

## **RFID – APPLICATIONS WITHIN THE SUPPLY CHAIN**

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### **INTRODUCTION**

Radio frequency identification (RFID) has been heralded by some commentators as a technology that will have as big an impact on supply chain operations as the advent of computer based planning systems in the early 1970's; others say it is just yet another technology fad that will have gone away in a couple of years. We are continually reading conflicting messages about RFID - this is partly due to the term being misused in some quarters and also because, as with all new technologies, it takes time for all those involved to define a common language.

This paper will examine the benefits and barriers to RFID implementation before moving on to discuss applications of the technology and to look at case study examples.

### **RFID BENEFITS**

When compared with other automatic identification systems like barcodes, magnetic stripes or manual data entry, RFID offers many potential benefits; currently the cost of the technology is a barrier but as implementation costs fall this will be less so.

Any cost justification of an RFID system should take into consideration the entire cost for the life of the system. Habitually, potential users of RFID tend only to compare the cost of the tag against that of a barcode label which results in the cheaper bar code option being favoured (Harrop, 2000). However if this comparison is made at a system level, RFID can be the lowest cost technology, with tags being reused and operational costs lower due to cheaper maintenance costs and lower labour requirements.

Table 1 provides an overview of the benefits of RFID over barcode type systems as identified by a number of commentators in the area.

<b>Author</b> <b>Benefits</b>	<b>Gerderman (1995)</b>	<b>Milner (2000)</b>	<b>Sarma et al (2001)</b>	<b>Das et al (2002)</b>	<b>Finkenzeller (2003)</b>	<b>Beck (2002)</b>
Lower long term system costs		✓		✓		
Less labour requirements	✓	✓	✓		✓	
Reliability and accuracy		✓		✓	✓	
Higher reading range	✓		✓	✓	✓	✓
Capable of carrying more data			✓	✓	✓	
Reading speed/ Multiple reading	✓	✓	✓	✓	✓	✓
Read-write capability			✓	✓	✓	✓
Higher security levels			✓	✓	✓	
No requirement for line of sight	✓	✓	✓	✓	✓	✓
Robustness	✓			✓	✓	

**Table 1: Benefits from RFID technology referred to by some authors**

**BARRIERS TO RFID IMPLEMENTATION**

**Cost of RFID Tags**

The cost of the tags is one of the most important constraints for the full implementation of this technology within supply chains (Chomka, 2003). The low cost of the tags will allow their application for single use or for low cost multiple use where the durability of the tag is suitable. These tags contain data that can be read remotely and cost less than five cents (Harrop *et al*, 2003), therefore cheap enough to be disposable.

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Assessing the return on investment of RFID's added features instead of focusing on tag cost might be the strategy to be followed by users. Nevertheless, sometimes, the payback from the implementation of RFID technology can be difficult to calculate.

In order to achieve low price RFID tags it is necessary to trade-off various factors like functionality, data capacity and construction. Presently chipless tags represent the lowest level of cost for RFID tags. The chip with the tag represents the most expensive component and this can be up to 90 per cent of the tag value (Das *et al*, 2002),

Many commentators state that for RFID tags to be used widely the price of a chip-based tag must be reduced to below one U.S. cent. This would enable full scale item level tagging within the supply chain. By early 2003 the cost of chip smart labels was around 40 U.S. cents and it is expected that by 2004 these costs will drop to 15-20 cents and finally to 5 cents by 2007. However, the full scale implementation of item level tagging will require the tags to cost one cent or less (IDTechEx Ltd, 2003a).

### **RFID TYPICAL APPLICATIONS**

RFID systems should not be seen as a substitute for other identification systems like barcodes. Their multifunctional capability can provide additional features that allow the use of this technology for other applications that consequently add value. RFID can be used to address the following important issues within a variety of business sectors:

- Asset/product tracking
- Product handshaking
- Anti-counterfeiting
- Safety and security
- Access control
- Condition monitoring
- Transactions
- Positioning/locating
- Real time theft detection - shrinkage
- Real time tampering detection
- Market research
- Entertainment
- eCommerce fulfilment
- Controlling grey markets
- Industrial and warehousing
- Merchandising

The following discussion will focus on just some of the most relevant applications of RFID within logistics and supply chain management.

### **Asset and Product Tracking**

Milner (2000, p.14) provides a clear definition of the use of low cost RFID technology for asset and product tracking. He says it “*can be used to monitor and manage the physical movement of materials and finished products, to generate and deliver a flow of critical information, and to form the basis for enhanced working between supply chain partners*”. This application is of particular interest in warehousing and distribution, as these activities, according to MIT (Harrop *et al*, 2003), account for 75 percent of a product’s retail cost. Tracking items like assets or products allows knowledge to be gained on the history of the item and the process it has been through (Graham, 2003). This capability enhances the control of operations by reducing stock losses and improving supply chain visibility.

