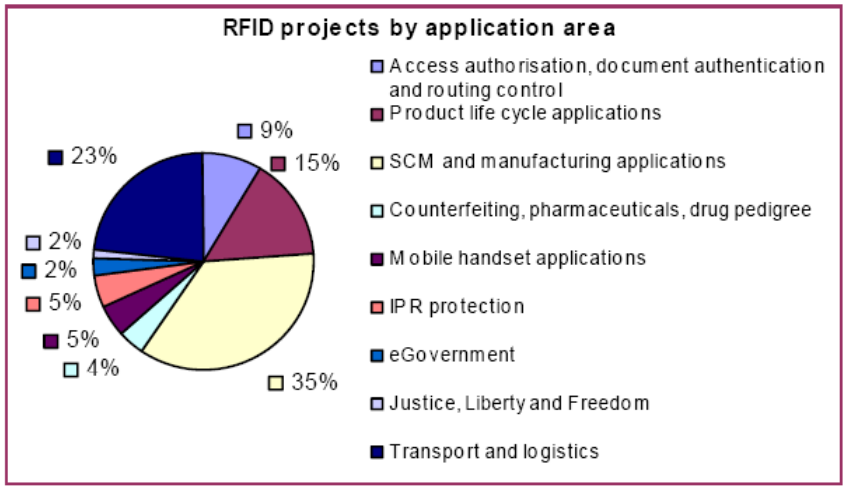

Figure 3 **Overview of application areas in European programmes**

An interesting first conclusion is the relatively large share of innovative applications and services (37 % of the Research domains) and the overweight of the SCM, manufacturing and logistics applications (close to 60 % of the application areas).

On the other hand, the total cumulative project budget of all RFID-related projects (312 m €) and EU subsidy level (153 m €) is a relatively small share of the total FP6/FP5 budget.

In view of the present importance attributed to RFID as European core technology, there is surprisingly little coherence between the projects and its consortia. We did not find past initiatives to form R&D competences base involving companies in the specific field.

In the run up for FP7 this clearly has been recognised: the creation of ETPs (European Technology Platform), bringing together the key stakeholders in a specific domain, allows the bottom-up definition of a Strategic Research Agenda (SRA), which in turn provides input for the FP7 programme.

Implementation of such an SRA can in principle be done through collaborative R&D in FP7 or other resources, a possibility that has been applied to RFID to some extent via the SRA of EPOSS.

As a short-term measure, a number of currently running FP 6 RFID-projects are currently organised into a strategic project cluster (CERP: Cluster of European RFID projects), with the explicit aim to coordinate research activities and establish synergies between the projects. Although this initiative seems to have been a temporary ad-hoc measure to answer criticism of RFID-related

framework projects (especially concerning a lack of coherence between project goals and their consortia), it certainly is a positive development.

Another more generic criticism concerns the relatively high administrative overhead for the framework projects, plus a rather low hit rate (probability of being accepted). Whether this has been addressed in FP7 remains to be seen.

Conclusions

Compared to the earlier Framework Programmes, FP 7 clearly gives more weight to the view and priorities of industry. Assuming that the numerous discussions on RFID-related topics will translate into focused themes and topics, RFID and its technology base will play a more prominent role in the project portfolio.

The question how to cluster (and make accessible) the RFID-related competence generated in those programmes remains an open issue.

Strengths	**Weaknesses**
Truly European, transnational, with central financing; Lately some large size "lighthouse" projects that span the whole value chain (example: Bridge)	Little coherence between RFID-related projects; Main focus of FP6 projects is on RFID technology, little focus on vividly discussed issues like privacy and data security
Opportunities	**Threats**
Use ETP structure to create focus for RFID technology and applications; Explore use of other (than FP 7) European programmes to support the adoption and acceptance of RFID (example: the competitiveness & Innovation programme)	No substantial threat given

Table 32 SWOT analysis of the European programmes

Country	EU projects: FP6	AMI-4-SME	BRIDGE	COBIs	DYNAMITE	Indisputable key	PRIME	PROMISE	SMART	SMMART	SToLPaN	SToP	TraSer	MIMOSA	MINAMI	OPTAG	PAPBDIS PROMISE	POLYAPPLY	Traceability of livestock	U-2010
Application fields	A. Logistical Tracking & Tracing		■			■			■				■							
	B. Production, Monitoring and Maintenance	■		■	■					■							■			
	C. Product Safety, Quality and Information							■				■							■	
	D. Access Control and Tracking & Tracing of Individuals															■			■	■
	E. Loyalty, Membership and Payment										■									
	F. eHealth Care														■					
	G. Sport Leisure and Household													■	■					
	H. Public Services																			
Project focus	1. Tag/Reader technology		■	■										■				■		
	2. Systems aspects	■	■	■	■	■			■	■	■	■	■	■		■	■		■	■
	3. Business model/ROI	■	■					■			■	■	■							
	4. Privacy/Data security						■								■					

Table 33 Project mapping on the RFID Reference Model EU projects: FP6

Country	EU projects: FP5	GROCER	LAUREL	MAMA	MYGROCER	PALOMAR	PARCELCALL	RFID-PACK	TRITON
Application fields	A. Logistical Tracking & Tracing	■				■	■	■	
	B. Production, Monitoring and Maintenance		■	■					■
	C. Product Safety, Quality and Information			■	■				
	D. Access Control and Tracking & Tracing of Individuals								
	E. Loyalty, Membership and Payment								
	F. eHealth Care								
	G. Sport Leisure and Household								
	H. Public Services								
Project focus	1. Tag/Reader technology		■	■		■		■	
	2. Systems aspects	■	■	■	■	■	■		■
	3. Business model/ROI				■				
	4. Privacy/Data security				■				

Table 34 Project mapping on the RFID Reference Model EU projects: FP5

3.1.6 Conclusions of RFID R&D Funding Programme Assessment

3.1.6.1 Thematic focus of funded programmes

Although it is sometimes difficult to obtain detailed information on the content of subsidy programmes (especially on a national level, due to confidentiality issues in some countries), we found some general trends as to where the different programme lines focus on.

National programme lines and especially those not based on thematic calls, but on bottom-up project proposal systems, tend to support programmes closer to market introduction, dealing with topics like robustness, reliability and cost. This trend is even stronger when the project consortia are located in a regional cluster and represent companies along the value chain, as in a number of French PdC (Pôles de Compétitivité) projects.

