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Radio Frequency Identification (RFID) Systems

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1 Comments on this Briefing Note

We welcome any comments or views on this Briefing Note. Comments may be submitted using the questionnaire in Annex 1 of this document and these should be sent to:

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to arrive on or before Friday 3rd September, 2004.

Comments will be reviewed by ComReg when carrying any out further work on issues covered in this Briefing Note. In submitting comments, respondents are requested to reference the relevant section of this document. Responses will be available for inspection by the public on request. Where elements of any response are deemed confidential, these should be clearly identified and placed in a separate annex to the main document.

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2 Executive Summary

One of ComReg's key roles is to encourage innovation in the Irish telecommunications industry. The Forward Looking Programme (FLP) is used to help achieve this aim by making people aware of various technology developments and trends in the ICT sector. This goal is primarily achieved through the release of Briefing Notes. These are documents that typically cover technical topics for non-technical people, although some basic background knowledge of communications technology would be helpful.

This briefing note is on the topic of radio frequency identification (RFID) systems. RFID systems can be considered as a new generation of bar-code technologies that enable information, such as identification codes, to be accessed over the air without the need of direct contact or a direct line-of-sight. Additionally, data can be stored on advanced RFID tags themselves. RFID systems can be applied to enhance business efficiency in many different situations, from automated consumer checkouts in supermarkets to pay-by-weight waste management systems. However, it is likely that over the next couple of years the majority of RFID applications will be in areas away from point-of-sale retailing. Many RFID system deployments are likely to be in 'back-office' and warehousing applications (e.g. logistics, inventory management). The widespread application of RFID technology could provide significant opportunities in the telecommunications industry as some RFID systems will create large volumes of data which will need to be transported, managed and integrated with existing IT systems.

RFID technology has existed in a commercial form since the 1960's[1] and is already installed in many systems that we are familiar with (e.g. access to buildings, automobile immobilizer keys, automatic payments on toll roads, and tags for cats, dogs and livestock). However, recent technology developments in RFID manufacturing processes are bringing us to the point where low cost RFID technology can be extended to far more applications, potentially generating large amounts of data and corresponding telecommunications traffic. Currently the most important issues relating to RFID technology are global standardisation, privacy concerns and the cost of RFID tags and systems. These issues are covered in this briefing note.

This document introduces RFID technologies and identifies some of their many potential applications. Market and regulatory issues, particularly relating to the global harmonisation of frequency spectrum for RFID systems to operate, are outlined. At ComReg we would be pleased to see the emergence of innovative new telecommunications products and services in Ireland to take advantage of the opportunities that RFID systems create.

[1] Electronic Article Surveillance (EAS) technology to counter theft, developed by Checkpoint and Sensormatic.

3 Introduction

Access to up-to-date ('real-time') information on individual items such as consumer goods, equipment and tools, or component parts in a manufacturing assembly, can be used to increase efficiency in a number of different business and personal applications. Information such as current location, temperature and history (e.g. when were they produced), could all be used to help people find the right item at the right time. Radio frequency identification (RFID) systems use electronic tags on items that can be queried for information about their status and history without the need to make direct contact with them. Wireless technology enables RFID tags attached to items to be accessed remotely from distances of a few centimetres to up to tens of metres, depending on the type of system (see Section 5). This gives significant improvements over standard bar-code technology, which RFID is often considered as a replacement.

RFID technology is being applied in warehouses, supermarkets, manufacturing plants, automatic toll systems, hospitals, libraries and many other areas where a large number of items need to be identified and handled. RFID systems can potentially save costs anywhere where inventory and stock control are important processes, i.e. anywhere where increased granularity of inventory is important. The use of RFID in a business environment can potentially bring about the following key benefits:

RFID can increase/improve:	**RFID can reduce:**
Supply chain performance	Inventory levels (lower costs)
Visibility – by keeping shelves re-stocked	Labour costs (individual checking of items)
Responsiveness to market demands	Risk of theft
The range of products in stock[2]	

Table 1: Benefits of RFID technology

Such systems can also help to improve efficiency in point-of-sale applications enabling automated, and cashless, check-out systems (e.g. E-Z Pass). See Section 4 for details of RFID applications.

3.1 How RFID Works

A RFID tag consisting of a computer chip and a radio antenna are attached to an item such as a package (see Figure 1 below). Information stored on the tag, most commonly a unique identification number (e.g. an Electronic Product Code (EPC)), can then be read remotely by a RFID reader device (e.g. from a few metres away). The reader device can then find out other details about the package by looking up the identification number in a database (e.g. its contents, outstanding tasks relating to it). Multiple devices can be scanned simultaneously greatly reducing the time needed to locate items and update records. These tags can be combined with sensors (e.g.

[2] Since efficient RFID systems will make more warehouse space available.

temperature sensors on food or medical packages) to provide readers with more information about an item than a simple identification code.