The use of this technology for asset tracking is mainly used for vehicle and container tracking (e.g. fleet management, military logistics, postal services, food and clothing retail) where the tag cost is very small compared to the tagged asset value. The use of RFID technology at item level is still restricted by the tag cost and other problems regarding physical features such as size and metallic/electrical interference (Finkenzeller, 2003).

### **Anti-Counterfeiting**

The anti-counterfeiting function of RFID technology is normally considered an additional feature provided by RFID chip-based tags and is partly addressed in the asset and product tracking and product handshaking functions. However, counterfeiting is a major concern for all industries and some companies are beginning to look for this type of functionality from RFID technology.

### **Condition Monitoring**

RFID tags with sensor functions can monitor physical conditions, like temperature and humidity and to register if the product has suffered any knocks. This feature is being used by the United States Military (IDTechEx Ltd, 2003a) to monitor the condition of munitions but it may also be used in the food retailing industry where chill products’ condition can be continuously measured. If some condition is altered the system can flag up a warning or set off a corrective procedure. Condition monitoring can also be used for anti-tampering purposes, detecting

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changes in some physical conditions of the product (IDTechEx Ltd, 2003b) or detecting if the tag has been peeled off (Harrop et al, 2003). This type of application is also being used in “cold chain” applications within the pharmaceutical/health industry to detect if products, have been subjected, during transit, to temperatures outside the tolerance limits set by the authorities.

### **Merchandising Support Functions**

The implementation of RFID technology focusing on merchandising functions is already being tested. One example that clearly illustrates this is the trial being conducted in an Extra store in Rheinberg, Germany - The Metro Future Store<sup>1</sup> (Benoit, 2003). One of the applications for RFID tags is being tested on “Pantene” shampoo bottles to achieve a more direct communication with the customer. When a tagged shampoo bottle is lifted from the shelf, it activates the display screen above the shelf starting a commercial advert or communication tailored to that product.

The use of RFID technology for marketing functions will be mostly dependent on item level tagging and at present this is still not feasible in the short term within the FMCG retail industry although Prada (the fashion retailer) has applied it to high value product in their New York store.

Other possible uses could be monitoring customer behaviour by using RFID loyalty cards and providing tailored marketing approaches according to customers’ shopping habits (Harrop, 2000).

### **Industrial and Warehouse Environments**

The use of RFID technology has many applications in the industrial and warehouse environment such as product handshaking, near real time inventory control and condition monitoring . Additional applications for RFID technology can be found in these areas. Warehouse picking can be made accurately and automatically (Graham, 2003), and warehouse yard management can be optimised so that vehicles and cargoes can be identified as they enter a compound and be directed to the right location to be unloaded/loaded. Another example is the application of RFID to conveyor picking systems resulting in increased efficiency due to the higher levels of accuracy achieved.

<sup>1</sup> Information on this project can be accessed at the internet address <http://www.future-store.org>

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**COMPANY CASE STUDIES**

We will now look at some actual implementations of RFID technology to understand the benefits that are being experienced within some organisations.

**Allied Domecq, UK – tracking ownership and duty paid status**

Allied Domecq is a major producer of wines and spirits. Trials were undertaken with RFID, within manufacturing and supply chain environments, that successfully demonstrated the benefits that could be accomplished in a closed system.

More recently, and under the “Chipping of Goods” initiative (Home Office, 2003), another trial was launched. In this trial, individual bottles of spirits were labelled with a unique serial number encrypted in a two dimensional bar code. These bottles were packed into cases and their information associated with the unique case serial number. The numbers for every case were associated with the RFID tag on the pallet on which the goods were transported, enabling the movement of product to be tracked through the supply chain from one distillery to two distribution centres.

The aim of this trial was to provide evidence of ownership and duty-paid status and to trace the products across the supply chain (IDTechEx Ltd., 2002). However there are no reports regarding the success and results of the trial.

**Woolworths, UK – total transparency for item-tote-dolly-container-driver-route-store**

Woolworths involvement with RFID technology came under the Home Office’s ‘Chipping of Goods’ initiative (Frontline Solutions, 2002a). For this retailer, the losses due to shrinkage, which had an impact on service and inventory levels, were considerable enough to justify a trial with RFID technology.