Thematic calls usually focus on novel systems' aspects and device innovations required for their implementation.

The past EU framework programmes show a similar trend: from a technological point of view, the majority of RFID-related projects concentrate on system innovation and to a lesser extent on device technology.

For this analysis of the EU project portfolio, a time period from early 2000 to early 2007 was considered, and it was discovered that earlier projects tend to have a higher technological content, while more recent projects concentrate more on novel system solutions and their application to advanced business processes, including studies and development of business cases.

Generally speaking, only few programmes explicitly focus on privacy issues (only two projects dealing with privacy were found), while the issue of data security is a topic in several others. This is all the more surprising, as this does not reflect the current discussions and to some degree the controversy around RFID and privacy concerns.

When looking at different national R&D programmes there are only a few dedicated to RFID explicitly. Two examples (which are described in more detail in this report under their respective titles) are the Impulse programme in Austria that orients towards SMEs, and the call "Microsystems Technology for Smart Label Applications in Logistics" within the Micro Systems Technology programme of the German Ministry of Education and Research.

In general, programme dedication to RFID and/or to topics related to the use of this technology seem to reflect the importance a national R&D policy gives to this technology and the role the respective national industry wants to play in the European economy.

3.1.6.2 Funding structures

The level and type of support varies between the countries we identified as key countries for RFID in our analysis:

Germany and France are in the lead concerning direct subsidies to companies, and subsidise almost exclusively cooperative programmes. The UK and Italy do not (or rarely) subsidise industrial company R&D directly; their support to RFID runs with the aid of programmes in publicly financed universities and research institutions, which in turn cooperate with companies. The same seems to be true for the Netherlands; although in the past there were specific arrangements with large Dutch companies which most likely also covered RFID-related R&D.

Direct single company R&D projects receive support in Austria and Finland, but due to privacy agreements only very restricted access to project information was available.

The status of RFID-related R&D in the new European Member States is difficult to analyse. There is no evidence for national programme lines in the Czech Republic, Slovakia and Hungary. Some companies, however, from these countries participate in EUREKA and EU projects with an RFID focus.

National R&D policy will focus on improving the position of national players. However, the success of RFID in many applications e.g. in the field of supply chain management and logistics needs a transnational/European approach. We found one example of regional cooperation of national funding bodies (NORDITE) supporting amongst others, transnational RFID R&D, an example which is worth further studying.

Apparently due to the restrictions of the existing state aid rules (in their original more restrictive formulation) most programmes and projects do not go beyond technology demonstrators and prototypes; in practice, a considerable development effort still has to be made to come to a functioning and economically feasible system; and in our judgment this is still 'pre-competitive' and highly innovative. In two countries (Netherlands and UK) initial discussions and ideas were found on side of government agencies about how to bet-

ter close the gap between development and validation. In Finland a partly publicly funded agency was founded to close this gap.

Looking at the French example, supporting regional clusters (and the recent ideas to make those clusters transnational) seems to be a formula for success to promote cooperation and networking along the value chain of innovation topics. This also applies to RFID technology.

Within those clusters RFID can be seen as one of the thematic areas, and in the example of the two PdCs in France, RFID projects labelled by the cluster are eligible for national funding. The real strong point of this system is the availability of earmarked funds for cluster projects (and thus for RFID-related topics, if those are focal themes in the clusters themselves).

Many of the RFID projects we found are cooperation between large companies and SMEs and many of them also with participation of public research institutions (one exception is a programme exclusively reserved for SMEs). On the other hand, there is an obvious tendency in many countries to favour SMEs in public funding schemes. From our point of view, part of the success for SMEs lies in cooperation with larger companies e.g. by improving market access etc. Therefore the public programmes should not discourage the participation of large companies in subsidised R&D projects. As there are many successful small and medium-sized companies in the RFID field, this applies all the more for this technological area.

The issue of creating a central RFID competence repository, either national or European, has not been addressed in the past, but is discussed in various ways by national authorities and industry alike. In most scenarios research institutions will play an important role, but the model of public-private partnerships for the development and validation of generic use cases will need further attention.

Concerning RFID within the EU framework programmes, there is little coherence between projects and project consortia. There even seems to be a certain overlap between project topics and goals. Given the Europe-wide focus on RFID, some kind of clustering would be beneficial. The strategic cluster CERP is a short- term means to address this point. One of the more strategic actions to support RFID would be the support for ETPs with a clear RFID technology and application focus.

3.1.6.3 Analysis of current subsidy programmes in the RFID Reference Model context

As previously explained, the RFID Reference Model has been used for this analysis to allow project themes to be highlighted, so that areas where little research is being carried out can be identified. In this section we try to answer the following questions:

- Is there a clear trend in the application focus of supported RFID R&D projects?
- To what extent do the national and European subsidy programmes address the bottlenecks identified in Chapter 6?

For this analysis, we map the project to the RFID Reference Model with an extension relating to the project focus:

- focus on the tag and reader technology
- focus on systems and application aspects
- focus on business case
- focus on data security and privacy issues

As it has been stated previously, the access to specific project information on national level was rather difficult, so our database, as given in the project mappings on the extended RFID Reference Model, is based purely on the information available. However, we can distinguish some indicative trends.

As to the application focus, the majority of the projects fall into the RFID Reference Model categories 'logistics, tracking and tracing', 'production, monitoring and maintenance', and 'product safety, quality and information'. This is not surprising and correlates well with the relatively large number of practical use cases in today's available RFID applications.

The project mapping on our bottleneck criteria allows drawing the following conclusions:

- A tag/reader technology focus is well represented in national subsidy projects and EUREKA bottom-up projects. Looking more closely at the project descriptions (to the extent available), the focus is frequently on added functionality (sensor integration) and achieving lower costs via novel technologies (e.g. printing).
- The system aspects' focus matches the tag/reader focus in national programmes and dominates the EU projects. Local/geographical clusters (e.g. France) seem to favour a system approach.
- Generally speaking, the business case focus is underrepresented. In most projects in our survey it is treated just as one of many topics. There are very few projects with a sole focus on the question of how to achieve a conclusive business case model.

- Privacy and data security: only a few projects, and mostly with a focus on "privacy by design" or data security in complex networks. Only two FP 6 projects focused exclusively on privacy (PRIME and MINAMI).

