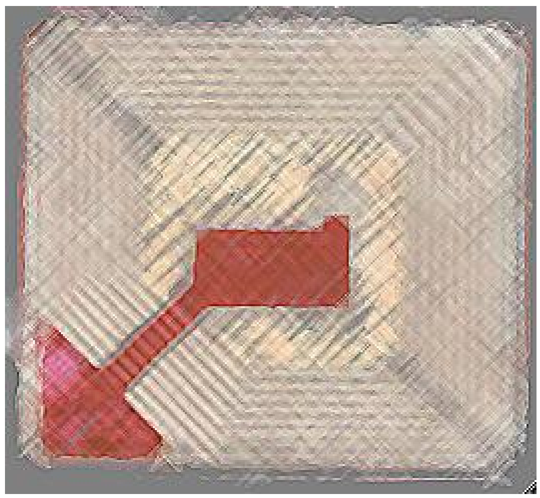

Radio Frequency Identification Device Technology (RFID)

(July 2005)

Radio Frequency Identification Device Technology
This FactFile is produced by the Institution of Electrical Engineers (the IEE) to provide authoritative information, and balanced advice, on the subject of Radio Frequency Identification Device (RFID) technology, and the social implications of its current capabilities.

What is this FactFile About?

For efficiency and economic purposes there is a need to track materials, components and products during their manufacture, and when they leave the factory floor through, at least, to their point of sale. With certain products there is a need to track their status even after acquisition by the end user – for example to keep a record of a safety critical capital plant's service history. Printed means, for example barcode, for identifying a product and its build status etc. has limitations, not least of which, is that to read them line of sight access is required. Further to update such printed identifiers requires that they be physically replaced.

This FactFile provides an introduction for Members and members of the public to Radio Frequency Identification (RFID) technology and its uses. Examples are drawn primarily from the product distribution chain, but reference is also made to other applications of the technology.

The Institution of Electrical Engineers

The IEE is Europe's largest professional engineering institution. Its 120,000 members are drawn from a broad range of engineering disciplines including those concerned with systems, control, instrumentation, telecommunications and the radio spectrum. The IEE's membership represents a wide range of expertise from technical experts to business leaders. Many of the most experienced members of the IEE, and their sector peers, voluntarily participate in a variety of IEE policy guidance groups. To these groups they bring their wealth of personal experience and knowledge independent of commercial interests, to address the issues of the day and to give the IEE independent and authoritative views of trends in technology and engineering. One of these policy guidance groups is the **Control and Instrumentation Sector Panel** that has produced this FactFile. Details of the Panel membership from academia, industry and government can be found at: http://www.iee.org/Policy/sectorpanels/control/index.cfm. One of the Panel's outputs is the production of public information on topics within its remit, such as RFID.

The background to RFID technology

Figure 1.

The ubiquitous barcode, such as diagrammatically portrayed in **Figure 1**, has been used since the late 1960's as a printed means of identifying product categories. The barcode system was effectively standardised with the widespread adoption in 1973, by users and equipment makers, of the Universal Product Code (UPC) 8 or 12 digit symbology. Since then there have developed different versions of this barcode technology (EAN, JAN) encompassing 8 to 14 digit systems. Barcode technology continues to perform an essential role in inventory control and distribution, particularly in the consumer product market sector, but can be found in use from car manufacture to library stock control.
Barcodes require close scanning with an optical reader, much like the laser scanning readers found at most supermarket checkouts.

Barcodes: -

- Are limited to the data printed on them and cannot be updated, other than by replacement or sticking a label over them (which may be labour intensive).
- Need to be substantially flat for reliable reading.
- Are typically (but not always) paper labels, or printed on paper based packaging, and therefore prone to damage.
- Typically provide inventory data to the level of product category. [For example it might indicate that the product is a 250g packet of Danish ‘Product Name’ unsalted butter, but is unlikely to indicate the sell by date (shelf life), nor the best before date.]
- Are very unlikely to show through which distribution depots and transport means the product arrived at the point of sale.

RFID technology has existed since the mid 1940s when it was used for military aircraft identification. Later high value goods inventory control applications were derived. In its early commercial manifestations each item to be tagged had a small electronic assembly (a transponder) fitted to it that would respond with a burst of radio frequency (RF) carrier modulated identification data when interrogated by a RF signal (on a different frequency) from either a hand-held scanner/reader, or one mounted, say, in a doorway. This burst of identifying data was intercepted by the scanner, decoded and used to both identify the tagged item and for it to be counted. The early RFID tagging means were battery powered (so called active devices). These were not only costly, but also relatively bulky. Since then RFID use, and potential, has greatly increased in large part due to the unit cost, size and power needs, of the essential ‘tag’ having decreased by many orders.

Despite the duration of its history RFID technology is still in its application formative years. **Chart 1.** gives a sample overview of the development of RFID applications with time, and some of the major activities that have lead to the current rapid uptake of the technology. Key to the development of applications has been the publication of standards as detailed in Appendices 1, 2 and 3.

Dependent upon the RFID technology used RFID memory does not have to be fixed but may be modified, extended/added to, or even erased.