In 1999, a small-scale pilot was launched and involved one distribution centre and one store. The Woolworths’ trial revealed that RFID has potential applications to improve supply chain transparency and to reduce supply chain costs. However, at that time, it was felt that the technology was too expensive, not robust

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enough and without any universal standards. Moreover there was a lack of a compelling business case to justify further investment in such a new technology.

In 2002, and within the Home Office's initiative, Woolworths started another trial using RFID technology in one distribution centre, two stores with fixed RFID infrastructures and 30 stores using mobile RFID infrastructures. In this trial the RFID tags were placed on 16,000 dollies instead of each product item because the average item value of £3 could not support the investment of individual tags (O'Neill, 2003).

The system uses an integrated approach using various technologies. Products are picked into tote boxes with a unique barcode identification that will be assigned to a dolly identified with a unique RFID tag; this dolly can carry up to ten totes. RFID readers distributed in strategic places within the distribution centre track the dollies' movement in real time and ensure that they are loaded into the correct vehicle ready for despatch. This also allows identification of mistakes before the product goes any further than the dispatch bay. When dispatched, a GPS system tracks vehicles that are associated with the dollies that they carry. Therefore, it is possible to track products through the supply chain from the vehicle level to the item level - item-tote-dolly-container-driver-route-store. At the store, drivers using handheld RFID/barcode scanners confirm the delivery without the need for paperwork related to proof-of-delivery. Finally, the stores involved in this trial were equipped with fixed position readers that gather and check information on the dollies' contents on arrival from the distribution centre.

This original six-month trial was extended and 2,500 deliveries were tracked and the movements of 350,000 tote boxes filled with goods were recorded (Frontline Solutions, 2002a). The results confirmed improvements on the processes by using information that identifies the causes of supply chain inefficiencies. This situation led to the reduction of costs associated with:

- shrinkage reduction (this was 1.8% of sales)
- reduced labour for deliveries' checking and claims processing
- improved utilisation of totes and dollies
- the reduction of inventory levels, improving product availability and customer service

**The Gap, USA – 100% on-shelf availability  
increasing sales by 12%**

A three-month trial was carried out in a Gap store in Atlanta where Texas Instruments RFID tags operating at 13.56 MHz were used for item level tracking of denim apparel. The aim was to reduce stockout situations and obsolete inventory, enabling staff to locate specific articles. It also aimed to improve supply chain efficiency by having an increased stock visibility from factory to store.

The result was an almost 100 percent on-shelf availability of the RFID-tagged merchandise and a 12 percent increase of sales of this merchandise in comparison to “control” stores that were not using an RFID system (IDTechEx, 2003c). The system also allowed easier store replenishment for employees and a more efficient inventory management system to be created.

The trial achieved positive results from improved handling efficiency with a return on investment of 1.7 years (Das, 2003), half the time that was originally estimated. Despite the advantage of working in a closed system where production is controlled by The Gap, a roll-out of an RFID system in their chain of stores is still not part of their plans because of funding requirements (Harrop et al, 2003), the lack of standards and a suitable open system (IDTechEx, 2003d).



**Tesco, UK – the intelligent shelf**

Tesco is currently trialling tags on DVDs at its Sandhurst and Leicester stores. In this trial Tesco is testing smart shelf technology in collaboration with MeadWestvaco, an American packaging company and Entertainment UK (EUK), that keeps DVDs stocked in 2,500 retail stores in the UK (Thomas, 2003).

It uses RFID tagged DVD's that are programmed using the MeadWestvaco Intelligent System (MWVIS). For the trial, MeadWestvaco retrofitted ten 4 ft. x 6 ft. shelving units with 13.56 MHz readers. Two readers provide power to hundreds of antennas using the MWVIS networking technology. The backroom of the Tesco store was also equipped with this technology that is designed to work with the electronic product code technology developed by the Auto-ID Center (IDTechEx Ltd, 2003e).

The trial will allow staff at Tesco and Entertainment UK to see, in near real time, exactly what is in the store (shelves and backroom) through a secure website and allow staff to see when goods are out of place or need to be restocked. The system records when a product was moved. Additionally it will allow staff to save time spent in sorting DVD titles and to improve on-shelf availability as the titles will be stored in the correct place and the system can give a warning if items are in an incorrect location.

