Mixed signals could spell danger for RFID

It is one of the big stories of 2005, but developments in RFID may be undermined by standards organisations

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For the past year that buzz you have been hearing has been all the talk about RFID – radio frequency identification – and how it is the next killer app. What you probably have not heard is all the discussion about the technical standards, transmission frequencies and data and ID naming structures that define how RFID works. These efforts to standardise RFID operations, and the standards organisations behind them, have been instrumental in bringing the technology to this point, but do they threaten to undercut the market just as it is about to take off?

In June 2003, Wal-Mart, the world's largest retailer announced, that beginning in 2005, its 100 top suppliers must ship their goods with RFID tags that automatically identify the supplier, product and other inventory characteristics. The US Department of Defence (DoD) notified its 43,000 suppliers of similar requirements. Across the Atlantic, in some European countries such as the UK, MasterCard and Visa have succeeded in shifting the liability to banks and retailers for any financial transaction, including ATM and electronic payment, that is not processed through an RFID-compliant machine. As a result of these and other company-specific initiatives, industry experts expect the RFID market to mushroom to nearly US$27 billion by 2015, more than 11 times current levels.

One of the things lost in all the noise about RFID is that RFID is not a monolithic market. Rather it is a loosely integrated collection of segmented markets, which are defined, and to a certain degree separated by, a variable matrix of factors that comprise the particular business application, operating frequency and technical/functional standards of each RFID market. In some cases, a single frequency may apply to multiple applications operating under multiple standards across multiple markets. In other cases, a market may consist of a single application, operating at one frequency, under one technical standard.

Any attempt to make sense of the RFID market, to separate the signal from the noise, must take into consideration not only these three factors: application, frequency and standards – but also the particular combination and interaction of these factors in the formation of a particular market segment.

Applications

The real buzz underlying RFID is not so much that of a singular application but that of a technology that can serve as platform upon which a virtually unlimited array of applications can be initiated, across virtually every sector of the economy: agriculture, mining, manufacturing, transportation, consumer retail, services, government, health care, and yes, even business supply chain.

Some of the first RFID applications were in the areas of animal and asset tracking (specifically, railcars). Not the most exciting uses of the technology. Over time, the applications spread across the entire business landscape: airline baggage handling, auto immobilisation, security access, transit cards, toll collection, tyre pressure monitoring, patient/medical records tracking, and of course, supply chain and inventory control. With the recent outbreaks of mad cow disease and the need to track individual cattle from the delivery stable all the way to the slaughterhouse, animal tracking is again a hot application.

Although global supply chain gets all the attention, currently the most ubiquitous

What is RFID?

RFID is a method of identifying unique items using radio waves. An RFID system consists of three components: a tag (also known as a transponder or label), a reader (also known as an interrogator or transreceiver) and a data processing system, in which the reader sends out a signal to communicate with a tag, which responds and transmits its information to the reader, which in turn passes the information on for data processing. The tag is located on the object to be identified and is the data carrier in the RFID system. Readers can both read data from or write data to a tag while the data processing subsystem utilises the data received from the transreceiver in some useful manner. Importantly, an RFID system can be passive, so that the tag has no power source save that supplied via the reader's RF signal, or active; here, the tag is equipped with a battery, whose life can extend up to five years. Active RFID systems can have much longer read ranges (one mile or more) and can transmit massive amounts of data.

RFID's key strengths are individual item identification, communication without line of sight contact and read/write capability. This translates into greater usability, in terms of application and environment, greater efficiency, and real-time and two-way communication. Within the supply chain context, some see RFID as, if not a replacement, then an enhanced refinement to bar coding.

application of RFID technology is the SIM (subscriber identification module) card utilised within that equally ubiquitous device: the cell phone. According to EuroSmart, RFID tag sales to the telecom sector accounted for nearly three-quarters of the 1.9 billion shipments of RFID (Smart) cards in 2003.

Prior to the Wal-Mart mandate of 2003, supply chain barely registered as a viable RFID application, or as a viable RFID market. With the degree of segmentation in the market, just how promising, let alone profitable, could any one application or even collection of applications be? As enticing and intoxicating as the market may be now, for those that would rush out and slap RFID technology on every application that comes along, it is perhaps prudent to pause and remember the recent dotcom and telecom businesses that were equally promising, and yet are no longer with us.

