RFID chips: Future technology on everyone's lips

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Radio frequency identification (RFID), the technology of the future, has long established itself in our everyday lives. It is already deployed in various areas ranging from efficient inventory management and road toll collection through to timing the performance of individual participants in mass sporting events. Given RFID's enormous potential it is only right that it is on everyone's lips.

RFID chips combine the physical world of a product with the virtual world of digital data. The technology meets the needs of companies cooperating in a closely knit value chain. RFID will soon be considered an indispensable part of the chain.

Inefficiencies in the value chain and efforts to shore up internal security are driving demand for RFID. The retail trade is playing a decisive part in the broad-based roll-out of RFID projects.

RFID represents an all-encompassing structural business concept that far transcends simply superseding the bar code. Speed of processing, reading error frequency, data protection and privacy issues, progress in standardisation, and investment costs are still challenges that will ultimately decide the potential of RFID. RFID projects focussed on transparency, reliability or speed of processing are particularly successful.

RFID systems will rapidly continue to gain significance. This holds especially in areas where they can be used to manage processes within the value chain. All told, the market for RFID systems is likely to grow globally from EUR 1.5 bn to EUR 22 bn between 2004 and 2010 (average growth rate: +57% p.a.). During the same period, the RFID market in the EU-15 is expected to expand from EUR 0.4 bn to EUR 4 bn (+47% p.a.).

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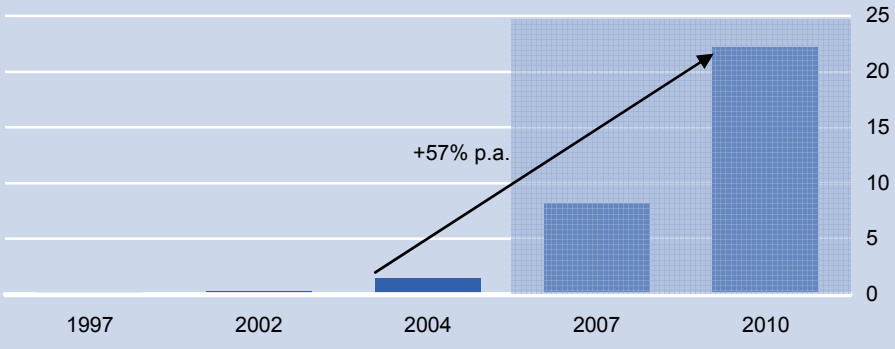
World RFID market is flourishing
Revenues, EUR bn



Source: DB Research, 2006

Vision of "the internet of things"

Radio frequency identification (RFID) technology builds a bridge between the physical world of a product and the virtual world of digital data.[1] The technology thus meets the demands of companies cooperating in a closely knit value chain and is being deployed promisingly in all sectors of the economy. Elgar Fleisch in Zurich already has visions of RFID emerging as "the internet of things". He envisions a future in which objects will grow together to form a global, omnipresent cognitive and nervous system for the real world. Such grand visions have awakened public interest in RFID.

RFID in everyday use

The idea of RFID is, however, not really brand new. Back in the second world war the predecessor of RFID helped the allied forces distinguish between friend and foe when aircraft and ships approached. RFID is still deployed for military uses today. Beyond military applications RFID is also in broad civilian use. As it is becoming part of everyday life, the public takes particular notice of the involvement of the retail trade. More and more products are being fitted with RFID tags.

RFID: Long a reality

RFID used for sovereign functions, product innovations, and distribution, inventory management and logistics

RFID has long been an integral part of totally diverse fields. At this juncture we shall outline a few RFID projects. They can be broken down into the following subject areas: sovereign functions, product innovations, and distribution, inventory management and logistics.

RFID helps in sovereign functions

— Hitachi, the Japanese electronics company, has developed an extremely tiny chip it calls the *mu-chip*; it is reportedly able to make money counterfeit-proof.

— The US Secretary of State requires that all US passports issued after October 2006 contain an RFID chip. The 64-kilobyte chip is meant to make passports impossible to forge.

— New German passports issued since November 2005 contain an RFID chip. For the time being it can only store the usual ID information, but from 2007 it will also be able to store biometric features.

