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# RFID IN JUNE 2005: A FUNDAMENTAL INNOVATION FOR THE RETAIL INDUSTRY

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## Abstract

In 2005, radio frequency identification (RFID) was quite new in the way it could be applied massively to supply chains. RFID was based on a small computer chip, no bigger than a grain of sand, with an antenna, called an “RFID tag” or “smart chip.”<sup>1</sup> The chip stored a number sequence, to a certain degree similar to the barcode. The numerical code was read with a special reader that “woke up the tag” without being in the line of sight. The reader was connected to a database that decrypted the number and categorized the smart chip accordingly. The system then provided information on product-specific properties such as manufacturer, price, weight, best-before date or any relevant data that might have been supplied to it. The smart chip went beyond traditional barcodes by adding the possibility of individually encoding each product unit with specific attributes.

A number of clear benefits of this technology emerged automatically. With the smart chip, different stakeholders could control the path of the goods from production to store shelves. This capacity could make a reality of the vision of a supply chain perfectly driven by demand. RFID could also improve quality assurance in logistical operations; an efficient warehouse management; a quicker and more precise control of inventory. RFID could also offer consumers comprehensive service information on product characteristics or could accelerate checkouts for a more convenient shopping experience. If smart chips could be implemented at item level, they would open up an amazing variety of possibilities for customization of the shopping experience while improving retailers’ processes.

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**Keywords:** Supply Chain Management, Warehousing, Retail Management, Technology, Innovation, Inventory Control

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<sup>1</sup> Other synonyms that we have found in the specialized literature are transponder, EPC tag and EPC chip.

## **RFID IN JUNE 2005: A FUNDAMENTAL INNOVATION FOR THE RETAIL INDUSTRY**

### **Antecedents: From Price Stickers to Barcodes<sup>2</sup>**

It is not hard to remember when brightly colored price stickers were stuck manually to products. Employees in the store priced each item as they loaded the shelves. When promotions were in place, they had to re-price all the items. The cash registers at the check-out were like calculators. The cashier typed prices and units and got a total amount. The receipt just contained the number of items, price per item, subtotals and the total amount. Information on concrete acquired products was not collected. That lack of information added additional tasks when controlling stock. When processing the incoming goods, the retailer had the information in terms of units and cost of goods. At the checkout they just got information on total sales value. Continuous inventories needed to be run to control stocks and to get accurate information on units sold. Stores needed to close for inventory taking, with a consequent loss in sales and an unproductive burden of manual labor used in stock taking.

A great advance in the retail industry came with the introduction of barcodes, laser scanners and intelligent cash registers connected to the merchandise management system. When a manufacturer sold a new product to a retailer, it filled out a product information form. On that form the manufacturer placed the product and company information as well as the EAN.UCC barcode number. The retailer assigned a price, promotions and stocks to the EAN code in the merchandise management system. This way, when the cashier scanned the barcode, the computer called up the form, and product information, including price, was automatically retrieved. Furthermore, units were discounted from stock levels at the merchandise management system. There was nothing mysterious about the black bars of the barcode. The bars were simply another way of representing the EAN.UCC number that identified a type of product (for example, a half-liter bottle of Coca-Cola Light with lemon). If barcodes were printed at 300dpi or higher, the EAN.UCC number could be read by a laser scanner and automatically translated into the product type. To make this happen, all retail products required the same type of identification number. In February 1977, the EAN association was formed to develop a uniform and standard numbering system for Europe, similar to the Universal Product Code (UPC) system that was in operation in the U.S. As a result, a compatible system called “European Article Numbering” was created. The EAN Association’s aims were the development of a set of

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<sup>2</sup> Information from press releases, EAN, EPCglobal, Eurocommerce, IBM and METRO Group.

standards enabling the efficient management of global, multi-industry supply chains by uniquely identifying products, shipping units, assets, locations and services. The EAN.UCC system standardized barcodes, electronic data interchange (EDI)<sup>3</sup> transaction sets, XML schemas,<sup>4</sup> and other supply chain solutions for more efficient exchange of information among businesses. By administering the assignment of company prefixes and coordinating the accompanying standards, GS1, the body that substituted the original association, maintained a robust identification system across the world of trade and retail. In less than 30 years the barcode was extended to almost all products traded in the world. In May 2005, the barcode was a standard established in more than 120 countries and used by more than 30,000 retail and industrial companies.