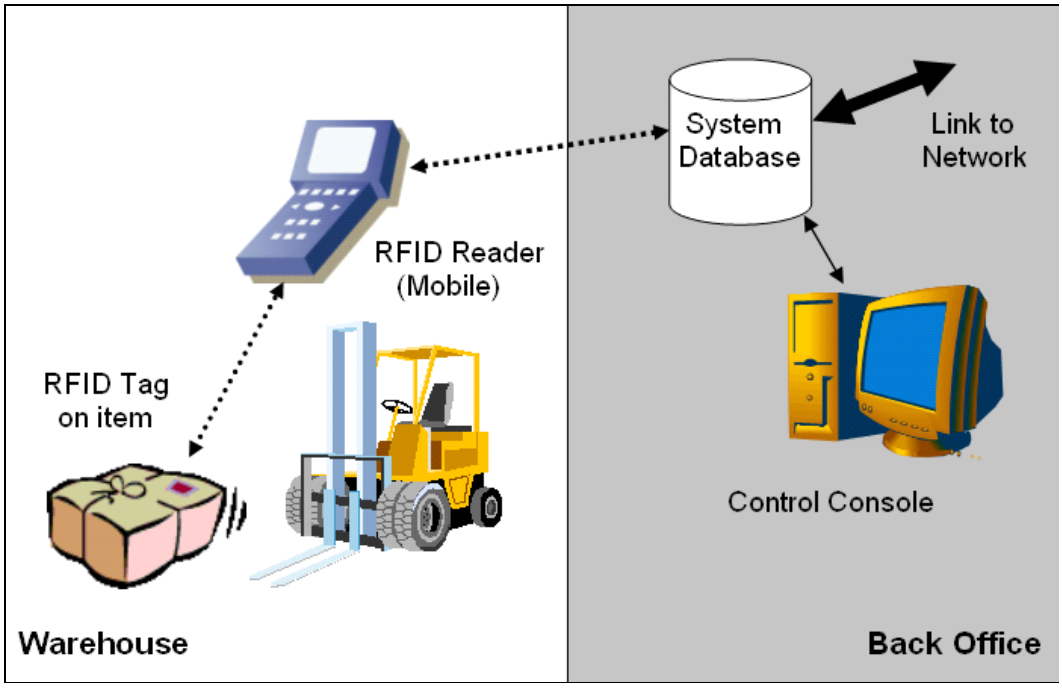

Figure 1. A RFID system.

It is expected that as RFID systems become more common and are integrated with other RFID and IT systems, they will have an impact on telecommunications markets. The aggregation of RFID data from a single location could produce significant amounts of telecommunications traffic if it needs to be distributed to other locations (e.g. thousands of tags in a truck's cargo could pass by a reader producing hundreds of kilo-bits of data per second, from a single reader device).

4 Applications

RFID technology can be applied to a wide range of different applications which can be broadly categorised into; Asset Management and Logistics, Inventory Management, Automated Transactions, and Identification and Security applications. A company may implement a RFID solution to cover more than one of these main categories so applications are described below according to the general situation or environment that RFID is being applied.

4.1 Supermarkets

Some of the most publicised applications of RFID systems are in the supermarket and retail segments. Although it is likely that the widespread adoption of point-of-sale and shelf re-stocking functions is expected in the medium term, supermarket and other retail outlets potentially have much to gain by introducing RFID to their store-room and inventory management systems (See Section 3 Table 1). Point-of-sale applications would enable supermarkets to eliminate check-out queues, since a customer's bill could be automatically calculated from the RFID tags located in their shopping basket/trolley.

The US supermarket chain Wal-Mart has embraced RFID technology by insisting that its top 100 suppliers adopt RFID technology by January 2005[3]. The level of RFID integration will involve pallets and cases only (i.e. not individual products), and is predicted to save Wal-Mart between $1.3 billion and $1.5 billion annually. Supermarket chains in Europe have also committed to, or began to test RFID systems, e.g. Metro (Germany), Tesco, Marks and Spencer[4].

Being able to trace the history of food and drink products is becoming increasingly important (e.g. new European regulations will require all food producers to do this from next year[5]). RFID tagging can offer a solution to this problem enabling information about a particular product to be continuously available.

4.2 Pharmaceuticals

RFID technology can be used for the purposes of preventing counterfeit drugs and drug theft through the use of RFID tags on packaging. RFID systems can also be useful in other cases where specific environmental conditions are necessary for storing drugs (e.g. correct temperature, expiry date). RFID tags are expected to be introduced on cases/pallets of pharmaceutical products by 2005 (see Section 4.1 – Wal-Mart case). Tagging of individual items may still be several years away, with item level shelf stocking applications possibly available by 2009[6].