Frequency

RFID operates via the emitting of a radio signal at a specific frequency. Different frequencies have different technological characteristics, with lower frequencies generally involving lower cost, less complexity and slower transmissions. The technological limitations/capabilities of a particular frequency have tended to restrict the utilisation of a particular frequency to a particular application or set of applications. This in turn has also meant that, as a practical matter, RFID manufacturers and suppliers have been restricted in their economies and efficiencies of scale, even if they ended up supplying product across a range of frequencies.

The connection between frequency and application is governed by its own matrix of factors, historical, economic and technical. Commercial application and use of RFID began first in the low frequency ranges, so this is now the most familiar and reliable. Low frequency RF signals are the most robust as they are less susceptible to absorption (degradation) around metal and liquids, which, together with a low cost base, makes them a preferred mode for use across a number of applications. Currently, the UHF band is the signal of choice, with a capability to read multiple tags very quickly (up to 1,000 tags/second) at relatively long distances.

Allocation of the radio frequency spectrum is controlled by national governments. One of the problems with UHF is the lack of standardisation across countries. Acceptable frequencies range from 868 MHz in Europe, to 915 MHz in the United States (France restricts 915 MHz to military applications) and 956 MHz in Japan. Some countries do not allow RFID systems to operate in the UHF band at all.

The economic and operational trade-offs due to frequency characteristics means no one frequency range is appropriate for all RFID applications. RFID suppliers, standards bodies and even end-users recognise they must choose a particular frequency to match a particular application, accepting its limitations and capabilities. Yet they must also recognise the further development to optimise RFID tags and readers for an application at a particular frequency may mean less applicability to other applications that also utilise that same frequency.

RFID standards

In general, the goal and role of standards is to establish broad conformity in terms of interoperability so as to encourage competition, promote manufacturability and user acceptance, thus lowering costs, spurring innovation, and increasing the size and growth of the market. By some accounts there are more than 140 standards that apply to RFID, and almost as many standards-setting organisations. Because of the broad and diverse application of RFID, some standards

RFID market matrix

		Applicable standards	
Application	**Frequency**	**Technical**	**Functional**
Animal tracking	<150 kHz	ISO 11784/85	ICAR, various governments
Transit	13.56 MHz	ISO 14443A,B ISO 15693	MIFARE, Calypso, UTFS, ITSO 2.1
Financial	Varies	ISO 7816	EMV
	13.56MHz	ISO 14443A,B ISO 15693	EMV, MIFARE
Supply chain	830 - 950 MHz	ISO 18000-6, EPC Global	EPC Global

apply only to a particular application or industry, country or even function – which would in part appear to defeat the purpose of standards setting.

One tends to think of standards as generally covering technical issues: physical characteristics, specifications, data format, software command codes, security, etc. But within RFID, the standards are also functional, relating to a particular business application, naming or identification schemes, or particular countries. And the standards setting organisations themselves reflect the same specificity, comprising various technical and non-technical representatives from industry and trade associations, national and regional governments, and even public interest groups and individual citizens.

As might be expected, different standards and their organisational bodies can sometimes come into conflict. Unfortunately more times than not this has simply meant an additional layering of standards.

One recent conflict, with huge implications, which has been generating a good deal of attention involves one of the oldest and one of the newest standards setting organisations, the International Standards Organisation (ISO) and EPCglobal Inc (a recently formed joint venture between EAN International and Uniform Code Council, the standards setting and governing bodies of bar codes) respectively. At stake is the interoperability and cost-effective applicability of RFID as the information backbone of the global supply chain industry.

The point is that while standards setting is a critically important function, not only from an operational or even public safety standpoint, it can be a long and complicated process, made all the more arduous by the consensus nature of the process and the multiple and oft-times contradictory interests of the participants. At times it appears that standards and standards setting bodies can just as likely be an impediment to market development as an enabler.

This way to market

Whether and how a particular RFID application navigates the shoals from concept to market depends on the combination and interaction of the factors mentioned above. Below are several examples of alternative permutations of the three variables and the resulting RFID markets they conceived.

Frequency FARE

Initially acquired and subsequently enhanced by Koninklijke Philips NV in 1996, the MIFARE technology was the first significant RFID application targeted specifically to 13.56 MHz frequency. MIFARE® went on to become the ISO 14443A standard, and the technology of choice for secure-memory, high-throughput transit fare applications. It has since morphed into several distinctive variants, and in the process has become a platform for a variety of applications – including airline ticketing, security access and toll collection – all driven by the efforts of its user community and Philips. Today, the MIFARE community consists of more than 260 participant users, and MIFARE is widely recognised as the leading technology for contactless Smart cards, with more than 80% of the transit fare market. Overall, according to the MIFARE website, more than 250 million MIFARE tags and 1.5 million readers have been deployed since its inception in 1997.