## RFID Evolution: From Cattle to Logistics

In 2005, radio frequency identification (RFID) was not new. The technology was invented in 1948 by Harry Stockman, but until the late 1990s it was essentially a technology waiting for an infrastructure. A similar technology was used for the first time during World War II to identify allied aircraft. RFID has been used to collect tolls on motorways, to identify cattle or to open security doors. What was quite new was the way it could be applied massively to supply chains. RFID was based on a small computer chip, no bigger than a grain of sand, with an antenna, called an “RFID tag” or “smart chip.”<sup>5</sup> The chip stored a number sequence that encoded product information. This number was, to a certain degree, similar to the EAN.UCC barcode, and was known as the “electronic product code” (EPC). As basic chips do not require an electrical supply, in principle, they can be manufactured cost-effectively. The smart chip was stuck or integrated into the item that it identified. The EPC numerical code was read with a special RFID reader. The reader sent radio frequency waves. The tag picked up those waves, “woke up” and provided the EPC number to the reader without being in the line of sight. So the tag could be read from up to four meters’ distance depending on the type of smart chip and the type of reader. Data transmission was effected via radio frequency, and several hundred tags could be read in a second. The reader was connected to a database that decrypted the EPC code and categorized the smart chip accordingly. The system then provided information on product-specific properties such as manufacturer, price, weight, best-before date or any relevant data that might have been supplied to it. All this information could be transmitted between different stakeholders, using the Internet.

The Auto ID Center, founded in 1999 at the Massachusetts Institute of Technology (MIT), tapped the RFID engineering prowess and intellectual capital of three of the world’s leading research universities: the Massachusetts Institute of Technology in the United States; the University of Cambridge in England; and the University of Adelaide in Australia. The Center also brought to bear the resources, business acumen, and real-world experience of more than 50 global organizations and companies, including Coca-Cola, Gillette, Johnson & Johnson, Procter & Gamble, Unilever, UPS, and Wal-Mart. This unique partnership between business and academia was in the process of assembling the building blocks needed to create an “Internet of things.” In 2002, the Center came up with a new chip that could store up to 96 bits of information. The algorithm defined provided identification numbers to 268 million companies. Each one could

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<sup>3</sup> The EDI system connects manufacturers’ and suppliers’ systems allowing online orders and also letting suppliers see the movements of stocks along the supply chain by tracking shipping codes.

<sup>4</sup> XML is a protocol that facilitates data interchange and standardizes the integration of different systems.

<sup>5</sup> Other synonyms that we have found in the specialized literature are transponder, EPC tag and EPC chip.

have 16 million object classes and, within each class 68 billion different serial numbers. This seemed to be enough to give a unique identification number to every single item in the world. The smart chip went beyond traditional barcodes by adding the possibility of individually encoding each product unit with specific attributes (e.g. a single half-liter bottle of Coca-Cola Light with lemon manufactured in a specific German bottling plant in May 2005 with an expiry date of May 2010).

## Applications for the Retail Industry

A number of clear benefits of RFID technology emerged automatically. With the smart chip in place at item level, different stakeholders could control the path of the goods from production to store shelves; it was just necessary to read the EPC numbers and transmit them over the Internet. This capacity could make a reality of the vision of a supply chain perfectly driven by demand: sell a product unit, replenish it on the shelf and manufacture another in the plant. RFID could also improve quality assurance in logistical operations as any single item could be localized without visual interference. An efficient inventory and warehouse management could be achieved by having real-in-time information on the stored products, thus lowering warehousing costs. A quicker and more precise control of incoming and outgoing goods could also be gained, and a permanent inventory visibility was also possible, resulting in a high availability of goods. AMR research estimated that US\$3 trillion of inventories were locked into U.S. and European supply chains, which suffered error rates of 20%.<sup>6</sup> RFID could also offer consumers comprehensive service information on product characteristics or could accelerate checkouts for a more convenient shopping experience. If smart chips could be implemented at item level, they would open up an amazing variety of possibilities for individual customization of the shopping experience.