As will be seen RFID technology will overcome the limitations of barcodes. But as with barcodes, to gain wide international acceptance as the preferred means for inventory control systems there will have to be open standards for their use – see Standards at the back of the FactFile. Further if RFID technology is to become as ubiquitous as barcodes in the distribution chain, then the unit cost of the ‘tag’ will need to be substantially as cheap as the printed barcodes. Arguably, an RFID tag may never become as cheap as the printed barcode incorporated on the ‘cereal box packaging’, but because of RFID’s advantages they may become the preferred inventory control means for consumer durables, and high value capital goods etc.

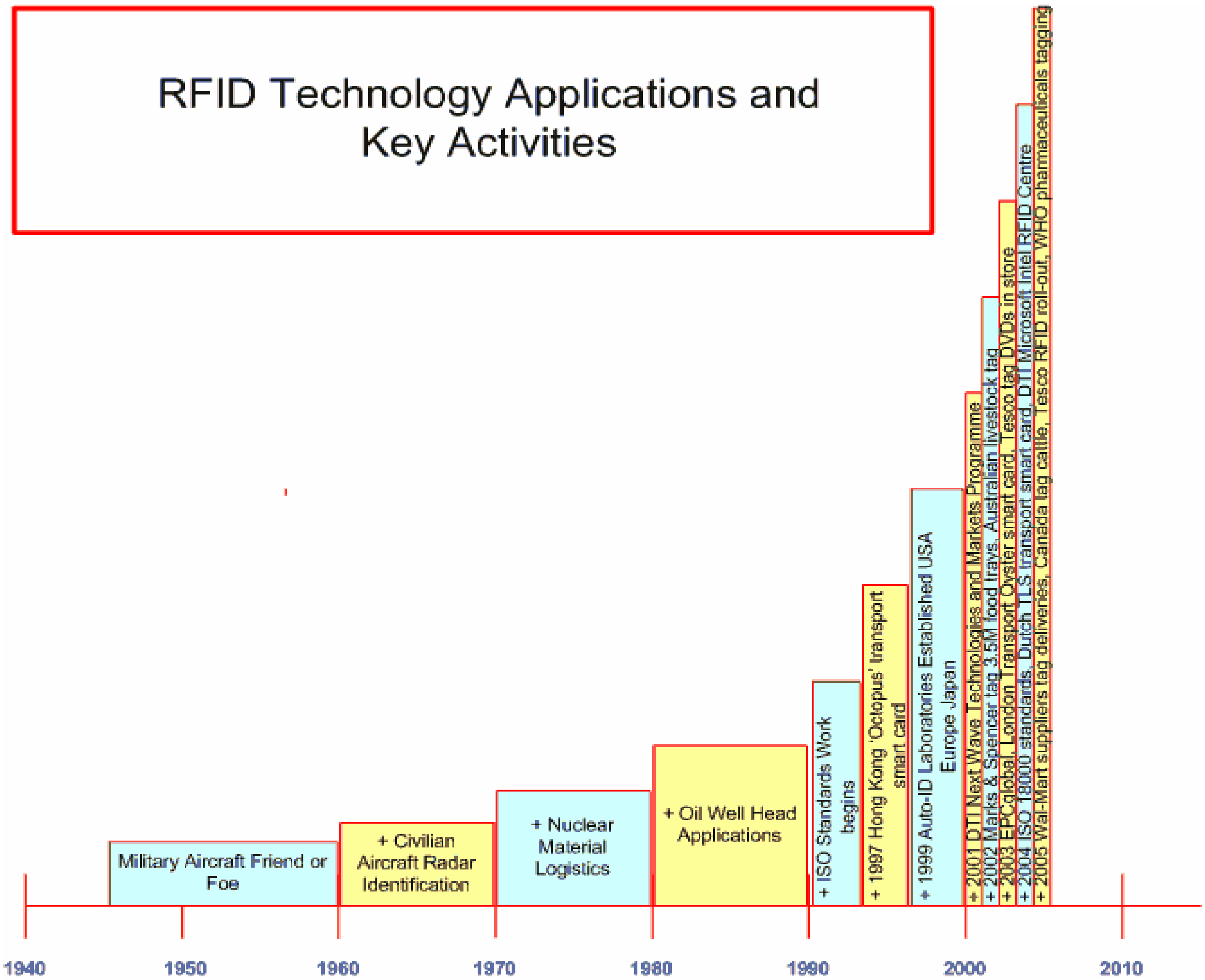

Chart 1.

Principles of RFID technology

The RFID 'tag' is essentially a memory device with a means of revealing and communicating its memory contents, when prompted (scanned) to do so. The memory consists of a plurality of binary (two state) digits, also known as bits, and the communication comprises RF reception and transmission means. The binary data (bits) are formed into binary words comprising typically 8, or 16 or 32 bits that can make up letters and numbers in the same manner as in computing, the Internet and 'texting' on a mobile phone. The 'tag' may comprise an electronic circuit (printed circuit board) with its own power supply – an active device; or be a very low power integrated circuit that is able to gain enough energy from the scanner/reader RF signal to actually power itself for long enough to transmit the contents of its memory – a so called passive device. In its passive embodiment RFID tag transmission power is very low and measured in millionths of a watt i.e. microwatts, μW. Figure 2, shows diagrammatically one of the latter style devices, which may be found on products, particularly consumer durables.