At one point, 13.56 MHz was thought to be the gold standard for RFID transmission; however, of late it has lost some of its lustre to the UHF band.

Application mandate

A contrast to a frequency-led pathway is the experience of EMVCo and its EMV 4.1 specifications for automated financial payments system. Formally established in 1999 (although initiated as early as 1996) as a cooperative and jointly owned venture by MasterCard International and Visa International (and most recently JCB Co Ltd of Japan), EMVCo is an example of a business application in search of a standards organisation and its technical standards.

EMV standards were initiated in response to the increasing level and threat of electronic payment and credit card fraud, with RFID technology offering a more secure environment than the existing magnetic strip

RFID buy-in

	Smart Card Shipments (Millions of units)		
Sectors	**Memory**	**Microprocessor**	**Total**
Telecom	800	670	1470
Financial services/retail/loyalty	35	205	240
Government/healthcare	20	40	60
Transport	50	12	62
Pay TV	-	35	35
Corporate security	4	7	11
Others	10	10	20
Total	**919**	**979**	**1,898**

Source: EuroSmart, 2003

Top US patent assignees RFID, tags & readers only
1988 - present

Intermec IP Corp	52
Texas Instruments	45
Gemplus	40
Amphenol Corporation	37
STMicroelectronics SA	34
Philips Corp	33
Siemens AG	31
Tyco Electronics Corp	31
ITT Manufacturing	28
Checkpoint System Inc	20
Infineon Technologies	19
Motorola Inc	16
Symbol Technologies Inc	12
Giesecke & Devrient GmbH	10

Source: *IP Economics*

payment system. The international credit card companies have forced the adoption of EMV and RFID technology by shifting liability for fraud to banks and other creditors for transactions not conducted over EMVCo approved terminals beginning 1st January 2005 in much of Europe, the Middle East and Africa; and in Asia beginning in 2006.

EMVCo has attempted to ease the sting (if not the cost) of its mandate by wrapping its set of application-specific processing requirements and certification procedures around the existing well-established, widely adopted (and therefore lower-costing) ISO 7816 standards for integrated circuits with contacts, ie, Smart cards. The 7816 standards have been thoroughly vetted and universally accepted by manufacturers, end users and service integrators for a variety of applications. The adoption and implementation of RFID-enabled payment systems by banks and retailers, while unlikely to be painless, should at least be smooth.

Visa International estimates that as of 2003, more than 100 million Visa EMV Smart cards had been issued globally, along with two million EMV-compliant point-of-sale terminals. MasterCard claims to have issued more than 200 million EMV Smart cards.

Standards compromise

Despite the mandates by Wal-Mart and the US Department of Defence, and others, RFID supply chain hangs in the balance awaiting some compromise or truce between the ISO and EPCglobal Inc.

EPCglobal Inc, while the smaller and younger of the two, has emerged as the leading standards-setting organisation for RFID supply chain. Primarily focused on the code structure and object naming scheme for participating end users, EPCglobal has established it own communications protocols (air interference). In the process, it has run straight up against the International Standards Organisation, the world's leading technical standards body, and its own ISO 18000-6 protocols, and the identification structure already in existence and utilised in other RFID applications.

Despite the fact that several major supply chain initiatives have already been launched (Metro AG, a European supermarket, and Gillette, a US razorblade maker), both RFID manufacturers and end users are seeking reassurance that differences between the two standards groups will not impinge interoperability or manufacturing cost efficiencies.

The two organisations, which share a number of the same members, both recognise that for the sake of the market there must be some resolution. As of January 2005, a proposed compromise was tabled that, if mutually adopted, would ensure that ISO-compliant tags and readers will be able to identify and accept the naming and identifications schemes of each organisation.

So what are we to make of the smoke signals coming from the RFID camp?

- Is the supply chain industry the saviour for RFID technology?
- If so, will manufacturers/suppliers abandon/ignore other, smaller segments?
- Is UHF the holy grail for signal transmission?

Technical specifications

RFID
Frequency characteristics

	Low (LF)	High (HF)	Ultra (UHF)	Micro
Freq range	10 - 150 kHz	13.56 MHz	830 - 960 MHz	2.4 GHz, 5.8 GHz
Read range	2cm - 200cm	up to 3m	up to 7m	up to 30m
Cost, relative	Inexpensive	Moderate	Potentially low	Expensive
Advantages	Inexpensive		Multi-tag read	
	Able to read near metal, liquid	Tags printable to paper, Item-level tracking	High tag/read ratio, fast read rate	Long read range
Disadvantages	Slow read rate			
	Copper antenna, small memory	Unable to read near metal	Unable to read near metal, liquid	Expensive, line of sight

Source: *IP Economics*

- What can new or emerging applications learn from past actions to speed through from standards development to market?