Product innovations with RFID systems: Broad spectrum

— Worldwide, product counterfeiting causes financial damage of USD 100 bn p.a. Lifestyle pharmaceutical products, especially, are continually the target of the counterfeiters. *Pfizer* plans to start putting RFID labels on the packaging of its blockbuster product *Viagra*. Using a reader retailers can then check whether the contents are genuine.

Long list of potential uses

— New York's *Jacobi Medical Center* has its patients wear an RFID wristband. The idea is that the stored medical data will enable more efficient treatment.

— *DaimlerChrysler* offers a child seat with RFID. The chip controls the airbag pressure, helping to prevent injuries to small children.

— Austria's road toll system uses stickers with an integrated RFID chip.

— At *Legoland* in Billund, children have to wear an RFID wristband. It enables the park administration to track missing children.

[1] See Heng, Stefan (2004). Rising stars in information and communication technology. Deutsche Bank Research. E-conomics No. 46. Frankfurt am Main.

— *FIFA* will implant an RFID chip in tickets to the 2006 World Cup football matches in Germany. The organisers hope this will cut down on the number of cases of theft, counterfeiting and black-market trading of tickets.

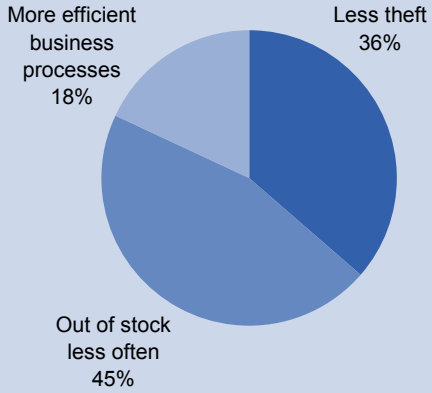
— The *ChampionChip* produced by the eponymous Dutch electronics company has been an established feature at running events around the world since the 1990s.

— The *Baja Beach Club,* a discotheque in Barcelona, uses RFID chips as a club card for cashless payments. The club injects a chip under a member's skin using a syringe.

RFID in distribution, inventory management and logistics: Efficiency is key

The RFID projects hold out enormous potential for efficiency gains in process management and warehousing. For example, *Siemens* calculates that a medium-sized distribution centre could achieve savings of EUR 500,000 p.a. It says about 5% of this sum would come from reducing personnel costs. The lion's share would be achieved by reducing the number of incorrectly loaded pallets. *Soreon,* a commercial market research institute, also sees positive effects for retailers. According to *Soreon,* customers would seldom find empty shelves when looking for merchandise because ordering would be more efficient using RFID. The company's analysis determined that 45% of savings and earnings would come from fewer items being out of stock, 36% from reduced theft and 18% from organising business processes more efficiently (chart 1).

Enormous upside potential for retailers
Savings and earnings analysis, stylised RFID retail project



Source: Soreon Research, 2005 **1**

RFID: Savings from improved management of resources

— *Marks & Spencer* attach RFID tags both to entire pallets and individual pieces of clothing. The aim is to raise the efficiency of inventory management.

— Since 2003, *Metro Group* has been testing the use of future technologies at its Future Store in Rheinberg. *Metro* reports that the volume of out-of-stock articles has fallen by 14%, and shrinkage by 18%.

— Together with *Gerry Weber, Kaufhof* is testing an "intelligent" changing room at its Innovation Center in Neuss. The RFID tag transmits product-specific information which is then displayed on a merchandising screen at the changing room.

— *Airbus Industries* has adopted a policy of only lending RFID-tagged precision tools to partner companies. Since then, far fewer of the expensive tools have disappeared.

— In 2005, the *US Department of Defense* rebased its pallet logistics management on RFID tags.

— The *Vatican Library* has RFID-tagged 2 million books and manuscripts. This has considerably raised the efficiency of inventory and lending procedures since then.

— *Volkswagen* Group transports chassis components in RFID-tagged containers. This enables *VW* to reduce shrinkage by one-third and save EUR 5 million p.a.

— In a joint project, the *Frankfurt* and *Tokyo* airports are switching their baggage-handling facilities to RFID technology.