In addition a trial is being made with Gillette razor blades. Tesco initiated a trial in September, 2003 in a non-food depot in Milton Keynes (UK) where selected cases of non-food items moving between the depot and its stores in Peterborough and St Neots in Cambridgeshire in the UK were RFID-tagged. From this trial, Tesco is already planning to roll-out RFID tagging technology across its supply chain in 2004 with its Secure Supply Chain Initiative (IDTechEx Ltd, 2003f). This roll-out will start with the tagged cases being moved between distribution centres and stores on selected products. It is hoped that from Autumn, 2004 Tesco will introduce its suppliers to the technology with cases tagged from source. By 2006, all suppliers will have to supply Tesco distribution centres with cases and pallets carrying RFID tags.

Tesco also plans to start tagging more individual products in 2004 with RFID technology

**Argos, UK – from 54% to 100% data capture**

Argos' involvement in the 'Chipping of Goods' initiative is mainly due to the fact that they are a retailer of high value products such as jewellery, electrical equipment and furniture. Since jewellery pieces are small and easy to convey, this was the chosen product to track for this nine-month trial, which aimed to reduce shrinkage. Up to 16 per cent of the products are returned so an improvement in supply chain transparency was also sought (IDTechEx Ltd, 2003e).

The trial involved twelve stores and three distribution centres. The RFID tags were used on roll-cages and totes - active tags on roll-cages and passive tags on totes. The product is put into the totes that are placed in the roll-cages and sealed. The tag movements are then tracked as they are loaded and unloaded throughout the supply chain.

The result was the ability to trace products and identify supply chain vulnerabilities. This immediately resulted in solving the throughput claims made by distributors.

Recent results have revealed higher levels of reliability showing 100 percent data capture against the 53 percent that had been achieved with manual data capture (IDTechEx Ltd, 2003e). However a decision regarding the rollout of the system will be considered after a final review of the trial.

**Figleaves.com, UK – picking errors down to 0.1%**

Figleaves, a UK-based website that sells intimate apparel, uses RFID technology provided by Texas Instruments to rationalise the picking and shipping of products so avoiding the need to expand their facilities.

Items are stored in carts that carry three tote boxes - each of them have up to eight compartments and feature a unique RFID tag (RFID Journal, 2003a). The carts are equipped with radio data terminals that tell the warehouse staff where to go to find the right tote. The system allows the pickers to assemble up to 24 orders on a single cart by selecting the best picking sequences in order to optimise walking distances in a single trip with total accuracy. These picking carts have a built-in radio terminal with a graphics display with picking instructions thus preventing staff from mixing up the orders to be sent out and saving the time and labour spent on double-checking orders before they are shipped.

When picking operations are finished, the tote boxes are delivered to a packing bench fitted with RFID readers that identify each tote and associate it with the order. When the order is complete the system prints a delivery note and a label and finally the order is sent to the mail sort.

The result is a system that enables staff to pick 60,000 items per month with an error rate of less than 0.1%. This has led the company to expand the use of RFID technology.

**CONCLUSION**

RFID projects have been found to be highly successful when applied to internal operations or for tracking goods between one or two trading partners. Cost is still seen as a barrier to item level deployment of the technology except on high value products in vertically integrated supply chains. The successful application of RFID tags in the retail industry at an item level is currently limited to specific 'closed loop' high value applications.

Early return on investment is however possible if investments are made in distribution and inventory management activities at pallet level. In this way, it is possible to avoid stock-outs, monitor transport and distribution centres, secure correct shipments and accelerate logistics operations.

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His Doctoral research, undertaken while employed at the University of Warwick, applied chaos and complexity science to logistics and supply chain management and resulted in the development of new management guidelines for supply chain re-engineering. This innovative research received international media coverage including features on the BBC World Service and articles in the Times, Financial Times and New Scientist.

More recently his research into inventory policies of organisations in times of uncertainty resulted in international media coverage including live interviews on BBC1 television news, BBC News 24, BBC Television's "The Money Programme", BBC 5 live and Independent Radio News. The research was also covered by the print media including the Financial Times, Sunday Times, The Guardian, and The Independent newspapers.

Richard is both a European and Chartered Engineer, he is a chartered member of the Institute of Logistics & Transport and Institute of Electrical Engineers (Manufacturing Division). He is a steering committee member of the Institute of Logistics Research Network, a global network of academics and practitioners involved in state-of-the-art logistics and supply chain research. He is also a Member of the Institute of Logistics and Transport Directors Forum, a group limited to the top 120 Logistics and Supply Chain Directors from Europe. Richard is also a member of the Institute of Learning and Teaching in Higher Education in recognition of his innovative approaches to teaching and course design.

Richard's special areas of interest include the creation of collaborative business environments, reducing supply chain vulnerability, time compression and techniques for aligning supply chains to maximise customer value and reduce cost.