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AUTO-ID CENTRE

WHITE PAPER

Auto-ID Use Case: Improving Inventory Visibility in a Retail Company – Impact on Existing Procedures and Information Systems

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ABSTRACT

Determining the impact of Auto-ID implementations on existing procedures and related information systems is a difficult task and requires deep analysis of both the current and Auto-ID-enhanced situation. Auto-ID offers many different implementation possibilities with their respective requirements, advantages and disadvantages, further complicating the impact analysis. This paper applies the "Use Case Approach" (Morán et al, 2003) to determine the impact of using Auto-ID in order to improve inventory visibility on the shelves and in the backroom of a leading retail company in the UK. This industrial study, the first of four of this type developed in the UK, involved numerous interviews with knowledgeable people in this company and some IS suppliers. It also included a thorough application of the aforementioned approach, which consists of:

1. finding representative use cases for process improvement, in terms of current operational procedures, issues, and implementation possibilities;
2. contrasting their associated operational procedures with the proposed ones; and
3. identifying the additional data and transactions required by their related information systems.

Although Auto-ID is a disruptive technology, this work concludes that the impact on the retail industry is not significant, thus allowing for incremental adoptions.

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Biographies

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With more than twelve years of IS experience, Humberto has occupied relevant positions in leading corporations such as Unisys, Lafarge, Oracle, and his own entrepreneurial venture. He has studied Computer Engineering; a Ph.D. in International Economics; and an MBA in the Judge Institute of Management, University of Cambridge. In the Auto-ID Centre, Humberto coordinates research on Auto-ID Use Cases, the impact of Auto-ID implementations on IS, and Auto-ID/IS integration possibilities.

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Sana Ayub graduated from the Institute of Manufacturing at University of Cambridge in July 2003. She was based with the Auto-ID Center – Cambridge Labs for the duration of her Master's thesis, and this white paper draws heavily on that research.

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Duncan McFarlane is a Senior Lecturer in Manufacturing Engineering in the Cambridge University Engineering Department. He has been involved in the design and operation of manufacturing and control systems for over fifteen years. He completed a Bachelor of Engineering degree at Melbourne University in 1984, a PhD in the control system design at Cambridge in 1988, and worked industrially with BHP Australia in engineering and research positions between 1980 and 1994. Dr McFarlane joined the Department of Engineering at Cambridge in 1995 where his work is focused in the areas of response and agility strategies for manufacturing businesses, distributed (holonic) factory automation and control, and integration of manufacturing information systems. He is particularly interested in the interface between production automation systems and manufacturing business processes.

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Contents

1. INTRODUCTION

The present document covers the findings and results of an industrial application of the "Use Case Approach" proposed by the Auto-ID Centre (Morán et al, June 2003) in order to determine the impact of Auto-ID implementations on existing procedures and information systems, and show the most evident and relevant implementation possibilities. This report presents the tracking of inventory in retail outlets in both backroom and shelves as a case of use for Auto-ID technology the Auto-ID Centre's vision involves the tagging of products in retail outlets. Through the analysis of a business system currently being used by a large UK retailer, opportunities for improvement have been identified and examples of possible implementation solutions have been discussed. This industrial study involved holding interviews with knowledgeable company personnel and analyzing the findings using the aforementioned approach. The study followed these basic steps:

1. Finding representative use cases for process improvement in terms of current operational procedures, issues, and implementation possibilities. This first step involved interviewing employees in charge of Auto-ID adoption and business innovation and employees who perform daily operational procedures related to handling, storing and interchanging physical goods within the shop and with direct parties such as customers, suppliers and distribution centres. Some Auto-ID implementation possibilities were identified by considering different technologies and configurations.

2. Contrasting their associated operational procedures with the proposed ones. This step required the offline analysis of the information found in the previous one, for each one of the implementation possibilities.

3. Identifying the additional data and transactions required by their related information systems. The supporting transactions and data currently performed or stored by the current information systems were identified by interviewing knowledgeable people in the IT department. This paper then proposes new reports making use of Auto-ID-generated information such as rotation quality or stock failures.

In summary, this Inventory Visibility Use Case explains how to utilize Auto-ID in a retail company so to improve the visibility of stocks in both the backroom and shelf. This report also describes some of the potential impacts on current procedures and installed information systems.

Following the classification proposed in the "Use Case Approach" White Paper, the Inventory Visibility Use Case is classified as a **Process Improvement Use Case**, because it focuses on specific operational areas of the organisation and does not bring significantly changes the current business model.