In some quarters, people are proclaiming that the RFID projects herald a change of regime away from the over 40-year-old bar code. However, the projects are actually far more extensive than mere substitution. RFID represents an all-encompassing structural business concept. Most of the players who take the plunge with this

concept report very positive results. They point above all to their success in combating criminal activity and raising the transparency and reliability of business processes.

RFID systems: A look inside

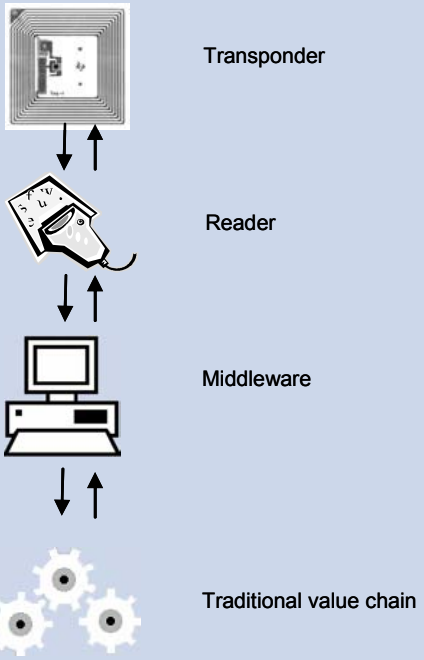
Leaving aside the variety of RFID projects implemented, all such systems have some elements in common. All RFID systems generally consist of a transponder, a reader, a database and a software program (also referred to as middleware) for processing the data collected (chart 2).

Open or closed system: Relevant for the degree of freedom

The following stylised concepts show the difference between open and closed RFID systems. Unlinked closed systems are defined for a unique, delimited environment. Since the system runs completely on its own, the individual components (e.g. the software's data format, the frequency area or the type of transponder) can be chosen freely and thus coordinated optimally with internal demands.

By contrast, open systems have interfaces to other systems outside their own area of definition. The degree of complexity in open systems rises rapidly with the number of partners to be integrated. One concrete requirement is the interoperability of the systems run by all the partner companies along the value chain. To this end, the transfers of data between the reader and the subsequent business applications, such as enterprise resource planning (ERP) or a warehouse management system (WMS), must function seamlessly.[2]

RFID chips integrated in the value chain



Source: DB Research, 2006 **2**

Transponders differ in many ways

The RFID transponder (from "transmit" and "respond"; also referred to as a tag, label or smart label) is made up of a silicon memory chip and a copper or aluminium antenna. To protect them from impurities transponders are often sealed in paper or foil covers.

There are active and passive transponders. These differ in terms of memory capacity, form, type of material and rewriteability. Unlike passive transponders, active transponders can transmit signals independently and in fact in some cases perform arithmetical operations. As they have their own power source, they can usually transmit radio signals in a radius of up to 30 metres.

Key transponder criterion: Active or passive

In contrast to active transponders, passive transponders usually only work within a radius of five metres at the most, but they perform convincingly thanks to their more or less unlimited lifetime and their low price of less than a few (euro-)cents. Passive transponders have less sophisticated technology. They have no energy source of their own and only pass on their information if "addressed" by an electro-magnetic reader.

The transponder usually transmits a 96-digit serial number. The first digit of the series identifies the type of transponder, the rest refer to product information such as article number, date of production, size and colour. This ID number can also be used to link up to a data-base. Beyond the limited data memory in the transponder itself, it provides access to a more or less unrestricted spectrum of in-formation in a database.

[2] See Floerkemeier, Christian and Matthias Lampe (2005). RFID middleware design – addressing both application needs and RFID constraints. In Cremers, Armin B. et al., (ed.). Informatik 2005: Informatik Live. Bonn. pp. 277-281.