Here are some of the ways companies will benefit from having the ability to track individual items.

**Fewer out of stocks.** Retailers and their suppliers have long struggled with how to make sure an item is always on the shelf when a customer wants to buy it. Today's inventory systems record only what's been sold and what's on the premises. They provide no visibility of what is on – or not on – the shelves. And in the case of clothes, where items have to be stocked in a specific order, inventory systems provide no information about what is in stock but not in the right place. RFID has the potential to dramatically reduce out of stocks. One day, readers installed on store shelves will automatically track every time an item is picked up or put back. When stock on the shelf gets low, the system can automatically alert staff to bring out more product from the back room.

**Better merchandising and promotions.** Readers on the store shelves will provide the first extensive real-time view of customer behavior in the store. By recording how often an item is picked up, purchased or put back, retailers and their suppliers will have instant feedback on promotions. The information can be broken down by product, store, region or chain, providing the means to better tailor promotions to a specific market segment.

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<sup>6</sup> "Keeping track starts it's move," *Financial Times*, 20 April 2005.

**Faster checkouts.** Customers hate long lines. RFID has the potential to finally eliminate checkout lines by making it possible to scan a shopping cart full of goods in seconds. Self-service checkout systems are already catching on in the United States and Europe, and RFID has the potential to make those systems foolproof.

**Lower inventory.** Every company would like to reduce its inventory without jeopardizing potential sales. RFID makes this possible by providing real-time information about not just what's in the store, warehouse and factory, but what material is in the supply pipeline. Knowing with absolute certainty what goods are available and where they are located will give companies that confidence to reduce inventory along every link in the supply chain.

**Reduced shrinkage.** According to the National Retail Security Survey conducted annually by the University of Florida, nearly two percent of total sales in the United States are lost each year due to "shrinkage" – employee and customer theft, vendor fraud and administrative error. RFID can reduce vendor fraud and administrative error by automatically matching the electronic product codes of items arriving or being shipped with those scheduled. It can reduce employee theft by providing real-time information about the movement of products. Perhaps RFID's biggest impact in this area, however, will be reducing shoplifting.

**Anti-counterfeiting.** Manufacturers can greatly reduce losses from counterfeiting by assigning a specific ID number to every item they produce. Any item without an RFID tag is immediately spotted as a fake.

**Better asset utilization.** Any company that invests in hard assets wants to get the most out of them. But today's tracking systems don't provide data about individual units, so it's impossible to know how they are deployed or how they could be used more effectively. RFID changes that by providing real-time information about each unit's location and status.

**Targeted recalls.** When a product has to be recalled, a company typically has to recall all units sold, even if the problem affects only a small fraction of them. That's because there is no way to distinguish which units have the faulty part. With RFID, companies will be able to save millions of dollars by having targeted recalls because they will be able to identify which specific units have a problem.

**More efficient recycling.** Because items can be tracked from the time they are made until the time they are recycled, RFID technology has the potential to improve recycling. Items are more easily sorted. And specific instructions for recycling items that require special care can be stored in a product's PML file.

## Complex International Logistics Needed a Standardized Solution

Modern retail logistics ensured that fresh food was available anytime, anywhere around the world. Even in winter, consumers in Scandinavia could have natural pineapples from Hawaii or fresh bananas from the Canary Islands. Before finally being offered for sale on the shelf, every product undertook a long journey from the manufacturer to the retail company's stores.

Conceptually speaking, with the aid of RFID, movements of goods and events along the entire process chain could be registered and documented automatically. If the manufacturer equipped the cartons and pallets with RFID transponders, an RFID portal at the outgoing goods gate

could check the logistic units. Exhibit 1 shows an RFID transponder and a portal at an incoming or outgoing goods gate.