From the analysis, it has been determined that the last two points, concerning establishing business cases and privacy and security, will need most attention in the near future, as it has been found that these are two major bottlenecks which prevent the development of RFID.

4 Conclusions

4.1 Recommendation for a future European R&D policy

4.1.1 Introduction

Regarding recommendations in the field of RFID it is important to be aware of the phase the technology and its applications are in: in major areas it has left the realm of basic and applied research and is on its way into the market.

So in terms of Schumpeter's view on research and innovation RFID and related technologies are already in the innovation phase, that means that R&D policy support for RFID should create the right environment and boundary conditions to make it a successful innovation (i.e. let it create value and allow its proponents to make money with it).

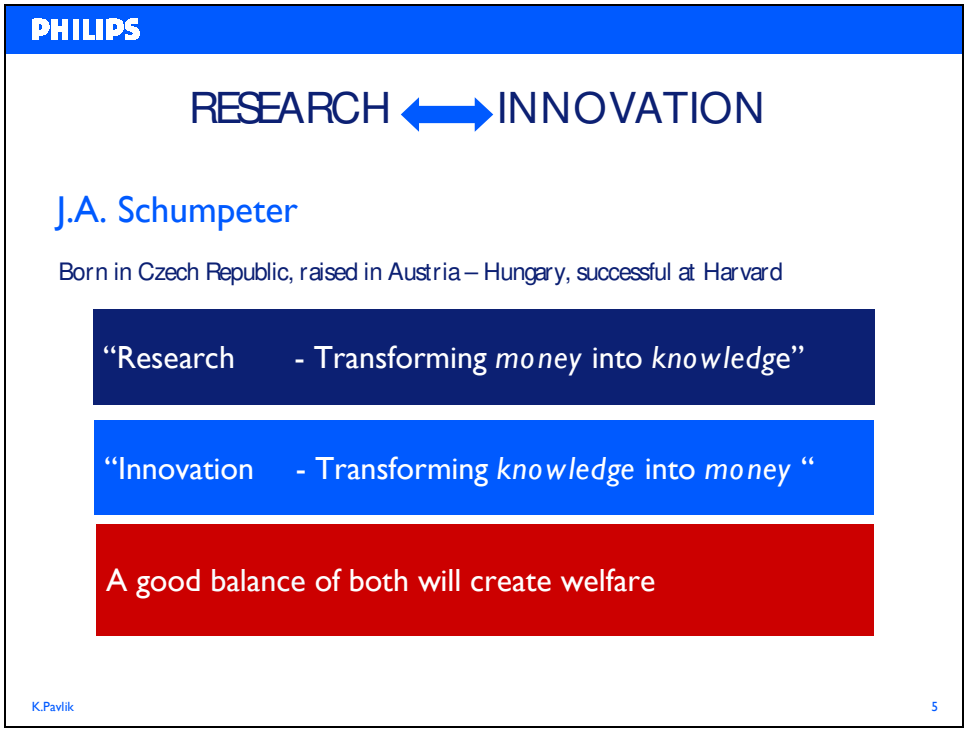

Figure 4 Schumpeter's view on research and innovation

On the other hand, there is a consensus, and not only within the academic research environment, that we have barely scratched the surface of what is possible with this technology, that there is an incredibly broad range of poten-

tial applications, which also means there are great technological challenges and open research issues to keep applied research busy for the coming years.

From a vantage point, this situation can be best described by what has been coined the open innovation environment, where research, application development, prototyping and market introduction not only co-exist, but exhibit intensive interrelations promoting quick transition from research to application, rapid and effective testing of novel ideas, and backflow of market and application experience to research.

So an effective R&D policy in support of RFID should create the right environment for such an open innovation scenario.

Concerning technological themes and topics for R&D programmes there are two areas to be considered:

RFID technology requires a solid understanding of many disciplines, from information technology to signal processing, semiconductor technology, materials technology, RF antennas, privacy/security aspects etc.

First, partly due to the rapid growth in specific application areas of RFID, there is an apparent lack of consistent methodologies, support tools and simulation and compliance test tools and methods. Application-specific developments lack a solid scientific basis; repairing this deficiency should be part of the thematic focus of R&D programmes, as this is a major stumbling block for rapid and cost-effective market introduction.

Second, RFID technology requires a solid understanding of many disciplines, from information technology to signal processing, semiconductor technology, materials technology, RF antennas, privacy and security aspects etc. Programmes focusing on advanced aspects of those technologies and their cross disciplinary aspects will be the basis for the successful development of advanced and novel RFID applications in the future.

Finally, a European RFID R&D policy can help to increase public acceptance of this technology and its applications by linking support for RFID (both in research and application development) to its contribution to solutions for major societal problems, e.g. in the fields of healthcare, security, or environmental management, and by underscoring the importance of privacy by sponsoring additional specific (and not exclusively technology-oriented) programmes.

4.1.2 Specific proposals and recommendations

4.1.2.1 Recommendation 1: Create and support an open innovation environment

An open innovation environment is characterised by:

- Close cooperation and frequently co-location of research institutions, large companies and SMEs.
- Rapid flow of ideas up- and downstream the R&D chain: Successful innovation requires interaction and iteration.
- Concurrent activities in research, development, prototyping and market testing activities.

In such a setting it is rather difficult (and very counterproductive) to differentiate between programmes according to the state aid classification as to maximum permissible aid.

Recent developments in the state aid issue show clear improvement over the older, more restrictive rules. Examples are: the relaxation of rules concerning the classification of academic participation in joint projects as state aid, and the inclusion of prototyping in the activities eligible for funding.

To make such a cooperation successful, it needs critical mass of academic and company R&D personnel, a trusted environment as to IPR issues, and stable rules of cooperation, including funding and financing for medium to long-term. We therefore think that all measures that enable and support industry-academia cooperation are of paramount importance to create this open innovation environment.

Judging from experience of companies in regional cluster programmes, geographical proximity of partners is beneficial, as successful regional and cross-border innovation clusters show.

Generally speaking, clusters prove to be a very effective innovation environment. One of the reasons certainly lies in the fact that clusters are formed by bottom-up initiatives of research institutions and regional companies and/or companies with the same or complementary business interests, common technology and market vision. This is often more effective than top-down definitions in thematic calls, which stimulate more or less ad-hoc interest groups for a limited time period.