1.1. Acknowledgements

We would like to express our deepest gratitude to the staff of the supporting retail company, who kindly and patiently cooperated in multiple interviews and provided valuable support.

1.2. Background

1.2.1. Business Information and Industrial Control Action Group

This research is part of the Auto-ID Centre's Business Information and Industrial Control Action Group activities. Combining theoretical research and industrial developments, this group aims at identifying the impact of Auto-ID on business information and industrial control systems while developing frameworks, models and methodologies to deal with this impact and provide sound integration alternatives. The Business Information and Industrial Control Action Group deals with business activities supported by commercial and bespoke information systems potentially suitable of improvement with Auto-ID, covering a broad area ranging from Auto-ID business strategy to Auto-ID use cases development and analysis of their impact on existing technology for business automation.

This research is also part of the Auto-ID Software Action Group, which aims at setting standards and legal frameworks for the software developments of Auto-ID. The Software Action Group recognises and proposes the development of specific Use Cases as a way of identifying technical requirements for the Savant™ and analyse Auto-ID integration possibilities with business information systems.

1.2.2. Previous Works

This paper includes ideas from other previous papers: Timothy Milne and Amit Goyal's "Track and Trace Shipping and Verify Receiving Use Case" (expected publish date: April 2003), Timothy Milne's "Sub Group and Use Case Focus Group Methodology" (November 2002), Duncan McFarlane's "Auto-ID Based Control – An Overview" (January 2002), and "The Intelligent Product Driven Supply Chain" (Brock et al, January 2002,), among others. Yoon Chang and Duncan McFarlane have also proposed specific methodologies to support the integration of Auto-ID and business information systems, and have provided a thorough classification for latter and an example use case – "Methodologies for integrating Auto-ID Data with existing Business Information Systems" (Chang, November 2002).

Finally, the research documented in this paper utterly followed the steps and methodology suggested by the "Use Case Approach for Determining the Impact of Auto-ID Implementations on Business Information Systems" (Morán et al, June 2003).

1.3. Use Case Characteristics

The retail industry in the UK generates over £200 billion of revenue per annum and year to year shows signs of healthy growth. With power being passed from manufacturers to retailers, the opportunities for further industry growth are substantial. Nevertheless, competition is high and steadily rising. Technologies being adopted by large retailers are becoming increasingly sophisticated, complex and expensive to install, raising entry barriers and further intensifying competition.

One important source of competitive advantages for retail companies is the technology and strategies used to move and store products. Despite the high investments in technology and infrastructure to achieve this, failures are frequent and costly. Inventory shrinkage is a common malady, as well as product wastage consequence of mishandling. Some advocate that Auto-ID will solve some of these problems and improve the inventory visibility in both the backroom and on shelves. By doing so, companies will have a clear and fresh picture of their product location, quantity and storage conditions, as well as detailed reports on current product handling performance which may help identifying and promoting best practices.

1.4. Document Structure

The Retail Inventory Visibility Use Case is defined in terms of the current situation, the elements it touches; and the proposed changes. Described in section 2 of this paper, the former is specified in terms of:

1. Processes to improve: actors, procedure steps, product and information flows, activities, level of automatism, decision points, contingency plans and supporting assets

2. Limitations of the current technology
3. Opportunities and issues to solve or improve
4. Auto-ID capabilities enhancing the improvement
5. Implementation decisions
6. Potential benefits

Described in section 3 of this paper, the latter can be specified in terms of:

1. Affected systems and their characteristics
2. Auto-ID-enhanced operational procedures
3. Impact of new procedures on installed information systems

In this paper, the affected systems and some of their characteristics were included in the Use Case definition section. This helps the reading by easing the identification of their relationships. The "proposed changes" section gives more detail by specifying transactions and information flows.

2. USE CASE COMPONENTS

As explained in the "Use Case Approach" document, a Use Case is more than a simple description of the Auto-ID-enhanced procedures and advantages. It requires a thorough analysis and description of the current situation, and a clear justification in terms of business benefits. That is, the Use Case must be framed within the business requirements themselves and under no circumstances should be justified for the sake of technology. In this section we list all of the use case components, aiming at giving a clear picture of the current situation and the factors bringing opportunities for Auto-ID.