Despite all the variety: Same keys to successes

Five keys to success

As discussed, RFID systems differ in respect of many elements. Despite this variety, we can identify five factors that determine the potential success of all RFID systems:

— Processing speed

— Reading error rates

— Observance of data protection and privacy issues

— Progress in standardisation

— Investment costs

Price of megabit of DRAM

Year	Price (Euro)	Equivalent value
1973	75,000	
1977	5,000	
1981	400	
1984	130	
1987	20	
1990	7	
1995	3	
2001	0.08	
2005	0.03	
2017	0.01	

Sources: BMBF, DB Research, 2004

3

Costs: RFID benefits from falling price of memory chips

The success of RFID technology in the mass market mainly depends on chip prices. At present, the price of transponders narrows the scope of RFID deployment to really high-priced goods. Those in the textiles industry, for example, assume that RFID systems will not be worthwhile until the transponder costs less than 2% of a good's selling price. Depending on the batch size required, a passive transponder now costs between EUR 0.05 (over 1 m units) and EUR 10 (less than 1,000). If technological advances continue to knock down the price of IT hardware, RFID technology will become attractive to the mass market by 2010 (chart 3).

Standardisation paves way to new business potential

Besides the price, efforts to standardise procedures will be key in deciding the success of RFID technology. This is an area in which a private-sector initiative, EPCglobal, is making an important contribution worldwide. The European, American and Asian EPCglobal representatives focus not only on the software data format in transponders but also on their transmission power and frequency range. This perspective is obvious since the business potential of the RFID system hinges directly on transmission power and frequency range. Since 2004 the EU has also allowed RFID use in the ultra-high-frequency (UHF) range, which is particularly suited for this application. The use of this bandwidth will significantly widen the scope of deployment for RFID technology in Western Europe. However, the RFID systems in the EU have to make do with comparatively low transmission power at 0.5 of a watt (US: 2 watts). This regulatory limitation on the power level in Europe reflects consumers' concerns about electro-smog. It automatically implies a shorter transmission range and as a consequence narrowly limits the business potential of RFID systems, however.

Data protection: Often put on the back burner, but still essential

As more or less with all new technologies, the suppliers of RFID systems have so far mainly sought a cheap way to put them into practice. In most cases they have not attached very high priority to the security aspect. The acceptance of RFID chips is still directly linked, though, with how the security standards are upgraded and the news communicated. The missing solution has to go beyond digitally encrypting stored data. However, the demand for more security drives up the direct costs and thus obstructs – for the time being at least – the use of RFID in the mass market.

The application of RFID opens up new avenues for third parties to invade users' privacy. For improved protection of the private sphere, consumer organisations have appealed to retailers only to deploy transponders that can be deactivated. However, bear in mind here that the deactivator does not, for technical reasons, delete the

From invasion of privacy to sabotage

identification number of the transponder altogether. This means that the transponder can clearly also pass on information even after it has been deactivated. Nevertheless, the near-realisation of the horror scenario in which the actions of a "transparent customer" can be traced at any time has to be put into perspective. The possibilities for monitoring others with RFID tend to be exaggerated. This holds particularly for passive transponders, as they have an extremely low transmission range of five metres maximum.

Invasion of privacy is not the only issue having to be addressed in the context of RFID systems, though. Sabotage could also be a problem. The calls for enabling RFID transponders to be deactivated can also be a disadvantage for retail buyers and sellers, for only rewriteable transponders can be deactivated. Therefore, product data and metadata might also be changed for purposes other than originally intended. For example, with rewriteable transponders there is a risk that the "Best before" date of perishable goods is manipulated after being set. Besides, a cyberspace saboteur could cause retail products to "spoil" or "be altered" or else change information on prices and age restrictions (for goods requiring parental guidance).

Conflicting demands: High security level versus low price

The RFID market is faced with the conflicting demands for cheap solutions on the one hand and guarantees of high-level security, which is predicated on additional investment, on the other. Only the division of investment costs harbours considerable potential for conflict if there is a large difference in the distribution of market power between suppliers and customers. Large retail chains demand, for example, that their suppliers shoulder the cost of equipping products with RFID transponders. In this situation much of the cost is borne by an economic agent other than the one enjoying the savings attained by using RFID. The distribution of market power thus largely determines the pace at which the systems spread among the potential RFID users.

Reading errors: Knowing the vulnerable points

Clearly define project environment to prevent reading errors

While sequential selection functions very satisfactorily with RFID transponders – up to 200 tags can be read per second – parallel selection (bulk selection) is less dependable, with about every fourth transponder not being recognised properly. The material environment can cause screening and reflection effects which in turn evidently influence error frequency. For example, many more errors are registered in the presence of metals and fluids. Therefore, the RFID system must be very closely coordinated with its environment in order to avoid system breakdowns from reading errors.