Therefore, we would recommend that the EU support the creation of regional/ transnational clusters to enable an open innovation environment

- by means of not discriminating specific partners (e.g. large companies) by excluding them from the participation beforehand in certain (funded) programmes. The cooperation between large companies (with their market knowledge and market access) and SMEs with their flexibility and focused innovativeness in prospect is a precondition for successful R&D projects. One the one hand, SMEs are needed for the quick developments of innovation technologies and new business models. On the other hand, most often only large companies provide the financial capability for the implementation of long-term research strategies due to economies-of-scale effects. Moreover, large companies are better suited to gain a critical mass of users or customers in an economically justifiable period of time (network effects). These arguments hold true especially for the case of RFID: The reduction of RFID tag costs is mainly the result of large technology providers like NXP and Hitachi. Large users like METRO or the Department of Defence have stimulated the market in a way not achievable for smaller organisations;

- by defining programmes dealing with the creation and operation of a European research infrastructure in a way to solicit and increase the participation of industry. This up to now was not the case with the Research Infrastructures part of the Framework programmes; integrating Industries private research infrastructure in such an open Innovation setting certainly will be beneficial for both industrial and academic research;

- by means of allowing/encouraging national support for regional cluster formation, e.g. by national support for infrastructural measures such as jointly owned and operated application testing facilities.

4.1.2.2 Recommendation 2: Support Europe-wide deployment

Our analysis has shown that the particular focus, emphasis, or support concerning RFID technology and application differ widely across Europe. New member states and CEE countries seem to lag behind, especially in pre-competitive applied R&D programmes.

On the other hand, in order to reap the benefits of this technology, we need Europe-wide balanced introduction in many areas (e.g. public transport; international logistics/SCM applications, public security, healthcare etc.).

The current Framework Programme (FP7) most likely will not close this gap alone, in spite of the fact that companies and research institutions from CEE countries do participate in framework projects.

Europe should check which instruments in its R&D and Innovation policy portfolio are best suited to stimulate regional participation in this development.

One of the likely candidates amongst the EU programmes for that endeavour is the Competitiveness and Innovation Framework programme (CIP) (CIP 2007), more specifically the ICT Policy Support (ICT PSP) part of the programme.

Therefore, we would recommend that the EU investigates the application of the CIP/ICT PSP toolset to promote the uptake of RFID technology and applications in areas and services of public interest within the CEE region and new Member State countries. By these means, competence and awareness for this technology should increase in local companies and institutions. This will also help to bridge the culture and language gap with local CEE SMEs and support their integration and participation in transnational programmes.

4.1.2.3 Recommendation 3: Balanced support for R&D themes and topics

In this recommendation, we want to address two distinct points. One refers to the content i.e. which topics should be supported (the "what") and the second point refers to the way How support should be given to be most efficient (the "how").

The content part

Recently a number of studies and papers have appeared presenting amongst other points an inventory of R&D topics that Europe's industry, academia and government authorities should focus on.

We, as part of this work package, and in parallel to our analysis of the European RFID subsidy programme scene, generated a list of potential R&D topics, starting from a technological bottleneck analysis of work package 1. This overview is contained in Appendix 1.

We do not want to discuss detailed R&D items in the context of this recommendation but we will point out that there is a general agreement on R&D theme clusters, which will need further attention. It should be stressed that although the R&D funding agencies currently favour mid- to long-term re-

search programmes, short-term research projects must also be supported in order to efficiently further RFID development.

Please be aware that the term "short-term" does not imply that the topic is of passing interest or importance and has little relevance in the long term. By saying "short-term" we want to indicate that the issue is of high urgency, work is needed now to clear immediate make-or- break bottlenecks. We will illustrate our recommendations by giving some typical examples:

A) Points to be addressed in the short/medium-term

Short-term

There are several recommendations which fall into the tag/reader technology cluster. Initially, it is recommended that there should be focus on solving shortcomings of present (UHF) implementations, such as improving operational reliability under difficult environmental conditions (heat, metal or liquid environment). Focus on improving readout ranges is also recommended besides providing solutions for false positive readouts and the multi-reader environment issue etc.

All of this should be carried out in a predictive, not case-by-case optimisation/trial and error approach, which implies more research in RF and antenna design, predictive modelling and emulation studies and similar issues, which might receive less attention in comparison to long-term programme points.

Short / medium-term

In the tag/reader technology field, it is recommended to focus on low cost via IC design breakthroughs in the short-term, mass production technologies for antenna/label manufacture, integration of the tag function into the packaging, and (medium-term) novel (non-silicon) technologies for the integral tag function. Attention must also be paid to developing low power consumption for tags to further improve readout range and allow passive tags where the energy for added functionality is taken from the electromagnetic field of the reader. Added functionality, such as integration of sensors (temperature, pressure etc.) or addition of bi-stable displays is also an area which should be researched.

Further research into system design is also required, such as developing system integration possibilities by standardising interfaces to system middleware and the standardisation of application layers. System and software architectures which will allow the transformation of data collected from smart tagged objects to business- relevant data should also be developed.

The question about already existing business cases and positive ROI for all partners in the value chain as an important motivation to adopt the technology appears in most studies. The lack of validated experience and accessible data, especially for SMEs, is addressed frequently. Typical suggestions relate to specific SME-focused programmes in "Centres of Excellence", similar to the public-private partnership initiative in Finland, to support them by developing their specific use cases and R&D on simple, low cost, open source systems to lower the investment and start-up cost barrier for SMEs.

Another Research field that should be tackled on shorter notice is the area of privacy and security. Further research into privacy by design, such as data encryption, access rights management and reliable deactivation methods, is required. As said before, privacy is not a technology – only a topic, but adequate technology is a necessary prerequisite.

Research also needs to be directed towards studying the impact of RFID implementation on European citizens, and guidelines should be developed for the industry. Information and communication strategies should also be developed to facilitate a positive and proactive approach towards RFID.

B) The long-term vision part

RFID as a whole is a very complex system technology requiring inputs from many technology fields (information technology, electrical engineering, signal processing and communications, data security etc.) Therefore it will benefit from general advances in those areas.

The common focus for of applied research in this area has to come from technology roadmaps on the one hand (e.g. as proposed and demonstrated in Work Package 1), and from proposals for new applications with their specific requirements profile on the other hand.

We can expect that most topics given in appendix 1 under the headings "RFID application-specific topics" and "System and networks" will have to be addressed.