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[3] Wal-Mart recently expanded this requirement to its top 300 suppliers by 2006. Walmart has conducted initial tests in April 2004, in stores in Texas

[4] Marks & Spencer trialled RFID technology on 3.5 million produce delivery trays and is now trialling the technology on clothing (where Marks and Spencer only stock their own brand goods). http://www2.marksandspencer.com/thecompany/mediacentre/pressreleases/2002/com2002-11-14-00.shtml , http://www2.marksandspencer.com/thecompany/mediacentre/pressreleases/2004/com2004-01-30-00.shtml

[5] http://europa.eu.int/comm/food/food/labellingnutrition/foodlabelling/comm_legisl_en.htm , http://www.fsai.ie/

[6] http://istresults.cordis.lu//index.cfm?section=news&tpl=article&ID=65315 . In the UK PA Consulting Group is running a pilot project with a number of top pharmaceutical companies (source – FT, May 2004, "Tags lined up to combat counterfeit drug trade". http://www.paconsulting.com/industries/life_sciences_pharmaceutical_consulting/insights/entry_product_authentication.htm

4.3 Libraries

Libraries are seen as a key early application of RFID inventory management technology. RFID systems could be used to generally increase efficiency in library administration. Features such as self-check-out of books can be implemented with RFID. Complete RFID solutions for library systems are available from companies such as: 3M, Bibliotheca, Checkpoint Systems, Libramation, VTLS. The Vatican library recently adopted a RFID system to manage items in its public reading rooms[7].

4.4 Medical Applications

RFID tagging can be applied to numerous applications in healthcare environments. From systems that help hospital staff to keep track of medical equipment (e.g. lifting equipment and trolleys) to tagging individual patients to ensure their identity. Advanced RFID systems, possibly in conjunction with other wireless technologies such as Wi-Fi, could enable a patient's medical records to be stored on a tag or smart card so that medical staff could easily retrieve and add information to individual records[8]. RFID is also being considered to help ensure that blood supplies selected for transfusions are delivered to the correct patients.

4.5 Automatic Transactions

RFID tags can be used as a method of automated payment for goods, and access to services such as public transport. Early examples of commercial RFID systems were in this area for the automatic collection of toll-road payments (the first system was introduced in Norway in 1987). The E-Z Pass system is now implemented in many countries[9]. Such systems work by issuing users with a RFID tag (fixed to their vehicle) which identifies them as they pass by RFID readers located at toll-plazas. Pre-registered users' accounts can then be automatically debited. Such systems can reduce the cost of operating toll-plazas and eliminate the build up of traffic queues. This idea has since been extended to include public transport initiatives in some countries (e.g. Oyster Card in London[10]). RFID Ski passes are another current application (e.g. Les Portes du Soleil, Swiss/French Alps). RFID technology (tags and readers) can also be integrated with mobile handsets so that end users can use their mobile phones to gain access to buildings or public transport. Other applications include posters with active tags that transmit information about the item being advertised (e.g. linking the mobile phone to an internet site selling the advertised item) – See Section 5.3.3 on Near Field Communications (NFC).

RFID technology can similarly be used to enable consumers purchase goods without using cash in what is known as proximity payment. The use of RFID systems in this way can help combat retail fraud as they link individuals to purchased items, recording both the time and point of sale. Credit card companies have shown an interest in this application of RFID technology (e.g. PayPass from MasterCard[11]).

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[7] http://www.theregister.co.uk/2004/07/09/vatican_library_rfid/

[8] http://www.rfidjournal.com/article/articleview/961/1/1/

[9] In Ireland the 'Easy Pass' system is available through National Toll Roads – www.easypass.ie

[10] http://www.oystercard.com/

[11] http://www.paypass.com/

Another automated transaction application being developed by a company in Limerick (AMCS[12]) applies RFID technology in the area of refuse collection. This system uses a combination of RFID tags on customers refuse bins and RFID readers on weighing scales incorporated in the refuse collection vehicle's lifting machinery to bill customers on a pay-by-weight basis.

4.6 Security, Personal Identification, and Health and Safety

An important application of RFID technology is to make items more secure from theft. This can be in the case of luxury or high value retail goods and valuable equipment or other stock. A fuel company in South Africa implemented a RFID system to prevent fuel theft by connecting RFID tags to fuel-truck nozzles[13]. Automobile immobilizer systems are an early example of RFID theft prevention. Other security applications include tagging suspect luggage in airport baggage handling areas so that it can be located again for closer scrutiny (e.g. explosive detection). This type of system has been implemented in the US by the Jacksonville Airport Authority[14]. Other wireless data applications to improve baggage handling efficiency and quality are being initiated in various airports (e.g. Delta airlines[15]).