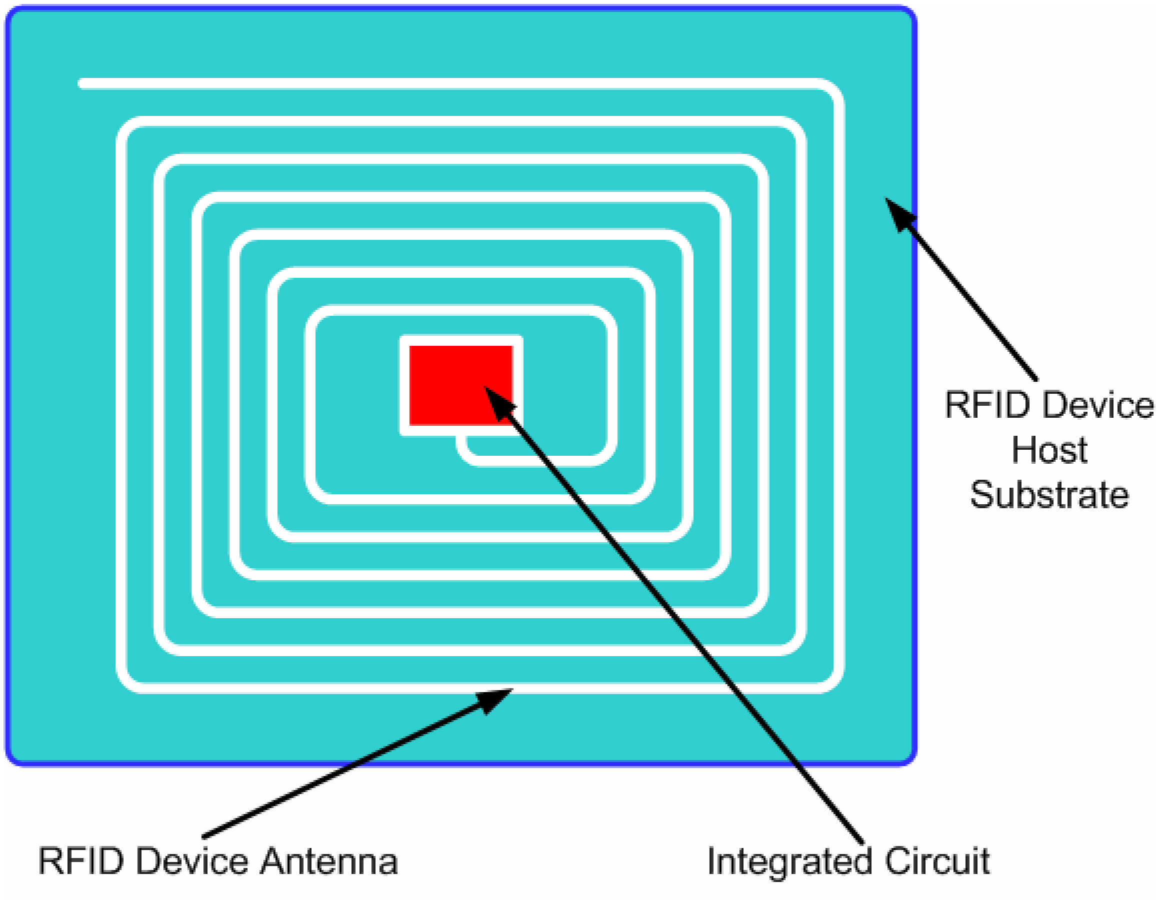

Figure 2.

The typical RFID tag portrayed in **Figure 2**., comprises a host substrate which is typically, but not exclusively, a flexible plastic (polymer), with an attached flexible etched aluminium alloy, or conductive ink antenna, plus a small (few millimetres square) attached integrated circuit connected to the antenna. The whole assembly is typically 30 millimetres square, a fraction of a millimetre thick, and is encapsulated so that it forms a flexible durable, attachable label.

The data in the RFID tag memory may be pre-loaded (determined at time of manufacture) as a Read Only Memory (ROM), or may be dynamically variable (Static Random Access Memory) and take up the status of the last write/read cycle. The data is always read out serially so that it can be correctly parsed. The information contained in the RFID tag memory is deliberately kept to a minimum, and typically, dependent upon the data format (its syntax, numerical format – decimal, hexadecimal etc) requires translating into a human readable form via a host system.

Dependent upon the technology used, and in particular its radio frequencies, RFID tags can be small enough to be humanely inserted under loose skin of animals as with cat and dog passports.