This requires a holistic approach. Bilateral/multilateral projects of limited duration, while essential to progress, selected chapters of technology and applications, cannot be the only means.

How should this be achieved? (The process/programme part)

Generally speaking, the long-term vision part reasonably matches the focus on advanced technologies and systems of the current FP 7 programme. One

of the drawbacks of FP 7 projects is certainly the one-time nature and the lack of cohesion between projects around similar topics.

Temporary clusters such as the Cluster of European RFID Projects (CERP) are a step in the right direction, but a more permanent setting is desirable.

It is therefore recommended to create a permanent project cluster covering all European programme lines as this would be a step in the right direction.

Additionally, we would recommend using the model of European technology platforms and their strategic research agenda to come to a structured and lasting focus on RFID-related technologies and their applications.

Two existing ETPs explicitly address (aspect of) RFID:

- EPOSS from the smart systems integration point of view
- ARTEMIS in its strategic research agenda on seamless connectivity and middleware.

These ETPs can provide a solid basis to turn long-term strategic RFID topics into joint R&D programmes, addressing available national and European funding possibilities.

On top of the thematic match, ARTEMIS addresses also the topic of innovation eco systems as one of the core enablers for its SRA, using existing regional clusters to build Centres of Excellence.

In addition to this, the declared focus on the involvement of SMEs comes very close to address core points of the "how to" wish list of RFID.

Looking at the short-/medium-term technology and system issues, some of these topics might appear to be straightforward product design and implementation issues, and thus not really eligible for sustained funding support (or at the lowest possible level specified in the new state aid rules).

In reality, major advances in those fields are needed urgently, requiring close cooperation of companies and research institutions, to shorten the presently lengthy and extremely costly "trial and error" design process and give quick and reliable answers as to the validity of business cases in new implementations.

A partly answer to the privacy concerns will come from studies and projects in the "privacy by design" area which is a very important topic in the short-term research portfolio.

Therefore, we would recommend that future R&D efforts shall also target these short- to medium-term topics, in order to make them eligible for public support i.e. national or by the EU.

The problem of not having a central competence repository accessible for all players in the value chain needs a specific approach:

We recommend that national or European authorities will (co-)finance application labs (in form of public-private partnerships) in order to support testing, validation and certification of technologies and concepts, and to generate relevant information relating to business case issue.

In some countries, organisations covering parts of the scope outlined above have either been created or are in the planning stage; supporting these to meet the wider scope and giving them an "official" status, could give a head start in this direction.

Such institutions can have an added benefit related to public acceptance of RFID technologies in daily life by giving conclusive answers to the privacy concern:

These institutions can provide compliance checks of technical and systems solutions against agreed standards and thus act as an impartial and independent authority.

4.1.2.4 Recommendation 4: Support "go to market" of novel applications

European initiatives in supporting R&D and innovation mostly deal with the "supply side" of innovation i.e. creating and supporting R&D infrastructures and generating technological competence but rarely deal with the "demand side" for those innovations. If, for various reasons, there is little demand for new products and processes, there is little interest in investing in the input side.

In this recommendation we intentionally take a broader approach on the issue of "R&D policy": in our opinion, any measure that stimulates industry's R&D spending on technologies and applications of economic and societal relevance, be it co-financing of projects, establishment of a responsive research infrastructure, or creating a favourable application environment, is an integral part of policy in support of R&D. This approach is in line with the core of the recommendations of the so-called Aho Report [14] (Creating an innovative Europe), and the so-called Wilkinson Report [15] (Public Procurement for Re-

search and Innovation), stating amongst other topics the need for Europe to provide an innovation-friendly market for its businesses, with actions on regulation, standards and public "procurement for innovation" ([14], [15]).

RFID may serve as a typical example: As mentioned above, new RFID applications with their specific requirements may spur research and technological advances in various areas of general importance to Europe's innovation drive. On the other hand, given the lengthy process from idea to market introduction, and lack of incentives due to highly fragmented national markets and their regulations, private companies may be reluctant to take the initiative and the cost and risk burden.

A typical example in the context of RFID is tagging of pharmaceuticals and medications in hospitals. On the upside, this would prevent counterfeiting and reduce the risk of wrong dosage and medication. However, presently the national diversity in regulations in that area makes widespread adoption of this RFID application a major business risk for all players involved. As a side effect for the European industry, not to invest into this novel application would mean losing out in technological areas related to such applications.

Here, European initiatives could help; clear recommendations on European and national level, comparable to the US FDA recommendation ("combating counterfeiting drugs") will support decisions of companies to invest in this area. Opening up public procurement for new technologies and thus not only looking at lowest price or no risk is another way of promoting novel RFID-related technologies. The tremendous success of passport applications, which is basically a windfall profit from enhanced security requirements worldwide, is a perfect example of public initiatives driving technology development.

Therefore, we would recommend that Europe takes the initiative to promote RFID applications in areas of societal importance e.g. drug authentication, efficient logistics and transport, automotive industry, or transnational use of eGovernment techniques by supporting the application of RFID–based solutions. State procurement should open up for novel, potentially risky solutions to foster technology development and application areas where RFID technology can provide the answers. In a recent communication to the European Parliament the European Commission has already outlined such an approach, by discussing the ground rules for the so-called "pre-commercial procurement", the procurement of R&D services on a non-exclusive and competitive basis to shorten the time-to- market of new and promising technologies [16]. This policy should be put into practice in general and be applied to RFID specifically.