RFID tags have been proposed for use in personal identification systems such as passports (e.g. to be trialled by the US Department of State[16]). RFID systems can be used to help monitor children in public places (e.g. supermarket crèches, Lego-land in Denmark). A trial project in Japan is using RFID tags in primary school children's school-bags to help monitor their locations[17]. Similarly, RFID identification systems can be applied to live stock for tracking, and disease control. Other systems to track household pets are also widely available (e.g. Identitrack Limited[18]). For health and safety purposes machinery could be RFID enabled to detect tags in the required safety equipment (e.g. gloves, helmets, etc) before it would function.

4.7 Other Inventory Management Examples

Some further inventory management applications are listed below:

Airbus (France – aircraft manufacturer) is using SAP (Germany) enterprise software solution to integrate RFID asset management[19]. Philips and IBM formed a partnership in March 04, where IBM Global is to build a RFID system for Philips Semiconductors manufacturing and distribution facilities in Taiwan and Hong Kong.

RFID tags can be attached to individual items when they are taken in by a dry-cleaning business to help them manage all items. In other cases tags attached to

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[12] http://www.amcs.ie

[13] Source – C. Nuttall, "Industries tune in to a new frequency", FT, May 2004

[14] Modern Materials Handling, "Ready to fly [radio frequency identification system]', vol.58, no.3, Page:40-1, Cahners Publishing, March 2003.

[15] http://zdnet.com.com/2100-1105_2-5254118.html

[16] http://www.nwfusion.com/newsletters/dir/2004/0524id2.html

[17] http://www.theregister.co.uk/2004/07/09/japanese_tag_schoolkids/

[18] http://www.identitrack.co.uk/petidsystem.htm

[19] Boeing has announced similar plans: http://www.rfidjournal.com/article/articleview/985/1/1/

clothing could give ‘smart’ RFID equipped washing machines instructions on how to treat the item[20].

RFID technology could be implemented in postal systems to help track the delivery of parcels[21].

[20] e.g. Merloni: http://www.rfidjournal.com/article/view/369/1/1

[21] http://www.rfidjournal.com/article/view/951

5 RFID Technology

The technology behind RFID systems, which can be considered a combination of wireless communications and radar systems, was initially conceived as early as the 1940's[22], with basic commercial products emerging in the 1960's[23].

5.1 RFID system elements

A RFID system consists of RFID tags, RFID reader devices and an IT system (see Section 3.1 Figure 1).

5.1.1 RFID Tags

RFID tags are attached to individual items so that they can communicate back into the RFID systems through the RFID readers. RFID computer chips typically consist of memory, some signal processing and an integrated antenna. The computer chips used are typically less than 1/3 mm wide and can be encased in plastic[24]; enabling them to be stuck onto an item. Other RFID tags can be fabricated from conductive inks and can be printed directly onto packaging. Tag memory sizes generally range from 64 bytes to a few kilo bytes. Tags are used to store unique identification details such as an Electronic Product Code (EPC)[25], which is a 96 bit unique identifier[26]. Some RFID systems involve a 'travelling database', i.e. not just ID and location, and such systems could record shipping information and other item history on RFID tags for example[27]. Tags can be read only, write once-read many times, and read write depending on their complexity (see Section 5.3.2).

5.1.2 RFID Reader Devices

Reader devices are used to collect data from RFID tags in their proximity. A reader typically consists of an antenna and a controller. Some devices are known as interrogators and have the ability to read and write tag memory. Reader devices must be able to distinguish between different tags to avoid confusion and special anti-collision algorithms are used to ensure data integrity (this can be a problem in some RFID environments)[28]. Readers can be handheld mobile devices or fixed devices (e.g. at a toll-plaza).

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[22] H. Stockman, "Communication by Means of Reflected Power," *Proc. IRE*, October 1948, pp. 1196-1204.

[23] Basic anti-theft technology: Electronic Article Surveillance (EAS).

[24] A semiconductor technology known as 'flip-chip' is typically used for RFID tags as this allows for more simple connection of the chip to the other elements of the tag.

[25] In Ireland 'EAN Ireland' control bar code information.

[26] This is an extension of EAN (European Article Numbering /UPC (Universal Product Code) barcode standards. See also EAN Ireland (http://www.ean.ie), and e.centre (http://www.e-centre.org.uk), for more information on barcode numbering and RFID standards.

[27] This type of system is sometimes known as a '2D' system or a Class 2 system, compared to a simple ID tag. Class 0 tags have their information written to them by the tag manufacturer and Class 1 tags can be written to by the user applying the technology.

[28] For more details on how RFID readers and Tags communicate see Annex 2.

5.1.3 RFID IT System

An IT system, typically consisting of an inventory database, is needed to store and collate data from RFID readers so that it can be used in a meaningful way to increase business efficiency. Such an IT system would typically be integrated with a larger company IT system (see Section 5.5 below).