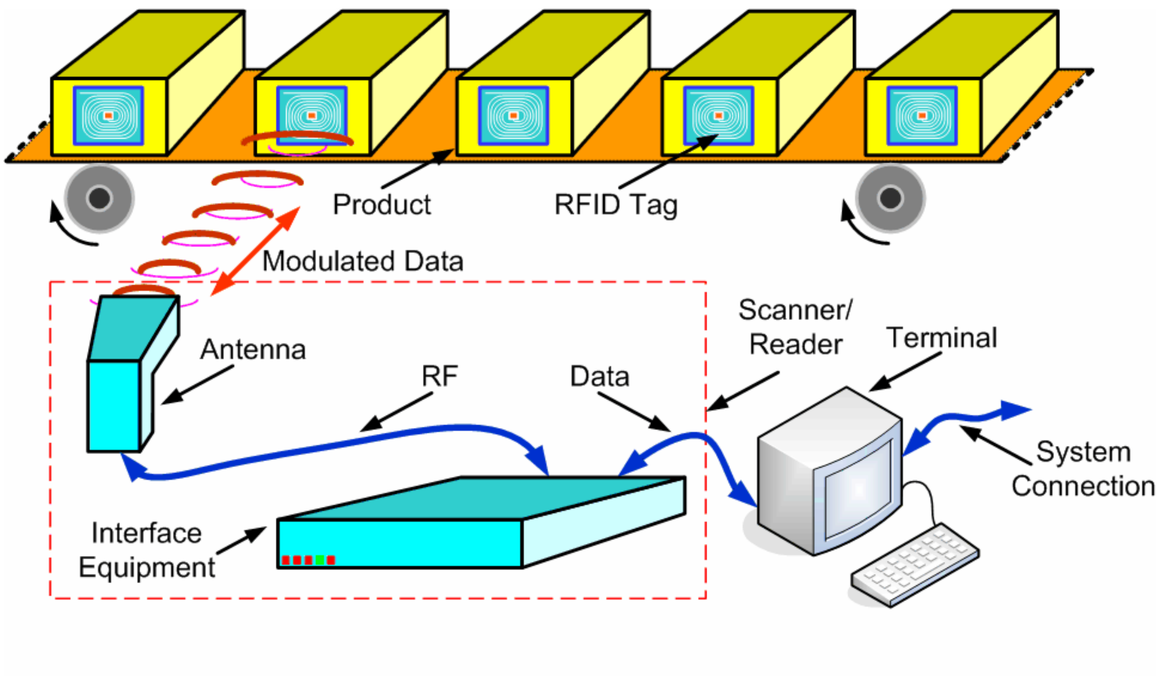

Figure 3.

Figure 3., shows a typical industrial RFID application where a conveyor belt of products is having each RFID tag scanned to detect the previously written product identifier, for example: -

- batch and serial number
- build status code

and then, for example, have written to the tag: -

- date of manufacture
- customer order number
- loading bay and shipping data.

In this example the RFID tag is attached to the product, passes in front of the antenna of the scanner that is connected to a host terminal that enables an operator to oversee the RFID programming. The Terminal is connected to a host system that has: -

- provided new data (to be written) appropriate for the information read off each product tag
- notified the shipping agent of the need to collect the goods
- informed the end customer that their goods have been sent to despatch
- raised an invoice.

Each of the products on the conveyor belt can be uniquely 'labelled' with its own RFID identifying data. RFID technology is characterised in relating a product to its associated information database(s).

This example shows that to activate the RFID tag it needs to be scanned with an RF beam of energy that powers it and prompts it to reveal its previously stored information. The scanner's reading mechanism receives the device information and passes it to an 'intelligent' database that can convert the information into a human intelligible form, make the necessary associations to complete the storing of data in the RFID tag, and to store the records for future retrieval.

The speed with which the scanner can interrogate the tag and write to it depends upon the RFID technology used, in particular the radio frequency used. Importantly, the necessary proximity between the scanner antenna and the RFID tag for successful operation is dependent upon the radio frequency and whether the tag is active or passive.

There are four main frequency bands, **Table 1**, used for RFID systems.

Generic Band Name	**Frequency Range**	**Comment** (National Frequency Allocations Vary)
Low Frequency (LF)	120 - 135 kHz	Short range inductive applications.
High Frequency (HF)	13.56 MHz	Worldwide common frequency, smart cards and labels.
Ultra High Frequency (UHF)	433 MHz	Active low power tags.
	860 - 960 MHz	Band with major supply chain development activity.
Microwave	2450 MHz	Active tag technology gives range and fast data rates.

Hz (Hertz) unit of frequency measurement, kHz thousands of Hertz, MHz millions of Hertz.

Table 1.

Each has differing characteristics and applications as shown in **Table 2**.

Band MHz	Typical Operating Range		Typical Tag Size		Typical Application	Relative Data Transfer Rate	Comment
	Read Only	**Read Write**	**Active (volume)**	**Passive (area)**			
0.125 – 0.134 (Low Frequency LF)	Up to 2m	Few cm	5 – 10cc	2-5cm^2	Animal identification Car immobiliser Controlled access Work in progress pallets	Slow Non -concurrent multiple access	Inductive applications Expensive tag Susceptible to electrical noise
13.56 (High Frequency HF)	Up to 1m	Up to 0.5m	3 – 5cc	10cm^2	Smart Cards Smart labels Domestic electrical goods Access and security systems	Medium Multiple concurrent read <50 items	Worldwide RFID frequency Different reader powers North America - Europe
433 MHz	Tens m	Few m			Specialist animal tracking	Fast	Active tags
860 – 960 (Ultra High Frequency UHF)	Up to 5m	Up to 0.5m	1 – 2cc	4cm^2	Item level tracking in factory, warehouse and distribution chain Mass produced consumer durables	Fast Multiple concurrent read >100 items	High ability to concurrently read multiple tags Highly integrated manufacture Inexpensive tag Tag modulates read to send data – back scatter Different frequencies and power levels in North America, Europe, Japan
2450 (Microwave)	Up to 10m	Up to 1m	-	1cm^2	Moving car electronic toll collection Prepaid travel cards	Fast	Bluetooth and WiFi systems Highly integrated manufacture Inexpensive tag

Approximate data rates: Slow up to 2 kilobits/s   Medium up to 10kilobits/s   Fast up to 100 kilobits/s
The passive devices tend to be very thin (<1mm) and for this reason the comparative area is given.

Table 2.

RFID technology advantages and disadvantages

Compared to barcode inventory control systems RFID technology has both advantages and disadvantages, many of which are outside of product manufacture and distribution chain applications.