5 References

[1] Maghiros I., Rotter P., van Lieshout, M. (ed.): RFID Technologies: Emerging Issues, Challenges and Policy Options. Institute for Prospective Technological Studies, Luxembourg: Office for Official Publications of the European Communities 2007

[2] Van de Voort M., Ligvoet, A.: Towards an RFID policy for Europe, Workshop Report, Prepared for the European Commission, Directorate General Information Society and Media, DRR- 4046-EC, 2007

[3] Buckley J. (ed.): Conference Report: From RFID to the Internet of Things, Pervasive Networked Systems. Brussels: CCAB 2006

[4] STOA European Parliament Scientific Technology Options Assessment: RFID and Identity Management in Everyday Life. IPOL /A/STOA/2006-22, 2006

[5] SEC (2007)312: Radio Frequency Identification (RFID) in Europe: steps towards a policy framework. Communication from the Commission to the European Parliament, 2007

[6] Bundesministerium für Wirtschaft und Technologie: European Policy Outlook RFID. Berlin 2007 [Federal Ministry for Economics and Technology]

[7] Bovenschulte M., Gabriel P., Gassner K., Seidel U. (2007) RFID: Prospectives for Germany. The state of radio frequency identification-based applications and their outlook in national and international markets. Bundesministerium für Wirtschaft und Technologie: Berlin 2007 [Federal Ministry of Economics and Technology]

[8] Bundesministerium für Bildung und Forschung: Jahresbericht 2005 Rahmenprogrammem Mikrosysteme. Berlin 2005 [Federal Ministry of Education and Research]

[9] Dissertation no. 3182: The impact of Auto-ID technology on process performance – RFID in the FMCG supply chain, Universität St. Gallen

[10] Bundesministerium für Bildung und Forschung: IKT 2020, Forschung für Innovationen. Berlin 2007 [Federal Ministry of Education and Research]

[11] Bundesministerium für Bildung und Forschung: Framework Programmem 2004–2009 Mikrosysteme. Berlin 2004 [German Federal Ministry of Education and Research]

[12] Bundesamt für Sicherheit in der Informationstechnik: Risiken und Chancen des Einsatzes von RFID-Systemen. Bonn 2005 [German Federal Office for Information Security]

[13] Article 29 Data Protection Working Party (2005) Working document on data protection issues related to RFID technology, 10107/05/EN WP 105. January 19, 2005

[14] Aho E. (ed.): Creating an Innovative Europe. Report of the Independent Expert Group on R&D and Innovation appointed and following the Hampton Court Summit and chaired by Mr. Esko Aho. EUR 22005, Luxembourg, January 2006:European Communities

[15] Wilkinson R. (ed.): Public Procurement for Research and Innovation. Developing procurement practices favourable to R&D and innovation. Expert Group Report EUR 21793 EN, European Commission: Luxembourg, January 2006

[16] COM(2007) 799 final: Pre-commercial Procurement: Driving innovation to ensure sustainable high quality public services in Europe. Example of a possible approach for procuring R&D services applying risk-benefit sharing at market conditions, i.e. pre-commercial procurement. Commission staff working document

6 Appendices

The classification of the RFID Reference Model and the classification of the RFID Stakeholder Model are provided as appendices.

6.1 Appendix 1: RFID R&D topics

This part of the document is the result of joint activities of WP 1 (input: focusing on technology bottlenecks for the implementation of RFID) and WP2 (list of potential RFID research topics collected from project partners and additional contributors).

These two input streams were used in a joint workshop with work package representatives and additional contributors, condensed into a draft document, which in turn was validated in bilateral discussions with selected representatives of research institutions (who were not available for the workshop in first place).

The complete list is given below:

6.1.1 RFID transponder technology

6.1.1.1 General tag topics

The following topics apply to all types of tag technology.

Environmentally independent tags

Adverse environmental conditions (e.g. liquids, metal) usually detune the tag antenna or coil which results in a significant reduction of the reading range if not a breakdown of the tag communication. Although some concepts exist on the market to cope with such situations (on-metal-tags, on-liquid-tags), there is still room for improvements for all RFID tag types (passive, semi-active, active, LF, HF, UHF). Simultaneously, inter-tag interference due to small tag-to-tag distance should be reduced as much as possible to provide high tag densities for item tagging (e.g. garments).

There are samples already, but not perfect; so-called universal tags (wide band) are more tolerant to detuning by the environment. Or: metal backing on the tag, but these are very expensive.

Ultra low power tag ICs

In order to improve reading range and reliability the development of new ultra low power designs for RFID tag circuits is desirable. Nano power technologies, intelligent power management, "system on chip" are the main drivers in this effort.

Increased reading reliability

An ongoing user demand still is an identification rate near 100 % of the tag population. This is an important requirement for all multi-tag RFID systems (LF, HF, UHF).

Robustness

One of the advantages of RFID technology is that it does not require line-of-sight to the reader and it can operate in harsh environments (humid, cold, warm, dusty).

There is room for research and development for systems that can cope with even harsher environments (e.g. read/write systems for low (<-40°C) or high temperatures (>200°C)).

Packaging and mounting

Develop new and more cost-effective concepts for the integration of RFID tags into packaging. New mounting and connection technologies help to improve tag reliability and durability.

Modular RFID manufacturing platform

A common modular technological platform enables the mass production of tags at very low cost. This also includes materials science, production technology (reel to reel), printing of components etc.

Low cost tag technology

As part of the modular manufacturing topic, the main focus is on printing of passive components, reel to reel production technology etc.

Tag integrated with product/packaging (no separate carrier)

Development of technologies like transfer moulding of IC+ RF antenna into plastic boxes, direct printing of antennas on flexible substrates (textiles etc.), using the product as a substrate.

Improvement of test coverage

Functional tests should be developed, that allow a conclusive correlation between the test results in near field with behaviour in the far field (normal operating mode).

Combination of EAS (Electronic Article Surveillance/ anti theft) and RFID functionality

Investigate whether there is a possibility (and is it a reasonable alternative) to integrate this functionality into one device / through integration of both functionalities into RFID chip?

6.1.1.2 Passive tags

Passive RFID tags use the energy of the magnetic (LF) or electromagnetic (UHF) field provided by the reader to generate the backscatter modulation (tag to reader) as well as to supply the whole tag circuitry.

Passive crypto tags

For mass applications that require security functions, sophisticated crypto engines have to be developed and integrated into passive tags. Since these engines also must be supplied (powered) by the magnetic or electromagnetic field of the reader, there is a trade-off between complexity of the crypto engine and the achievable reading range.

Nano power sensors

New Concepts of sensors with very low power consumption can be combined with passive RFID tags ("system on chip", monolithic integration of the sensor into the chip) in order to provide sensor functionality without additional energy source. Since the sensor will be supplied from the tag's power source (magnetic or electromagnetic field) the reading range of the sensor tag will drop.

No power sensors

This is an extension of the nano power approach to "no power" sensors, e.g. via bistable effects, that can be read via the RFID reader.