5.2 RFID Characteristics

RFID systems have typical ranges between 2.5cm to 30metres, depending on the frequency band and type of tag used. Longer range systems typically require powered tags (see Section 5.3.2 below). RFID is a contact-less non-line-of-sight technology, which means that it can be operated in cluttered, dirty, and wet environments that would be unsuitable for existing bar-code technology. RFID readers have the ability to read a large number of tags in a short space of time which is necessary when scanning an entire container of items. As RFID systems use electromagnetic radiation to function, they could be susceptible to radio interference from unauthorised users[29].

5.3 Types of RFID Technology

5.3.1 Frequency Bands

Different types of RFID systems operate using different parts of the radio frequency spectrum. These frequencies typically range from 30 kHz to 2.5 GHz. The following frequencies are commonly used: 125 kHz, 13.56 MHz, 2.45 GHz. The introduction of UHF[30] services in the 860MHz band in Europe is currently under review by the CEPT[31] Electronic Communications Committee (ECC)[32]. These UHF frequencies are important for emerging RFID systems, and although not fully harmonised internationally they will enable the development of RFID tags that can work in different regions. In the US frequencies in the 900MHz band are also used for RFID, but cannot be used in Europe due to GSM mobile systems. Unlike standard radio communications systems, longer range RFID systems are associated with higher frequencies. This is because it is impractical to place the large antennas necessary for standard radio communication at low frequencies on useable RFID tags. Low frequency systems operate on a slightly different principle that involves the devices magnetically coupling together[33]. Low frequencies are generally considered to be 30 kHz to 500 kHz, and have short transmission ranges (i.e. less than two metres). High frequencies are considered to be 850 MHz to 2.5GHz, with longer ranges (i.e. up to 30 metres). International harmonisation of frequencies will be a key factor in the success of RFID systems (see Section 6.4).

5.3.2 Active and Passive Systems

Depending on their function and the environment that they are to operate in, RFID tags can be active or passive. Passive tags are simpler than active tags and are less expensive. They do not require batteries as they harvest their power from energy

[29] Static noise from nylon conveyer belts can also cause problems for some RFID solutions.

[30] Ultra High Frequency

[31] European Conference of Postal and Telecommunications Administrations (CEPT)

[32] ERC Recommendation 70-03 Annex 11 deals with RFID and is currently under public consultation. http://www.ero.dk

[33] This is done using inductive loop antennas.

emitted from the reader devices (see Annex 2 for a description of this process known as radar backscatter)[34]. Typically passive tags are read only, whereas active tags are read-write and have longer ranges. These tags often require battery power sources to provide sufficient energy for longer range transmission (at higher frequencies), to perform read and write operations and carry out some simple data processing.

5.3.3 Other Systems

Other devices related to RFID systems that operate over wider ranges in some cases forming mesh networks are sometimes known as sensor networks or Remote Intelligent Communications (RIC). Zigbee is the commercial name for one such technology with potential applications in remote sensing networks (e.g. environmental sensors). Zigbee is standardised under the IEEE as 802.15.4. For further information on Zigbee see ComReg Briefing Note on add-hoc and mesh networks[35].

Near-field communications (NFC) is a type of RFID that involves the incorporation of RFID tags and readers into end user devices such as mobile phones. Nokia, Philips and Sony are among the companies developing this technology, and commercial products are expected by the end of 2004. NFC technology is being developed for the 13.56 MHz band[36]. Data rates of 106 kbit/s and 212 kbit/s are expected, with up to 424 kbit/s planned for dedicated NFC devices. NFC systems can be used to help simplify connection and management of multiple different devices for end users. A typical application might use NFC to set up communications between two devices to use a higher speed system such as WiFi by simply holding the two devices close to one another. Other applications include point-of-sale cashless transactions and interactive advertisement (i.e. interactive billboards). In such cases a user would place their NFC equipped device (e.g. mobile phone) near to the NFC enabled device they wish to communicate with (e.g. a shop check-out, an interactive advertisement sign) initiating the transfer of data.

RFID is also closely related to smart card technologies which allow personal information such as pre-paid credit details to be stored and deducted from a credit card sized device. WiFi technology can also be adapted to perform RFID type functions.

5.4 Technology Developments

Some low cost RFID type technologies have emerged to meet current consumer needs. For example, printed RFID technology from Power Paper[37] incorporates a flexible battery and antenna. These tags can be applied to almost any surface and are tolerant of tears, holes and folds. CrossID[38] is developing a RFID technology that uses chemicals. Certain particles can be printed to form a RFID tag which gives off a distinct RF signature when exposed to a signal from a RFID reader. This technology is being developed in the 3-10 GHz range.

Embedded Electromagnetic Identification (EMID) tags are embedded within a material or package (e.g. pharmaceutical blister packaging). This is achieved by

[34] Less than 10uWatts of power is typically required.