ADVANTAGES versus Barcodes

- Not requiring line of sight access to be read.
- The tag can trigger security alarm systems if removed from its correct location.
- Scanner/reader and RFID tag are not (so) orientation sensitive.
- Automatic scanning and data logging is possible without Operator intervention.
- Each tag can hold more than just a unique product code.
- Each item can be individually 'labelled'.
- Tag data can be comprehensive, unique in parts/common in parts, and is compatible with data processing.
- With the right technology a plurality of tags can be concurrently read
- It can be read only or read-write.
- There is a very high level of data integrity (character check sum encoding).
- Provides a high degree of security and product authentication – a tag is more difficult to counterfeit than a barcode.
- The supporting data infrastructure can allow data retrieval and product tracking anywhere **provided the scanner/reader is close enough to the tag.**
- Combined with its authentication is the ability to monitor shelf life – a societal advantage in the pharmaceutical and food industry.
- Since each tag can be unique they can act as a security feature if lost or stolen e.g. a stolen smart travel card can be cancelled.
- The technology is rugged and can be used in hostile environments such as down oil wells (heat and pressure) to carry data to remote equipment.
- The technology lends itself to being updated, for example, as a car goes through its life its service record can be electronically logged with the car.
- The technology could be inserted within a suit so that when it is sent to the cleaners it automatically gets the right cleaning procedure applied to it.
- The technology can be used to increase security so that, for example, it may be construed that a child is at school as their tag in their school bag was logged when they came through the school gates. [Clearly, this does not of necessity mean the child is at school, but only that their bag with the contained RFID tag has been taken into the school, which in most circumstances will mean the child was with it at the time.]

DISADVANTAGES versus Barcodes (See also Societal Concerns)

- Even in six figure production quantities, the simplest of these tags is more expensive (say tens of pence) than a printed barcode – this extra cost, plus the potential greater infrastructure capital cost, has to be bettered by other benefits in the distribution chain or represent an application for which the barcode is not suitable e.g. Smart Cards.

- There is a high cost (long pay-back) for integrating RFID technology into existing inventory control systems.
- External influences such as metalwork, material dielectric properties and radio interference can constrain RFID remote reading.
- If a significant number of RFID's greater systems capabilities are implemented then the host system and infrastructure have a higher capital cost and complexity than for barcode systems.
- There are currently a range of RFID application numbering systems which need unifying to increase uptake. [The International Standards Organisation (ISO) and Electronic Product Code [EPC] Global consortium, amongst others, are working to address this issue.]
- Currently there are not internationally agreed frequencies for RFID operation (other than 13.56 MHz, which is primarily used by smart cards but can also be used by other RFID tags) and permitted scanner/reader powers differ between countries. This limits product take-up. [For example, there are significant differences between the USA and European UHF frequencies.]

To address these disadvantages there are programmes to develop standards which will enable interoperability. This will increase confidence in the technology, stimulate greater competition and produce consequential reduction in costs.

Standards

Technical standardisation has made, and will continue to make, a major contribution to reducing the costs of RFID systems, and to the development of RFID applications. Several bodies are currently progressing RFID device and system standardisation including: -

- The International Organisation for Standardisation – ISO in conjunction with the International Electrotechnical Commission - IEC,
- Electronic Product Code (EPC) Global – EPCglobal, and
- The European Telecommunications Standards Institute (ETSI)

Appendix 1. lists the major RFID standards from the ISO/IEC organisations and gives website references (valid April 2005) for obtaining further details of these standards.

The EPCglobal work is to define a networked RFID system architecture by specifying standard interfaces between the elements, in order to guarantee global interoperability between elements from different technology vendors. This can have the effect of commoditising RFID system elements, reducing costs and enabling businesses to adopt RFID technology throughout their national/international product manufacturing logistics and distribution chains.

In the EPCglobal model these systems involve a number of components including (see also Appendix 2): -

- Electronic Product Code (EPC): a unique number reference for a physical object be it a product, case or pallet.
- Electronic tags: that uniquely identifies an object, to which it is attached, via a unique EPC number that can be read without contact by a (RFID) reader.
- Object Naming Service (ONS): an application run on a host computer/system that collects the read EPC number and informs the host computer/system where to find information about the object. Typically this information may reside on the host computer, host network, or on other computer systems accessed via the Internet.
- RFID Air Interfaces – specifying radio communication protocol between tags and readers.

The European Telecommunications Standards Institute (ETSI) produces RFID standards as shown in Appendix 3. These concentrate on RFID scanner/reader radiated power levels, which, in turn, determines their read range. These standards are designed to help avoid device interference, and ensure compliance with safety guidelines on exposure to non-ionising electromagnetic radiation.

Societal Concerns

Society's concerns about RFID technology largely relate to privacy issues. Society's privacy concerns have arisen with RFID technology because the process of scanning and logging data is 'invisible', is imagined to be possible from great distances, and has the potential to relate together various data. However, most of the contributory factors to these privacy concerns existed with the widespread adoption of barcodes and loyalty cards, and are therefore not uniquely attributable to RFID technology.

- There is currently no regulation to constrain the specific use of RFID technology and its remote reading. It is possible however that data privacy legislation in Europe may apply to some uses of RFID.