The reader could transfer the data to the merchandise management systems of the manufacturer and retailer, so both of them would acquire real time information on goods movements. The commissioned goods could be automatically compared with the order and be released for transport within a matter of seconds. The goods would then be taken by truck to the distribution center. Here too, RFID readers could accelerate the incoming and outgoing goods procedures. The readers would scan the information stored on the smart chips of the incoming pallets and cartons so that logistical units would be effortlessly sorted according to their individual destinations and distributed to trucks. In the warehouse, the forklifts and high shelves could also be equipped with RFID transponders. This would facilitate the correct placement of the logistic units. At the gate for outgoing goods, the commissioned articles would be checked again, automatically and contact-free. The information would be transferred electronically from the central warehouse to the stores' merchandise management systems. When the truck was unloaded at the incoming goods gate of the supermarket, an RFID reader would register the cartons and pallets again. The merchandise management system would compare the incoming data with the goods ordered, so undertaking the check effortlessly. Here too, forklifts and high shelves equipped with RFID would facilitate the placement of the goods in the correct areas. Employees could accurately and precisely locate the pallets and cartons at any time. As soon as they were brought onto the sales floor, RFID readers could once again scan the EPC stored on the transponder. The delivery would be booked in the merchandise management system.

With the help of RFID, the path of the goods could be efficiently controlled in the supply chain if all the parties involved – producers, transporters, intermediate distribution companies and retailers – cooperated in a common system that retrieved and distributed the information at any point where merchandise was moved. To be able to do so, the internationally networked retail sector needed global standards as a prerequisite for the successful use of the RFID possibilities.

In the light of this situation, EPCglobal™ Inc was established in 2003 as a not-for-profit body, and it took the baton of the Auto-ID Center in business relations, while the Auto ID Labs continued investigating with additional and coordinated research centers in Japan and Switzerland. The not-for-profit international organization brought together representatives from all industries in order to collaborate in the development of uniform guidelines for the electronic product code stored on the smart chip. In addition, EPCglobal made a commitment to handling the necessary technological standardization for applications and devices.

There were four key aspects that EPCglobal aimed to solve within the standardization process of the so called “Generation 2 Smart Chip.” The first was the definition and management of a *homogeneous numbering system* that allowed individual products to be tagged in a uniquely distinctive way. The second issue was the *settlement of an UHF frequency* that, through being compliant with the regulations in place all around the world, could become a standard for tags and readers, so allowing the free development of these critical pieces. The third objective was to find a solution for *dense radiofrequency areas*. The solution ought to allow several readers and tags to be in operation in a closed area where multiple devices would not disturb each others' work. The final point was the conception and display of a *worldwide communications network* that allowed EPC numbers to be transmitted as the merchandise flowed through the global supply chain. This network, something of an “intranet,” would provide the different stakeholders with a real time view of the haulage position, thus providing perfect visibility of

the stocks in the international supply chain. (Refer to Exhibit 1 for a fuller explanation of the EPCglobal™ Network.)

## Quick Implementation and Expected Widespread Availability

An article published by the *Economist* in June 2004<sup>7</sup> gave some clues about different movements that were taking place in the recently created RFID industry:

“Wal-Mart, the world’s biggest retailer, said it would require its 100 top suppliers to put tags on pallets and cases of products for shipment to a cluster of its supercenters in northern Texas. On June 17th, Wal-Mart said it would extend its RFID roll-out to its top 300 suppliers and to more shops.

“Alien Technology announced that its current production line can assemble 2 million smart chips a month. By the end of the year, it will have a second-generation line, able to assemble 2 billion chips a year. By 2006, it plans to introduce two third-generation production lines, each able to assemble 10 billion chips a year. For orders of 1 million, Alien Technology sold the tags for 20 cents each. When the third-generation arrived, said Tom Pound of Alien Technology, ‘we believe that our best customers will be able to order finished tags for prices approaching 5 cents.’