[35] http://www.comreg.ie/_fileupload/publications/ComReg03110.pdf

[36] NFC is related to the following standards: ISO 18092 & 14443A, ECMA 340, ETSI TS 102 190.

[37] http://www.powerpaper.com Based on Motorola's BiStatix technology, uses Flip-chip direct die attachment.

[38] http://www.ponsholdings.com/CrossID/index.htm

embedding magnetic materials with particular spatial separations that can be uniquely detected by magnetic readers. This type of technology is typically more resilient to gamma ray sterilization, freezing, boiling, and microwave heating, than many other RFID technologies, which is necessary in some applications.

The term 'Mote'[39] is used for devices that are placed along with goods for tracking. This idea is being extended to tiny devices (currently 2mm x 2.5mm) known as 'smart dust'. This technology is being developed by Crossbow[40], and devices are expected to cost $0.30. Smart dust technologies are related to sensor networks (see Section 5.3.3 above).

5.5 Systems Integration

A RFID system is an extension to an IT system that is used to keep track of real-time information relating to individual items. Therefore integrating RFID systems with existing IT systems (e.g. for supply chain management or enterprise resource management (ERM)) is a key step towards using RFID technology to improve efficiency. Solutions for RFID systems are available from many enterprise IT solutions providers such as SAP, Oracle, Siebel, Sun Microsystems, and IBM. It is vital that companies are able to manage the additional data that a RFID system can provide in the most efficient way, avoiding an overload of information.

Current RFID implementations are typically closed loop systems. This means that items stay within a single company's IT systems, and therefore proprietary technologies can be implemented without compatibility problems. However, many of the potential benefits of RFID systems come from outside of the closed loop, i.e. sharing information between IT systems (e.g. tracking goods as they pass from manufacturer to supplier to delivery company to customer). Further integration is required for such systems to work, particularly where information must be passed between proprietary systems operating in different companies. Standardisation will help to increase the interoperability of various RFID systems. (see Section 6.2).

5.6 Standards

Standardisation is important for the market development prospects of RFID systems. Globally interoperable standards are essential for applications that involve international movement of goods (i.e. so that a product need only be tagged once).

EPC Global[41] is the leading industrial authority on RFID and they are currently in the process of formulating industry standards. Companies supporting two competing candidate standards for a new generation of RFID systems recently merged their approaches to help form a single standard[42].

[39] Term is derived from mobile Totes which is a term used in warehousing.

[40] http://www.xbow.com/Products/Wireless_Sensor_Networks.htm

[41] http://www.epcglobalinc.org/

[42] http://www.rfidjournal.com/article/articleview/1001/1/1/

Other existing standards for RFID technology include:

- ISO[43]/IEC JTC1/SC31 (Traceability Standard)
- ISO 18000-6 (Tag standard (EAN/ECC))
- ISO 15693, ISO 14443 (Smart cards)
- EIA[44]/RS.232 (Physical Communication Standard)

[43] International Standards Association

[44] Electronic Industries Alliance

6 Market Development and Regulatory Issues

6.1 Market Development

The RFID market is currently fragmented with numerous different companies offering different proprietary solutions (e.g. many different tag designs). Consolidation is likely as larger companies become more interested in RFID. According to analysts the European RFID market could grow from €400m at the moment to €2.5 billion by 2008[45]. Up to 80% of this total market value is likely to be in transponders (i.e. RFID tags). Much of this growth is expected in 2006 and 2007, with a compound annual growth rate from 2003 to 2010 of 32.2% (creating global revenues in the region of $11.66 billion USD by 2010)[46]. Although the prospects for RFID systems appear good from these forecasts, estimates need to be considered carefully at this early stage of development.

A widespread adoption of RFID systems could also impact telecommunications markets. New sources of telecommunications traffic are likely to emerge as RFID systems are integrated with existing corporate IT systems. RFID technology also provides opportunities for automatic identification systems manufacturers to expand into mobile territory.

There are many new opportunities for RFID systems developers, installers and systems integrators. Some predictions indicate that RFID product integration revenue will surpass that of RFID product revenue by 2007[47]. Integration of multi-site RFID solutions also creates potential opportunities for service providers to create new telecommunications services for such applications. Organisations such as €uroTag (www.eurotag.org) are helping to promote the potential advantages of using RFID technology.

6.2 Factors Effecting Market Development

A RFID system can potentially introduce significant savings to a business. The US National Retail Security Survey quantified this as $5.8 billion of inventory loss per year due to administrative errors and 3.8% of sales per year lost due to out-of-stock items. Further savings would be likely through theft prevention. These are losses that RFID systems could significantly reduce. There is a general movement by warehouse management software and supply chain execution companies towards incorporating RFID into their systems, to capitalise on these benefits. Three main factors which may effect market development are outlined below.