Whilst this is true, the reality is that today with the mass produced (very low power) passive tags, the scanner/reader has to be in close proximity to the RFID tag for it to be read. For all practical purposes this is within 0.1 – 2m, dependent upon the technology. To be read, a tag needs an uninterrupted (low attenuation) path to the reader. Further, the scanner/reader has to be operating in the correct frequency band to activate the tag and reveal its contents.

Even if the tag is correctly activated the reader and host intelligence has to know how to interpret the received data and convert it into meaningful information i.e. know the device protocol.

Most mass produced passive tags are either stuck on the product packaging, or in the case of the more expensive consumer items, attached inside the product casing. In the former case the tag can be removed and destroyed. In the latter case the product is likely to be kept in isolation (greater than a few metres) from any unknown scanner/reader e.g. inside the home.

- With RFID technology there is the potential for significant amounts of personal data to be accumulated about an individual's buying habits, and this information could be subject to misuse.

But this is no different to what can already be gathered from the combination of barcodes and loyalty cards.

It has been argued that RFID tagging of products is a further step towards 'Big Brother' because RFID tags can be written to as well as read. The only reason that a tag is written to is if the data needs to be read at some other time. But this need not be a cause for concern if: -

- The purchaser keeps control and can remove and destroy the unwanted tag, or have it irrefutably disabled at the checkout.

There are ways that RFID devices can be disabled – for example a fusible link may be forced to blow by a magnetic field to disconnect the tag antenna from the integrated circuit. In store disabling of the tag, and or checking of its disable status, could be a way to alleviate consumer concerns about the technology. Alternatively, for high value goods, at the checkout, the end purchaser might encode the tag with a personal identification number, known only to them, which has to be entered to allow further reading of the device data.

It should be remembered that store loyalty cards are an 'opt-in agreement' to allow the store to collect data about the customer's purchasing habits in exchange for receiving rewards. Already the ubiquitous barcode + loyalty card at the checkout gives the store this information. It is unlikely that replacing the barcode with RFID technology would give the store any significant increase in personal information. There is end user control of the situation if: -

- The purchaser (safely) uses cash at the checkout, and does not present a loyalty card.
- There was regulation over use of data collected about purchases and their tie-in with other personal data such as debit/credit card information.

Under the European Data Protection Directive 95/46.EC an organisation that collects personal data has to be registered with the Data Protection Commission. An individual has to give a collector of personal information written permission for that information to be passed to a third party. Thus there is already relevant legislation to protect the individual. That is not to say additional legislation is not ideally required – for example, it might be appropriate to legislate that purchaser details cannot be embedded into an RFID tag without the written consent of the purchaser. For example, a purchaser might want their details embedded in a 'hidden' RFID device within a Laptop if this meant that it increased the chances of its return if lost or stolen.

One aspect of these privacy concerns is that the individual does not necessarily know when the RFID scanning is taking place and data collected. This is true, but it only becomes an issue if information about the person (their identity) can be remotely sensed as well. This circumstance can be eliminated if no credit, debit, loyalty or other 'card' has RFID technology attached to it, and the product RFID tag does not contain purchaser details – see previous paragraph.

If legislation is introduced to regulate use of RFID technology then it will also require a Complaints Procedure, which may include the appointment of an Ombudsman.

To avoid regulation RFID users might voluntarily decide to limit its use to be not beyond palette level in the distribution chain. If the benefits of cheaply avoiding out of date food/pharmaceutical products being on the supermarket shelf are so beneficial that RFID technology needs to go beyond the 'palette' then users may decide to make its (tag) presence clearly evidenced so that it can be removed and disposed of at the point-of-sale.

In summary for the concerned individual to protect their privacy they should:

- Remove, and destroy, RFID tags after purchase of a tagged product.
- Use cash, rather than card payment, when practical, and safe to do so.
- Not sign up for loyalty cards.
- Ask for tags to be disabled when completing a purchase.
- Keep an eye on consumer legislation and take appropriate opt-in/opt-out action on matters that concern their privacy.

RFID Applications

This FactFile has largely used the distribution chain as an example of the application of RFID technology as it is one to which many people can relate. However, the versatility of RFID means that it has potential for application in many different roles some of which are suggested in Table 3, but this should not be regarded as a definitive list, or as being in any perceived order of importance.

RFID Applications
• Product distribution chain
• Manufacturing inventory accounting and control
• Hospital patient identification, treatment and medication recording
• Library, museum, art gallery item identification, logging, security and control
• Capital goods (e.g. car) service record logging and recall
• Smart Card technology, commodity purchase, travel cards etc.
• Police investigation evidence tagging and location
• Mass transport carrier baggage handling
• Asset management – asset tracking
• Motorway tolls
• Food and pharmaceutical 'best before date' control
• Pharmaceutical authentication
• Animal tagging and passports

Table 3.

How can I find out more?

Further information about RFID technology, and its application, is produced by the following organisations: -

UK Home Office: http://www.crimereduction.co.uk/securedesign14.htm
e.centre: http://www.e-centre.org.uk/sec_home.asp?fid=61
Cambridge Auto-ID Lab: http://www.autoidlabs.org.uk/
Information about EPC: http://www.epcglobalinc.org/

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APPENDIX 1.