“The American government is becoming a big user of the new tags, too. Last October, the Pentagon said it would require its suppliers to put tags on cases and pallets shipped to its warehouses. It expects suppliers to have the technology working by January 2005. The Food and Drug Administration wants drug manufacturers, distributors and retailers to adopt the new RFID technology to combat counterfeiting.

“Marks & Spencer, a British retailer, has just extended a trial in which tags are applied to suits, shirts and ties for men. James Stafford, head of RFID at Marks & Spencer, gives one example: a customer could take a tagged suit to a kiosk, which could then suggest a matching shirt and tie. Mr. Stafford points out that men often lack confidence when shopping for clothes and would welcome advice, but are reluctant to ask for help.”

In September 2004, EPCglobal™, the organization entrusted with the standardization, demonstrated that the EPCGlobal Network was ready for commercial deployment.

Two months later, they also announced the ratification of the “EPCglobal Class 1-Generation 2” specification.<sup>8</sup> Some significant features of the new standard included:

- “a) Global operations: as products built to the new standard are expected to work with each other in any area of the world. The UHF Generation 2 standard uses frequency and power in a way that complies with the major regional regulatory environments.
- “b) Increased security: to better protect data stored on the tags and corresponding databases, products built to the UHF Generation 2 standard will feature, among

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<sup>7</sup> “The future is still smart,” June 24th 2004, *Economist*.

<sup>8</sup> “EPCglobal UHF Generation 2 Standard Fact Sheet” and EPCglobal press releases. December 2004.



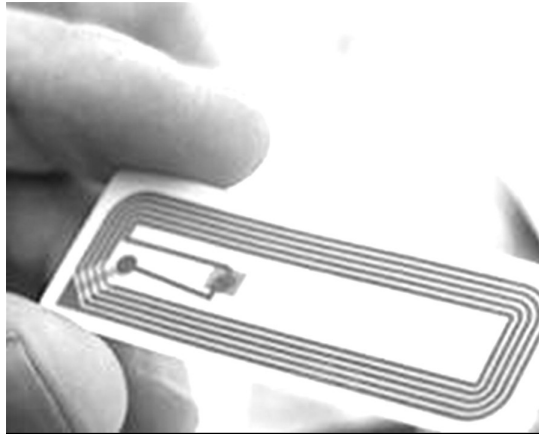
other improvements, advanced encryption technology, password protection and authentication.

- “c) Designed for real-world performance: To provide tag read and write speeds for real supply chain operations, as well as the ability to work in dense reader environments (distribution centers, warehouses, etc.).”

With the Generation 2 standard in place, technology providers would be able to create products that would meet the requirements of suppliers, manufacturers, and end users. Industries as a whole could speed up EPC implementation with standard-based equipment. As it was a royalty-free open standard it would drastically lower the manufacturing costs of tags and readers. At the same time, key technological suppliers of RFID components disclosed that they would have commercial availability of Gen 2 tags and readers on a large scale by July 2005.

## Exhibit 1

An RFID Transponder and a Portal at an Incoming or Outgoing Goods Gate<sup>9</sup>



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<sup>9</sup> Pictures courtesy of METRO Group.

## Exhibit 2

### The EPCglobal™ Network<sup>10</sup>

EPCglobal Inc is industry's trusted partner for driving the global adoption and implementation of the EPCglobal™ Network across industry sectors. Our mission is to make organizations more effective by enabling true visibility of information about items in the supply chain. To that end, EPCglobal develops and oversees standards for the EPCglobal™ Network.

The EPCglobal™ Network is a new, open, global standard for real-time, automatic identification of items in the supply chain of any company, in any industry, anywhere in the world.

The EPCglobal™ Network was developed by the Auto-ID Centre, a global research team directed through the Massachusetts Institute of Technology with labs around the world. Their research effort was supported by more than 100 leading companies. Companies and consumers are the ultimate beneficiaries of the EPCglobal™ Network as it enables organizations to be more efficient, flexible, and responsive to customer needs. RFID technology is a fundamental element of the EPCglobal™ Network.