Printable electronics

One way to yet easier mass production and therefore cost reduction is to use new non-silicon based technologies like polymer (organic) electronics and reel-to-reel manufacturing procedures. The antenna can be printed and possibly integrated into the packaging with a simple printing process (similar to bar

codes).The circuitry can also be printed for thin, flexible, low cost and high volume applications

Environmentally compatible tags

For many applications where huge numbers of tags are used (item tagging) but where the tags cannot be re-used, environmentally compatible or neutral RFID tags (including antenna material) are needed in order to avoid electronic waste. The introduction of non-toxic electronics (e.g. polymer) may help to achieve that.

Multi-band tags

For some RFID standards there is no common worldwide frequency allocation (e.g. UHF; 868MHz in EU, 915MHz in USA, 960MHz in Asia). For worldwide logistics applications the tags must be designed to operate in all allocated frequency bands (multi-band tags). A tag antenna that is optimised for 868MHz has very low performance on 960MHz and vice versa. The reading range drops down radically when the tag is used on the wrong frequency. There are some tags on the market that use a compromising broadband approach that achieves reduced reading ranges on edge frequencies.

New technologies might improve the reading ranges and performance over all allocated frequency bands (multi-band, multi-port, multi-antenna).

This is one of the major business challenges.

A possible alternative are multi-antenna tags with multimode IC, covering both HF and UHF.

Combined near field / far field UHF tags

Appropriate design of a combined Near Field/Far Field tag antenna will give an UHF tag HF-like properties in Near Field, will lead to just one infrastructure; this will require a reader with a specific near field antenna.

Tags with display

Tags with visual displays (e.g. bistable nano power displays) show some tag data to the user without the need of a reader (e.g. temperature, itinerary, manipulation attempts, etc.).

6.1.1.3 Semi-passive (battery assisted) tags

Semi-passive RFID tags use the energy of the magnetic (LF) or electromagnetic (UHF) field provided by the reader to generate the backscatter modula-

tion (tag-to-reader) only. The rest of the tag circuitry (decoder, encoder, state-machine, memory) will be supplied by an auxiliary energy source (battery). The achievable reading ranges are higher than with passive tags but lower than with active tags.

Tags with alternative energy sources

Energy scavenging technologies that convert energy out of physical energy sources (e.g. temperature difference, pressure, vibration, light, magnetic field, electromagnetic field) may help to replace conventional batteries. The obtainable amount of energy from these sources usually is rather small but may suffice to increase reading range on ID-only tags or to supply additional hardware on semi-passive tags.

New battery concepts

New battery technologies (e.g. polymer, fuel-cell) can be combined with semi-passive RFID tags in order to increase functionality or battery lifetime.

Example: power paper -> paper battery

6.1.1.4 Active tags

Active RFID tags actively generate RF energy for the response communication (tag-to-reader). They use an auxiliary energy source (battery) to supply all parts of the RFID tag (receiver, transmitter, decoder, encoder, modulator, state-machine, memory). Due to the active generation of RF energy active RFID tags reach significantly higher reading ranges. Active tags can easily be combined with additional functions (e.g. sensors) that need an auxiliary energy source anyway.

Due to more complex circuitry and battery usage, active tags are significantly more expensive than semi-passive or passive tags.

Specific R&D topics in this context are:

Tags with additional functionality

The auxiliary energy source of active tags can be dimensioned for supporting additional hardware.

Sensors of physical parameters

Besides the ID functionality the tag supplies an integrated sensor and responds to the physical sensor value via RFID communication link on the reader. This concerns physical parameters like temperature, pressure, humid-

ity, strain, brightness, chemical substances (gas, liquid, biological), vibration, etc.

Data processing, decision making, intelligence, storage ("thinking tags")

The additional energy may be used to support micro-controller functions like simple data processing, decisions out of processing steps or intelligent storage management (e.g. for flash memory).

Application example: a tag that tunes itself to the systems frequency (for multi band applications).

Data communication

Since active tags commonly use full RF transceiver chips they are able to establish additional communication links apart from the RFID link.

This would require a MCP, and optimally a monolithic/singe chip integration of e.g. BT, FM and RFID functionality. Such integrations are a topic in the communications industry, RFID up to now has not yet been considered.

Networking functions

Active tags can use their increased communication capabilities to connect to networks or to build networks (e.g. with other tags, mesh network). Smart tag networking, inter-tag communication (ad-hoc) and in general wireless (sensor) networks may be established. Such networks help to achieve higher reading rates (time and completeness) and/or higher reading ranges (multi-hop reads). RFID tag systems may interoperate with other networks (e.g. low power sensor networks based on ZigBee technology).

Miniaturisation

Current active tags often use conventional components. There is still room for further miniaturisation that might be required for some applications.

Nano power sensors

New concepts of sensors with very low power consumption can be combined with active RFID tags in order to increase battery lifetime or the number of measurements per time period.

New battery concepts

New battery technologies (e.g. polymer, fuel-cell) can be combined with active RFID tags in order to increase functionality or battery lifetime.

Nano power wake-up receivers

On active-tags that receive and transmit RF signals, the tag has to be woken up by the reader or the tag wakes up itself periodically. A significant part of energy has to be used for the wake-up process. Most RF chips available on the market support the general reception mode only. There is no very low power wake-up mode.

The development of a special receiving mode (nano power wake-up) together with high sensitivity will help to increase battery lifetime explicitly or to decrease volume and cost of the battery.

6.1.2 RFID interrogator (reader) technology

Multi-frequency, multi-standard readers

There is a demand for multi-frequency, multi-standard readers for some applications. Readers that may operate on several LF, HF and UHF standards simultaneously may recognise many kinds of RFID tags (ISO, EPCGlobal).

(Low-cost) mini and micro readers

The ongoing miniaturisation of communication devices in general raises a demand for RFID readers or reader modules in mini or even micro format (e.g. CompactFlash, SD-Card, MiniSD-Card format). E.g. the integration into mobile phones will surely increase the usage and acceptance of RFID technology.

New intelligent reader concepts will not only reduce the size but also the cost of the readers to enable large-scale integration in small communication devices.

Low-cost stationary readers

Besides the mini and micro RFID reader modules there is also a demand for less expensive stationary RFID systems. In order to achieve better coverage e.g. at gate systems multi antenna and multi reader arrangements might improve identification up to 100 %. Standardised reader interfaces will help to further reduce total system costs.

Reader-to-reader communication

In order to provide higher reader densities (coverage) and better reader interoperability, the readers must be synchronised. New procedures and standards must be developed and introduced to reach this goal.