ISO/IEC RFID STANDARDS		
Reference	**Title/Topic**	**Status**
ISO/IEC 18000-1 :2004	Radio Frequency Identification for item management – air interface communications.	Published 2004
Internet:	http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=34112	
ISO/IEC 18000-2 :2004	Parameters for air interface communications below 135kHz	Published 2004
Internet:	http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=34113&ICS1=35&ICS2=40&ICS3=	
ISO/IEC 18000-3 :2004	Parameters for air interface communications at 13.56MHz	Published 2004
Internet:	http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=34114&ICS1=35&ICS2=40&ICS3=	
ISO/IEC 18000-4 :2004	Parameters for air interface communications at 2.45GHz	Published 2004
Internet:	http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=34115&ICS1=35&ICS2=40&ICS3=	
ISO/IEC 18000-6 :2004	Parameters for air interface communications 860MHz to 960MHz	Published 2004
Internet:	http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=34117&ICS1=35&ICS2=40&ICS3=	
ISO/IEC TR 18001: 2004	Radio frequency identification for item management – application requirements profiles	Published 2004
Internet:	http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=40733&ICS1=35&ICS2=40&ICS3=	
ISO 11784:1996	Radio frequency identification of animals – code structure	Published 1996
Internet:	http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=25881&ICS1=65&ICS2=40&ICS3=99	
ISO 11785: 1996	Radio frequency identification of animals – technical concept	Published 1996
Internet:	http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=19982&ICS1=65&ICS2=40&ICS3=99	
ISO/IEC 14443-1/2/3/4	Contactless integrated circuit(s) cards – Proximity cards <10c /1 Physical Characteristics /2 Radio frequency power and signal interface /3 Initialisation and anti-collision /4 Transmission Protocol	Stage date: 2003 2001 2001 2001

Internet:	http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=28728&ICS1=35&ICS2=240&ICS3=15 http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=28729&ICS1=35&ICS2=240&ICS3=15 http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=28730&ICS1=35&ICS2=240&ICS3=15 http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=31425&ICS1=35&ICS2=240&ICS3=15	
ISO/IEC 15693 – 1/2/3	Contactless integrated circuit(s) cards – Vicinity Cards >10cm /1 Physical characteristics /2 Air interface initialisation /3Anticollison and transmission protocol	Stage date: 2003 2001 2001
Internet:	http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=30995&ICS1=35&ICS2=240&ICS3=15 http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=36188&ICS1=35&ICS2=240&ICS3=15 http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=31428&ICS1=35&ICS2=240&ICS3=15	
ISO/IEC 15961: 2004	Radio frequency identification (RFID) for item management – Data protocol	Published 2004
Internet:	http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=30528&ICS1=35&ICS2=40&ICS3=	
ISO/IEC 15962: 2004	Radio frequency identification (RFID) for item management – Data protocol: data encoding rules and logical memory functions	Published 2004
Internet:	http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=30529&ICS1=35&ICS2=40&ICS3=	
ISO/IEC 15963: 2004	Radio frequency identification for item management – Unique identification for RF tags	Published 2004
Internet:	http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=30530&ICS1=35&ICS2=40&ICS3=	

APPENDIX 2.

EPC GLOBAL RFID SYSTEM STANDARDS RELEASE 1.0		
Reference	**Title/Topic**	**Status**
EPC Tag Data Specification Version 1.1	Specific encoding schemes for a serialized version of the EAN.UCC Global Trade Item Number (GTIN®), the EAN.UCC Serial Shipping Container Code (SSCC®), the EAN.UCC Global Location Number (GLN®), the EAN.UCC Global Returnable Asset Identifier (GRAI®), the EAN.UCC Global Individual Asset Identifier (GIAI®), and a General Identifier (GID).	EPCglobal Board Ratified
Internet:	http://www.epcglobalinc.org/standards_technology/specifications.html	
900 MHz Class 0 Radio Frequency (RF) Identification Tag Specification	Specification of the communications interface and protocol for 900 MHz Class 0 operation. It includes the RF and tag requirements and provides operational algorithms to enable communications in this band.	Release 1.0
Internet:	http://www.epcglobalinc.org/standards_technology/specifications.html	
13.56 MHz ISM Band Class 1 Radio Frequency (RF) Identification Tag Specification	Specification defines the communications interface and protocol for 13.56 MHz Class 1 operation. It also includes the RF and tag requirements to enable communications in this band.	Release 1.0
Internet:	http://www.epcglobalinc.org/standards_technology/specifications.html	
860-930 MHz Class 1 RFID Tag Radio Frequency & Logical Communication Interface Specification	Specification of the communications interface and protocol for 860 - 930 MHz Class 1 operation. It includes the RF and tag requirements to enable communications in this band.	Release 1.0
Internet:	http://www.epcglobalinc.org/standards_technology/specifications.html	
UHF Class 1 Generation 2 Air Interface specification	Specification of the following for the EPCglobal Class-1 Generation-2 UHF RFID Protocol for Communications at 860 MHz – 960 MHz (the Protocol): • Compliance requirements for physical interactions (the signaling layer of the communications) between Interrogators and Tags, and • Compliance requirements for Interrogator and Tag operating procedures and commands	Release 1.02
Internet:	http://www.epcglobalinc.org/standards_technology/specifications.html	

APPENDIX 3.