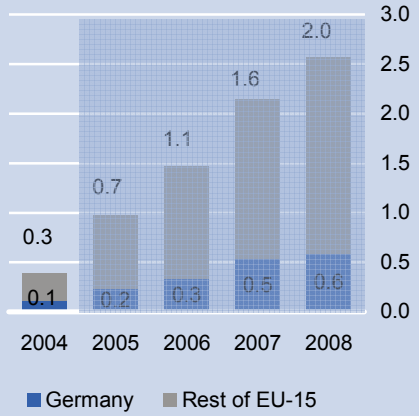
Processing time: RFID based on rapid response

RFID projects still face major challenges above all as the interface to ERP systems. The problems appear especially when large batches of data, which are typical of RFID systems, are being processed. New information may possibly be processed too slowly, obstructing attempts to attain rapid responses and thus undermining a major argument for RFID systems. Software houses are racing to develop systems that prioritise data sensibly and arrange it in a way that enables rapid reaction times.

RFID market has excellent prospects

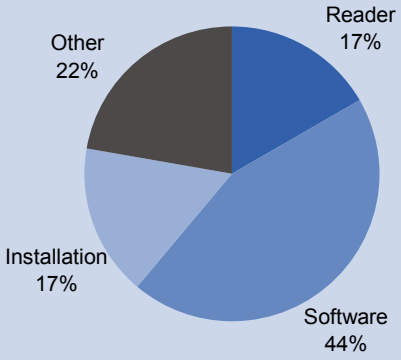
Once the bugs in current software development have been eliminated, RFID systems will quickly obtain a crucial role in managing processes throughout the value chain. This increase is

Strong growth in the EU-15
Number of RFID tags in retail segment, m



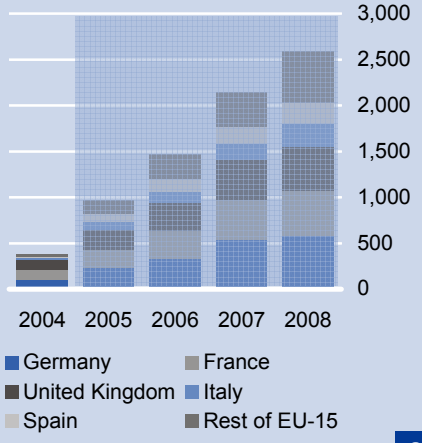
Source: VDC, 2005 **4**

Software is the biggest cost factor
Cost analysis of a stylised RFID retail project



Source: Soreon Research, 2005 **5**

DE, UK and FR leading the EU-15
RFID investment in the retail segment, EUR m



Source: Soreon Research, 2005 **6**

particularly attributable to the wide use of the technology in the retail segment. VDC, a US-based commercial market research institute, forecasts that over 2.5 m RFID tags will be in use in the retail trade of the EU-15 by 2008; they claim that nearly one-quarter of the tags will be deployed in Germany alone (chart 4).

Among the RFID projects, the relative significance of hardware as a proportion of total RFID project costs is usually overestimated today. According to Soreon Research, software and installation services account for nearly two-thirds of project costs (chart 5). Going forward, RFID software and services will gain significance. These two RFID submarkets are growing much more dynamically than the submarket for RFID hardware. By 2010 the market for RFID software will grow fastest with an average compound annual growth rate of 60% p.a., followed by RFID services (average growth rate: +50% p.a.) and RFID hardware (+20% p.a.).

Germany is the European leader in investment in RFID projects, ahead of the UK and France. However, these three big countries' share in total investment volume in the EU-15 is shrinking to the advantage of smaller countries. Soreon Research says that, combined, Germany, the UK and France accounted for close to 90% of the total investment in this area in the EU-15 in 2004. This reading is set to fall to only 60% in 2006 (chart 6).