6.2.1 Cost of Implementation

Companies considering adopting RFID technology must consider the total cost of implementation. This will include the cost of the tags, the supporting infrastructure (i.e. IT systems and connectivity), and systems integration costs including the training needs for staff. These costs would typically be considered in a RFID business case and strategy evaluation process.

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[45] Soreon Research, May 2004 – http://www.soreon.de

[46] https://www.frost.com/prod/servlet/press-release.pag?docid=19827196 , http://www.manufacturing.net/mmh/article/NEb0621009.8sw?industry=Automatic+Data+Capture&industryid=21966

[47] Source - Allied Business Intelligence (ABI)

Cheaper materials and the benefits of mass production will bring about lower costs in RFID tags themselves. The cost of tags varies depending on the complexity of the functions they are expected to carry out. Some tags currently cost between $0.30 and $1 (USD), and are expected to eventually fall to as low as 1 cent. Active tags are more expensive and range from approximately twice as expensive as passive tags to up to $15 (USD), depending on the amount of processing power they possess. Low tag costs are particularly important for application to mass market goods where profit margins are smaller than with high value luxury items. Costs of tags have recently begun to reduce. Software costs are now declining also.

6.2.2 Global Standardisation

A significant potential barrier to widespread RFID deployment is a lack of global standards which limits the ability to utilise RFID tags on internationally traded products. While it is possible to create multi-mode RFID tags that can operate in several different frequency bands, to comply with different national regulations, these are likely to be more expensive. Standardisation is also needed to ensure interoperability between RFID systems from different vendors. This is an important issue for companies considering implementing RFID technology. In some cases intellectual property issues are slowing the development of industry standards[48].

6.2.3 Privacy

There are currently strong concerns over privacy and the use of RFID technology in consumer goods and personal identification systems (e.g. passports). The clothing retailer Benetton experienced some negative publicity following an announcement that it was considering applying RFID technology to its products[49]. Measures such as the ability to de-activate (or remove) tags once they have left a shop for example would help mitigate these concerns. It is also possible that data protection guidelines could prevent the misuse of RFID technology on mass consumer products.

6.3 Regulatory Issues

6.3.1 Spectrum Issues

RFID systems utilise radio frequency spectrum and are therefore required by national regulators to operate according to certain specifications in order to avoid causing interference to other radio services. RFID systems typically operate as low power devices in licence exempt spectrum[50]. While some bands have been harmonised internationally among some countries there is a lack of global harmonisation in certain bands of interest to systems developers (e.g. 800 MHz UHF bands – see Section 5.3.1). Technical parameters such as power limits, frequency bandwidth, proportion of time spent transmitting (duty cycle), and indoor or outdoor use are typically specified in standards based regulations. In the US the FCC made proposals for rule

[48] 'Due to time constraints and developing standards, prior relationships will drive RFID integration contracts even more than previous rollouts, such as ERP or supply chain management systems.' Erik Michielson, ABI (Source – Microwave Journal, March 2004).

[49] http://www.rfidjournal.com/article/articleview/471/1/1/

[50] For more details of the use of licence exempt spectrum in Ireland see ComReg document 02/71 - http://www.comreg.ie/_fileupload/publications/odtr0271.pdf

changes in April 2004 to permit increased power for commercial shipping containers, and improved security[51].

6.3.2 Privacy Issues

Other regulations that are relevant to RFID systems relate to privacy. European privacy legislation (Data Protection Act, 1998) is different from in the US where many current concerns originate. In the US privacy is dealt with in a number of different areas through separate legislation and initiatives (e.g. the Department of Commerce's 'Safe Harbour' framework). In Europe the Data Protection Act generally prevents companies from using data for purposes other than for the reason it was collected. Privacy is a particularly sensitive issue in relation to RFID at the moment and a number of organisations have formed to help preserve individuals' rights with respect to privacy[52]. In the UK the 'Liberty' group was established to monitor RFID activity. In the US the Consumers Against Supermarket Privacy Invasion and Numbering (CASPIAN) was formed. For more information on data protection and privacy see the Data Protection Commissioner's website (www.dataprivacy.ie).

Other regulatory organisations have plans to introduce RFID system for end users such as The International Civil Aviation Organisation's (ICAO) plan for biometrics and RFID tracking in passports by 2015[53], which have privacy implications.

[51] More power in the 433.5 – 434.5 MHz range. The duration of continuous transmissions is also increased from 1 second to 60 seconds.