2.1. Processes to Improve

Supermarkets are complex businesses in which thousand of products are manipulated, stored, and exchanged every day at extraordinary pace. As simple as it might appear, receiving, storing and moving products within the retail store's micro-supply chain becomes exponentially complex as many products items must be efficiently stored and moved within the store premises. Storage itself poses many challenges as goods must be stored and recovered expeditely and with minimum human effort. Some products require special storage conditions such as a specific temperature or humidity. Some others perish, hence requiring constant rotation. Product handling poses many challenges as well. Products move more easily than their related information; in these exchanges full product verification is often impossible, cumbersome or prohibitive; and mistakes are frequent and costly.

The general processes involving product handling, storage, and exchange in a supermarket are:

Product reorder: supermarkets must keep a constant flow of goods in order to stay in business.
The product reorder process guarantees the upstream side of this flow by requesting replenishments from suppliers or distribution centres.

Product receipt and put-away: once goods arrive they are verified, however optional, and must be added to current stocks and stored properly.

Product recount: once stored, product items may unexpectedly change their status or disappear, generating important differences between automated records and reality. A product recount and review process is essential to keep information system data close to reality and act accordingly.

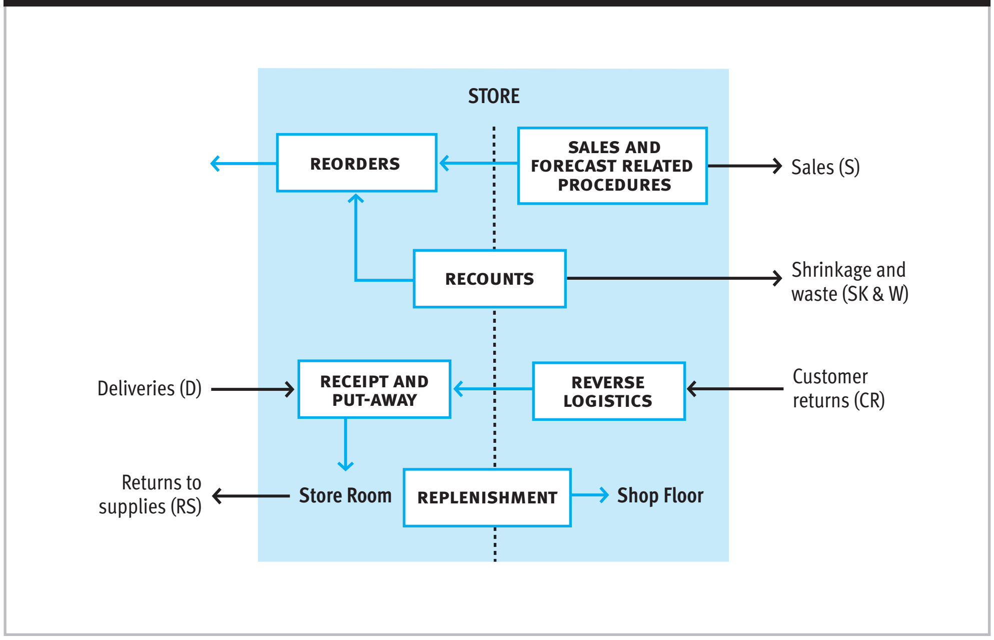
Replenishment: goods are constantly moving from the backroom to the shelves as customers remove them from the latter. Keeping shelves saturated of goods is not only necessary to avoid stock-outs, but also for marketing and branding reasons: customers do not visit a supermarket where shelves are empty.

Reverse logistics: for various reasons, some product items are sent back throughout the supermarket's micro-supply chain. Among these reasons are product returns from customers, product returns from the shop as a result of internal decisions (e.g. unsuccessful sales or marketing practices or safety reasons), and product recalls result from external decisions (e.g. government or suppliers themselves).

The following drawing helps illustrate these product flows and related procedures:

Figure 1

NORMAL FLOW OF GOODS IN A SUPERMARKET, AND THEIR RELATED PROCESSES



Sales and forecast procedures are not covered by this paper as they are part of other ongoing research.

From this diagram it is easy to see that the inventory formula variation within a supermarket is equal to:

$$\Delta E = D + CR - RS - SK - W - S$$

Where E is the current stock level for a specific product.

Using Auto-ID to improve inventory visibility in both the backroom and on shelves of a retail company directly or indirectly affects most of these operational processes, which are detailed as follows.

2.1.1. Product Reorder

The store or supermarket regularly sends replenishment orders to either the distribution centre or directly to suppliers. Product reorders are triggered automatically, and they may be scheduled to be made daily, every few days, or more than once a day. The order quantity depends on the current stock level, delivery time, expected product life, forecasted shrinkage, sales, and safety stock. Normally an automated procedure, the reorder process determines the order based on a combination of manual and automated data from many different sources such as sales from the point of sales system; stock levels from the inventory management system; sales forecast from either the sales system, manual estimations, or a combination; orders in transit from the order entry system; and historical statistical information from the order entry and sales systems such as delivery time and supplier's reliability, forecast variance, and product expected life. It is the first input of the equation (stock level) where an improved inventory visibility would ensure more accurate orders.