RFID and IP

The message for IP managers is clear: stay attuned, not just to the development of future applications, but also to the current market(s) and the existing stock of RFID patents.

Within the overall RFID market there are literally thousands of patents, most of which are specific to certain applications. According to research by the authors, since 1988 there have been nearly 500 patents issued specific to the technical operation or manufacture of tags and readers. These patents represent a substantial investment of intellectual and financial capital on the part of a number of companies. With standards organisations such as ISO and EPCglobal typically requiring members to make available patents essential to the standards on a royalty-free or equitable (ie, reasonable and non-discriminatory, RAND) basis, it may not be in the best interests of some companies to participate.

Intermec Corporation recently announced that it was withdrawing some of its IP that it has determined as essential to recently approved (Generation 2) standards from EPC and that it is actively pursuing licensing agreements with RFID companies on a non-RAND basis. Earlier, Intermec had filed a patent infringement suit in the US against one of its competitors, Matrics, which was subsequently acquired by another RFID company, Symbol Technologies. Intermec is still pursuing the infringement.

SamSys Technologies has similarly announced that it will defend and pursue licensing of what it considers fairly broad claims of its multi-frequency, multi-protocol RFID reader patent.

As Wal-Mart, the Department of Defence, and others are about to launch their RFID initiatives will other patent holders come forward to assert their IP rights? If these and other patent assertions are put forward leading to a stacking of royalty rates and/or a rise in tag/reader prices, the next sound that we hear may be that of the implosion of the RFID market.

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Standards organisations

There are scores of standards-setting organisations that are or are likely to come into existence with regards to the application and operation of RFID. In general, these organisations can be broken down along technical, industrial/application or governmental lines. Below is a small sampling of the standards-setting organisations directly or indirectly involved in RFID.

Technical
- International Standards Organisation (ISO)
- International Electrotechnical Commission (IEC)
- EPC Global Inc (Electronic Product Code)
- EAN International (European Article Numbering) – soon to be GS1
- Uniform Code Council (UCC)
- European Telecommunications Standardisation Institute (ETSI)
- American National Standards Institute (ANSI)

Industrial/application
- EPCglobal Inc (supply chain)
- International Commission on Animal Recording (ICAR)
- EMVCo (financial payment system)
- Calypso (transit)
- MIFARE (user community, Philips)
- Universal Transit Farecard Standards Task Force (UTFS) (transit)

Governmental
- US Dept of Defence, Unique Identification (UID) initiative
- US National Institutes of Standards and Technology (NIST)
- British Standards Institute (BSI)
- Standards Australia (SAA)

Two of the premier standards-setting bodies are the International Standards Organisation (ISO) and EPCglobal Inc. The ISO is the world's largest developer of standards and a non-governmental network of the national standards institutes of 148 countries. Its members are both public and private sector institutes, or are mandated by their government. ISO is able to act as a bridging organisation in which a consensus can be reached on solutions that meet both the requirements of business and the broader needs of society, such as the needs of stakeholder groups like consumers and users.

The EPCglobal Network is a system comprised of the Electronic Product Code (EPC), RFID technology and supporting software based on EPCglobal standards. It merges RFID technologies with the internet. The EPCglobal Network was born as a direct result of the then AutoID labs commercialising the Electronic Product Code (EPC) by partnering with two international standards bodies, EAN and UCC.

The EPC is a number made up of a header and three sets of data, as shown below. The header identifies the EPC's version number – this allows for different lengths or types of EPC later on. The second part of the number identifies the EPC manager – most likely the manufacturer of the product the EPC is attached to, for example, The Coca-Cola Company. The third, called object class, refers to the exact type of product, most often the stock-keeping unit, for example, Diet Coke 330 ml can, US version. The fourth is the serial number, unique to the item – this tells us exactly which 330 ml can of Diet Coke we are referring to. This makes it possible, for example, quickly to find products that might be nearing their expiration date.

Example of EPC

01.115A1D7.28A1E6.421CBA30A
01 Version of EPC (8 bit header)
115A1D7 manufacturer identifier
28 bits (> 268 million possible manufacturers)
28A1E6 product identifier
24 bits (> 16 million possible products per manufacturer)
421CBA30A item serial number
36 bits (> 68 billion possible unique items per product)