ETSI GENERIC RFID STANDARDS		
Reference	**Title/Topic**	**Status**
EN 300 220	Electromagnetic compatibility and Radio spectrum Matters (ERM); Short-range devices; Technical characteristics and test methods for radio equipment to be used in the 25 MHz to 1 000 MHz frequency range with power levels ranging up to 500 mW. Parts 1 - 3.	Published 1997 through 2005, ratified
Internet:	http://pda.etsi.org/pda/queryform.asp Search EN 300 220	
EN 300 330	Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Short Range Devices (SRD); Technical characteristics and test methods for radio equipment in the frequency range 9 kHz to 25 MHz and inductive loop systems in the frequency range 9 kHz to 30 MHz. Parts 1- 2.	Published 1999 through 2004, ratified.
Internet:	http://pda.etsi.org/pda/queryform.asp Search EN 300 330	
EN 300 440	Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Radio equipment to be used in the 1 GHz to 40 GHz frequency range	Published 2001 through 2004, ratified.
Internet:	http://pda.etsi.org/pda/queryform.asp Search EN 300 440	
EN 302 208	Electromagnetic compatibility and Radio spectrum Matters (ERM); Radio Frequency Identification Equipment operating in the band 865 MHz to 868 MHz with power levels up to 2 W. Parts 1 and 2	Published September 2004, Ratification June 2005.
Internet:	http://pda.etsi.org/pda/queryform.asp Search EN 302 208	
TR 101 445	Electromagnetic compatibility and Radio spectrum Matters (ERM); Short-Range Devices (SRD) intended for operation in the 862 MHz to 870 MHz band; System Reference Document for Radio Frequency Identification (RFID) equipment	Published 2002, ratified
Internet:	http://pda.etsi.org/pda/queryform.asp Search TR 101 445	

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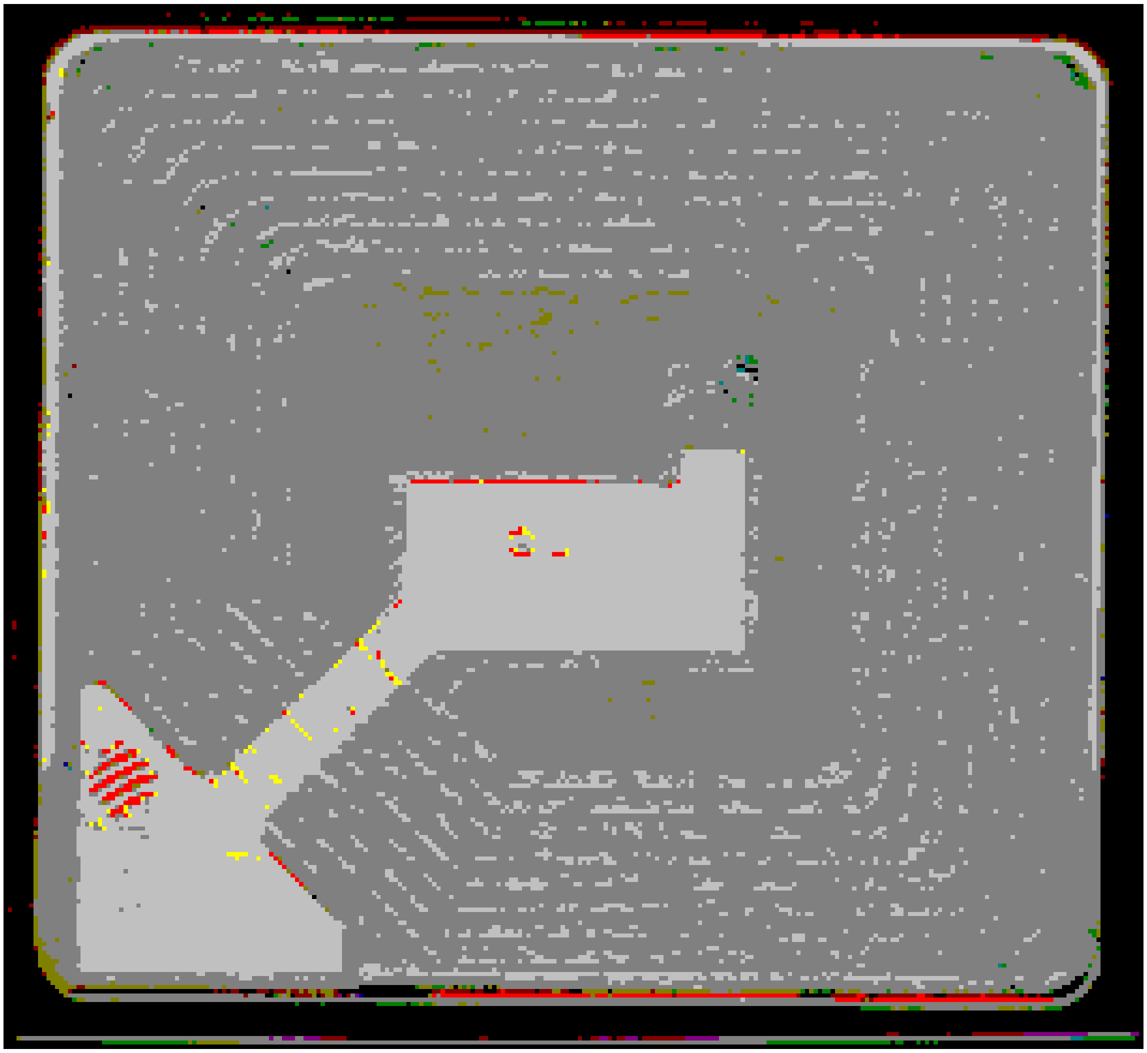

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