This shift of weight away from the early adopters to the volume market shows that the RFID technology is maturing and diffusing rapidly. Ultimately, the overall market for RFID systems (services, hardware and software) is likely to grow globally from EUR 1.5 bn to EUR 22 bn between 2004 and 2010 (average growth rate: +57% p.a.). During the same period, the RFID market in the EU-15 will expand from EUR 0.4 bn to EUR 4 bn (+47% p.a.). (charts 7 and 8)

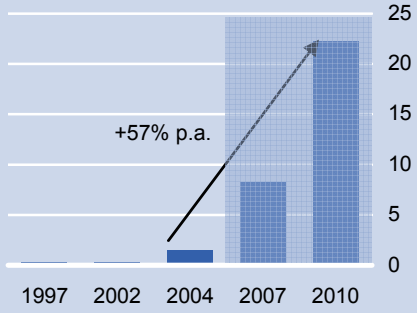
Conclusion: Future technology has long established itself in our everyday lives

RFID chips combine the physical world of a product with the virtual world of digital data. The media celebrate RFID as a technology of the future, but RFID has long been established in our everyday lives. From registering vehicles in road toll systems to timing the performance of individual participants in mass sporting events, many RFID projects have already turned into reality. The inefficiencies in production and inventory management and the struggle to combat crime in all segments of the economy only encourage broader interest in RFID.

RFID represents an all-encompassing structural business concept. This concept goes far beyond the change of regime away from the bar code. Successful RFID projects are not to be had as cheap standard solutions, but instead have to be configured especially for each area of deployment. They can be broken down into the following subject areas: sovereign functions, product innovation, and distribution, inventory management and logistics.

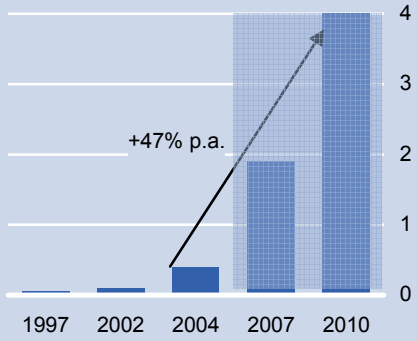
With their large degree of freedom, unlinked closed systems have long been particularly successful on the production line. In open systems, by contrast, the five aspects of processing speed, reading error frequency, observance of data protection and the private sphere, progress in standardisation and the cost of investment still pose major challenges. In standardisation, not only software data formats but also the transmission capacity and frequency range of the RFID tags are in the spotlight. Transmission power and

World RFID market is flourishing
RFID revenues, EUR bn



Source: DB Research, 2006 **7**

Burgeoning growth in EU-15
RFID revenues, EUR bn



Source: DB Research, 2006 **8**

frequency range decide the transmission range and thus the business potential of RFID.

Transmission power in particular is an area where the interests of system users rapidly come into conflict with the interests of the consumer. The current regulatory limit on transmission power in the EU pays particular heed to consumer fears about health problems triggered by electrosmog. In the short term this consideration comes at the price of limitations on the business potential. In the long term, though, the regulatory limits could considerably broaden the acceptance of the technology and strongly enlarge the market's potential. The reason is that paying attention to the consumer's fears will play a big role in the success of RFID. However, besides the health problems caused by electrosmog there are also equally serious worries about the invasion of privacy. Even though the horror scenario of the "transparent customer" that can be traced at all times has to be put into perspective, security concepts are required that can largely rule out unauthorised access to and manipulation of stored data. The demand for RFID that can be deactivated is inadequate, for these tags in fact offer new ways to invade the consumer's privacy and to commit sabotage.

The viability of RFID for the mass market is dependent on reconciling the conflicting demands for cheap solutions and guarantees of high-level security, which is predicated on additional investment. When implementing RFID projects in the mass market, retailers will play a crucial role. However, beyond deployment in the retail market, RFID will soon be considered an indispensable part of the entire value chain in all sectors of the economy.

By 2010, the market for RFID systems should expand to EUR 22 bn worldwide, and EUR 4 bn in the EU-15. Two sub-segments, RFID software and RFID services, will continue to develop much more dynamically than the RFID hardware segment. The technology will also diffuse regionally. The growth will spill over from the countries of the technological leaders to the broad global market. All in all, RFID – a technology with future promise – has long been an everyday fixture. Given RFID's enormous potential it is only right that it is on everyone's lips.

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