RFID at a simple level is a technology that involves tags that emit radio signals and devices called readers that pick up the signal. The tag pulls its EPC number to the reader. The Electronic Product Code™ (EPC) is a simple, compact "license plate" that uniquely identifies objects (items, cases, pallets, locations, etc.) in the supply chain.

The EPCglobal™ Network is a set of technologies that enables immediate, automatic identification and sharing of information on items in the supply chain. In that way, the EPCglobal™ Network will make organizations more effective by enabling true visibility of information about items in the supply chain.

## How the EPC Network Will Automate the Supply Chain<sup>11</sup>

With the new EPC network, computers will be able to "see" physical objects, allowing manufacturers to be able to track and trace items automatically throughout the supply chain. This technology will revolutionize the way we manufacture, sell and buy products. Here's how it works...

SuperCola, Inc. adds a Radio Frequency Identification (RFID) tag to every cola can it produces. Each tag is cheap – it costs about five cents – and contains a unique Electronic Product Code, or EPC. This is stored in the tag's microchip which, at 400 microns square, is smaller than a grain of sand. The tag also includes a tiny radio antenna. These tags will allow the cola cans to be identified, counted and tracked in a completely automated, cost-effective fashion.

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<sup>10</sup> Copied from EPCGlobal site. <http://www.epcglobalinc.org/> Copyright permission pending.

<sup>11</sup> "Idiot's Guide to EPCglobal Network." [http://archive.epcglobalinc.org/aboutthetech\\_idiotsguide4.asp](http://archive.epcglobalinc.org/aboutthetech_idiotsguide4.asp). Copyright permission pending.

## Exhibit 2 (continued)

The cans are packed into cases – which feature their own RFID tags – and loaded onto tagged pallets. As the pallets of cola leave the manufacturer, an RFID reader positioned above the loading dock door hits the smart tags with radio waves, powering them. The tags “wake up” and start broadcasting their individual EPCs. Like a good kindergarten teacher, the reader only allows one tag to talk at a time. It rapidly switches them on and off in sequence, until it’s read them.

The reader is wired into a computer system running Savant. It sends Savant the EPCs it’s collected, and Savant goes to work. The system sends a query over the internet to an Object Name Service (ONS) database, which acts like a reverse telephone directory – it receives a number and produces an address. The ONS server matches the EPC number (the only data stored on an RFID tag) to the address of a server which has extensive information about the product. This data is available to, and can be augmented by, Savant systems around the world. This second server uses PML, or Physical Markup Language, to store comprehensive data about manufacturers’ products. It recognizes the incoming EPCs as belonging to cans of SuperCola, Inc.’s Cherry Hydro. Because it knows the location of the reader which sent the query, the system now also knows which plant produced the cola. If an incident involving a defect or tampering arose, this information would make it easy to track the source of the problem – and recall the products in question.

The pallets of cola arrive at the shipping service’s distribution center. Thanks to RFID readers in the unloading area, there’s no need to open packages and examine their contents. Savant provides a description of the cargo, and the cola is quickly routed to the appropriate truck.

The delivery arrives at SpeedyMart, who has been tracking the shipment thanks to its own Savant connection. SpeedyMart also has loading dock readers. As soon as the cola arrives, SpeedyMart’s retail systems are automatically updated to include every can of Cherry Hydro that arrived. In this manner, SpeedyMart can locate its entire Cherry Hydro inventory automatically, accurately and without incurring costs.

What’s more, SpeedyMart’s retail shelves also feature integrated readers. When the cans of cola are stocked, the shelves “understand” what’s being put in them. Now, when a customer grabs a six-pack of Cherry Hydro, the diminished shelf will route a message to SpeedyMart’s automated replenishment systems – which will order more Cherry Hydro from SuperCola, Inc.

With such a system, the need to maintain costly “safety volumes” of Cherry Hydro in remote warehouses is eliminated. Auto-ID makes the customer’s life easier, too. Rather than wait in line for a cashier, she simply walks out the door with her purchases. A reader built into the door recognizes the items in her cart by their individual EPCs; a swipe of the debit or credit card and the customer is on her way.