[52] http://www.privacyrights.org

[53] In one scenario it is feared that passports equipped with RFID tags could be used by criminals to identify potential victims in a crowd. In Finland RFID smart cards can be used to identify and bill customers for ticket-less flights - http://www.finnair.com/web/finnair/scripts/template_2level_white.jsp?pageid=-8882

7 Conclusion

RFID technology has the potential to introduce greater efficiencies into applications where it is helpful to know up-to-date details about individual items. Applications in warehousing, point-of-sale retailing, manufacturing and security are all currently available. Other applications have been long established (e.g. identification devices for domestic pets, manufacturing plant automation). Applications in new areas are likely to emerge as technologies develop and costs fall. Recent developments with significant market development implications involve the introduction of RFID technology to back-office warehousing operations of large retail organisations such as supermarkets (e.g. Marks & Spencer, Tesco, Wal-Mart). While many of these systems will be introduced over the next two years, it is generally felt that point-of-sale retail applications may still be up to five years away. It is likely that many initial RFID applications will be outside of the retail sector.

There are currently three main potential barriers to the widespread introduction of RFID systems:

Cost - RFID tags are still too costly for implementation in consumer products other than high margin luxury items. RFID is likely to experience greater take-up as tag prices fall (i.e. €0.01 - €0.1 per tag).

Standardisation - Global standards are needed to help encourage the adoption of RFID technology by companies who are afraid of being locked into proprietary solutions. Furthermore, international harmonisation on RFID wireless standards is needed to ensure international operation of RFID tags on items undergoing international transit.

Privacy - Privacy is a sensitive issue when it comes to RFID systems. Many fear that RFID tags on items that they purchase could be used to collect and pass on personal information without their permission. There are also fears that this technology could be exploited by criminals. Strict enforcement of data protection laws and an ability to de-activate RFID tags would help reduce privacy concerns.

Significant amounts of data will be generated by RFID systems, and where this data needs to be transmitted between different company offices there are opportunities for telecommunications service providers. Other opportunities exist in the areas of integration and data management as companies seek to incorporate RFID technology into their businesses. A key factor to the continued success of companies that adopt RFID technology is that they learn to use the additional data provided by RFID in the most efficient ways.

8 Annex 1 - Briefing Note Questionnaire

Section 1.	This Briefing Note

Q1. Did you find this Briefing Note useful? _____

Q2. Was the level of detail appropriate? _____

Q3. Was there enough information and do you feel that any issues were overlooked? _____

Q4. Any other comments in relation to this briefing note? _____

Section 2.	The Briefing Note Series

Q5. Have you read other ComReg briefing notes (which ones)? _____

Q6. Where did you find out about this document?

ComReg alert ☐ The Internet ☐ Referred by someone ☐

Q7. What other topics would you like to see covered by the briefing note series?

(1) _____
(2) _____
(3) _____
(4) _____
(5) _____

Q8. Any other comments on the Briefing Note Series _____

9 Annex 2 - Technology

Directory of RFID companies:

http://www.rfidexchange.com/manufacturers.aspx?topic_type=at

More detailed description of how RFID works.

RFID tags work by harvesting energy transmitted from RFID readers using a technique known as 'radar backscatter' or 'Modulated Back Scatter (MBS)'. This process is described below:

1. RFID reader transmits a signal
2. Tag couples this energy - 'energy harvesting'
3. Reader communicates with the tag using a Continuous Wave (CW) carrier, once the tag has harvested enough energy to operate
4. Tag communicates back to the reader by reflecting the incident CW signal at its own modulation rate

Homodyne receivers are suited for this purpose (since the received and transmitted frequencies are close together).

RFID Middleware

Middleware is specialise software that is used to link different pieces of software together such as databases and enterprise systems. Middleware solutions are needed for integrating RFID systems to existing IT systems and products are currently available (e.g. Catamaran from Shipcom). RFID middleware typically performs: data aggregation, forwarding, storage and monitoring, screen design, set-up of back-end connectivity to enterprise applications, configuration of logic for decision making, and user notifications/alerts, among other things. Much research and development of RFID middleware was carried out at the MIT Auto-ID Centre (now known as the Auto-ID Lab), where the 'Savant' system was developed.

10 Annex 3 - Glossary

3G	Third generation mobile
CEPT	European Conference of Postal and Telecommunications Administrations
EAN	European Article Numbering
EAS	Electronic Article Surveillance
ECC	Electronic Communications Committee
EIA	Electronic Industries Alliance
EMID	Embedded Electromagnetic Identification
EPC	Electronic Product Code
ERM	Enterprise Resource Management
ETSI	European Telecommunications Standards Institute
FCC	Federal Communications Commission
GPRS	General Packet Radio Service
GSM	Global System for Mobile
ICAO	International Civil Aviation Organisation
ICT	Information and Communications Technology
IEEE	Institute of electrical and electronic engineers
ISO	International Standards Organisation
IT	Information Technology
LAN	Local area network
NFC	Near Field Communications
NLOS	Non line of sight
RF	Radio Frequency
RFID	Radio Frequency Identification
RIC	Remote Intelligent Communications
UPC	Universal Product Code
USD	US dollars
Wi-Fi	Wireless local area network technology (IEEE 802.11)
WLAN	Wireless Local Area Network (Wi-Fi)