Reader networks may help to increase reading rates (time and completeness), reading ranges and to support intertag communication, adaptive reading scenarios, etc.

More effective anti-collision protocols

In some applications a big number of tags within reach of the reader must be identified completely in a short period of time. An anti-collision technology is used to be able to address each tag individually.

New anti-collision protocols might improve multi-tag reading reliability (completeness) as well as reduce reading time (fast reading).

Increased reading reliability

Tag identification rates near 100 % also require some improvements on the reader side (e.g. by additional signal processing of backscatter signals).

Defined reading range in UHF in the far field,

e.g. by changing the lobes of the field, using specific antenna arrays, subtopic: ranging, to avoid false positive reads.

6.1.3 RFID system technology

Higher frequencies

The current number of RFID systems and standards on higher frequencies (≥ 2.45 GHz) is very small. On the other hand there is a growing demand for smaller antennas, compact handheld readers and modules as well as enhanced positioning resolution for localisation systems. The usage of higher frequencies is one key answer to these demands (e.g. 5.8 GHz is a withdrawn ISO standard proposal, problems due to other emitters, such as BT or dig TV.

Ultra-wideband (UWB)

Another interesting approach for low (nano) power communication with high band width efficiency is ultra-wideband technology. These properties might be used to introduce new RFID systems that require high data rates together with moderate reading ranges.

Real-time localisation and tracking

Localisation is one add-on capability to RFID systems. Some applications do not only require the exchange of the ID number and some data of a tag, they also need the absolute or relative position of the RFID tag. Although there are some active RFID systems with this functionality on the market there is plenty

of room for improvements in terms of positioning resolution, maximum tracking speed, reading reliability, passive RFID, etc.

High data rates

The more functionality we pack into the IC, the more Info has to be transmitted; although today the requirements come primarily from e-Government this also will be an issue for logistics.

New modulation formats Investigation on new modulation formats for passive backscatter, higher order modulation possibilities and their impact on higher data rates and increased read out range.

Improved system integration

System enhancements and the introduction of new technologies should include all interfaces of the RFID system to middleware systems. In order to provide second source capability, easy replacement and cost reduction, these interfaces should be standardised.

Plug and play infrastructure

Technology developments such as RF self tuning antennas, adaptive filters and signal processing depending on the environment can contribute to an automatic adaptation of the RFID system to actual environmental conditions.

Increased interference immunity

Many RFID systems can easily be interfered with simple jamming devices or other RF equipment that use the same frequency allocation. Such devices might be operated even legally in some countries. There is a need to identify such problems and plead in banning these devices or to develop techniques to easily detect such devices or turn them ineffective.

This is an extremely important topic, as there are no really satisfactory solutions in sight. This will also need regulatory measures.

Possibility: reader with built in identification of sources of interference that can "warn the system" and block erroneous read outs.

Modelling and simulation

Today modelling and simulation SW and Systems are very slow and expensive, results quite unreliable.

We would like to model the entire application (analogue, digital, mixed signal).

6.1.4 RFID application-specific R&D topics (SW / system aspects)

The real-time-enterprise

The potentials for efficient logistics and manufacturing practices are improved by RFID technology. Just-in-time philosophy minimises stock times and costs.

RFID helps to monitor and control the manufacturing process. Product quality and production safety is improved. Widely accepted standards support business to business communication (information exchange between enterprises).

Standardisation of application layers

There are some standards world widely accepted that define the air interfaces and data representation of RFID systems. Although there are some application focussed standards as well, there still is a need for other application layer standards that are widely used.

Traffic security and safety aspects

Smart systems may improve security and safety (e.g. traffic safety: car to car, car to road signs communication).

Pairing objects

Pairing applications range from "smart refills" (e.g. toner or ink cartridges) for printers and fax machines, tools for kitchen machines, brush heads for electronic toothbrushes, types of motor oil or fuel for car engines, etc. The idea is to match disposable or refill parts with consumer electronic devices with the help of RFID technology. The electronic device accepts only parts that are designed for the device and may adapt its settings according to the part.

Some of these applications need coordination or standardisation work in order to provide a cost-effective service across many companies and countries.

Improving of medication compliance

An intelligent pharmaceutical packaging (IPP) can be developed with the help of RFID technology. Each time a pill is taken from the blister pack, an electric conductor is physically broken. A time stamp is recorded when the pill was taken from the package. The pharmacist or the doctor may read the time stamps with a special reader and monitor the medication compliance of the patient.

Supporting blind people

RFID technology might help to track people and give them better orientation.

Another application is a "smart glove": An RFID reader integrated into a glove helps to identify RFID tagged items (e.g. via acoustical messages).

6.1.5 Systems & networks

Internet of things

The idea of the "Internet of Things" tries to combine RFID technology with techniques of the Internet. The Object Naming Service (ONS) e.g. uses the Domain Name System (DNS) of the Internet in order to provide links to further information about a tag's ID number. This service is pushed by one big RFID user organisation (GS1, EPCglobal) and is currently limited to EPCglobal RFID tags. In order to build a real "Internet of Things" this principle should be extended to many other RFID systems as well.

6.1.6 Socio-economic studies

There is a strong need to complement the research on certain fields of RFID technology by socio economic studies which deal with matters like new RFID application areas besides logistics like health care or ambient intelligence, technology acceptance, privacy, environmental aspects, and economic effects. These studies should provide recommendations for public institutions, companies, and NGOs how to cope with the impacts of RFID technology.

Trust and acceptance

Research into the issue how to improve the acceptance and willingness of the consumer to adopt RFID, how to remove perceived barriers to RFID introduction.

6.1.7 Environmental aspects

Environmentally compatible tags

In order to avoid electronic waste, non reusable tags should consist of non toxic materials (active components, substrate material etc)

6.1.8 Privacy / data security topics

Data security, privacy by design

Many present and future RFID applications require securing of data transfer and data storage on the RFID tag.

Research and development is needed in order to effectively prevent tag cloning, compromising (private) data, eavesdropping, man-in-the-middle attacks, etc.

Some techniques like secure authentication, secure authorisation and data encryption use cryptographic procedures. Tags with integrated crypto engines exist merely for HF RFID (13.56 MHz). Most of them use proprietary symmetrical cryptography. There is a need to expand these technologies to other bands (LF, UHF) as well. The introduction of energy efficient asymmetrical encryption will help to ease key deployment and key management.