The product reordering process involves three main information systems:

The ordering system (OS): supports the process of ordering from suppliers, with the aim of guaranteeing a constant supply of products at the lowest possible cost. It hosts the list of suppliers, products, hierarchy of substitute, and related products. There is also a log of historic and agreed upon delivery times. The OS is the most important system in the reorder process. It deals with placing orders for more stock based on the inventory level, average delivery time and other delivery and supplier characteristics. The OS is a supporting system as opposed to a tracing system, and performs inter-organisational transactions as well by sending order transactions to suppliers. In the specific case of the studied retail company, the ordering system calculates up to two normal orders per day using the latest picture of bookstock and expected sales. A fill up order, which is designed to replenish the shelves, is calculated so as to arrive in the late evening. The fill up order is designed to top up the stock of certain lines during the day.

The inventory management system (IMS): keeps track of the stock levels by product type, store, deposit and shelf, aiming at optimising stock levels, avoiding stock failures, and reducing waste result of unsold perishables. Their master files include products, deposits, stores, and shelf and backroom spaces. Their transactions come from sales, deliveries, returns, transfers, waste and recount processes through the logistics and distribution, point of sales and ordering systems and manual recount procedures. In the reorder process, the IMS stores inventory counts and triggers replenishment orders to the ordering system. The IMS calculates inventory by subtracting what has been sold from what was previously ordered and received from suppliers. The IMS sends information on current stocks to the OS so that the right order quantity can be calculated. The IMS system is a tracing and supporting system at the same time. It traces product stocks and their location, and support location and ordering decisions as well. In the case of the studied company, the inventory management system maintains the store position using all available stock movements. Its stock position is maintained using sales drips – sent every 15 minutes which are received throughout the day to keep track of store stock. Stores can also count at any time of day.

The sales system (SS): support sales forecast by store, region, season, time frame, product or product hierarchy; which are groups of substitute or related products. Their main files include product and product hierarchies, their sales history in money and volume, and regions and stores. Their transactions come from the sales procedure through the POS. In the reorder process, the SS registers sales per product and holds sales history to allow forecasting. The SS sends sales forecasts to the OS so the right order quantity can be calculated. The SS is essentially a tracing system as it registers sales for forecasting purposes mainly. In the case of the studied company, the sales forecast system forecasts the expected sales and product trading percentages that are used in the main order calculation system.

The product reorder process has the following characteristics:

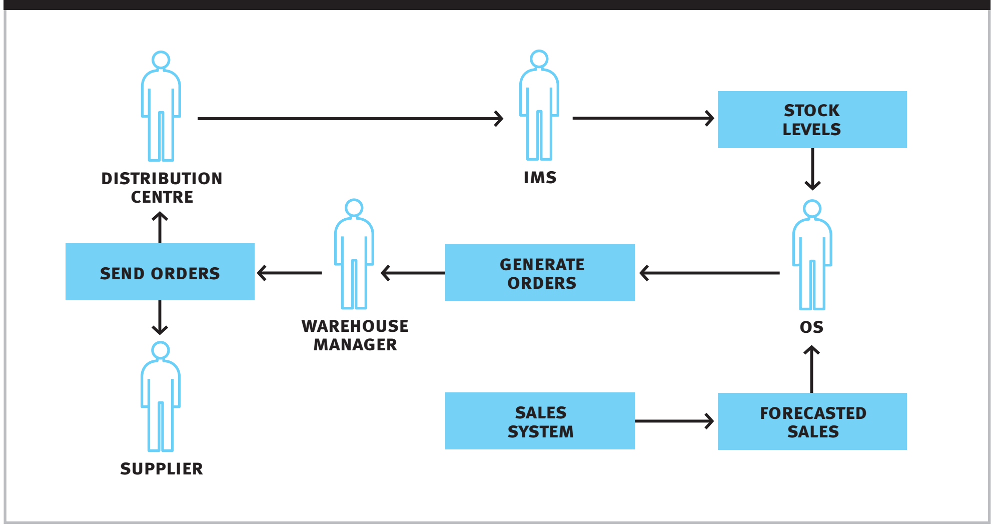
Table 1: Product Reorder Characteristics

PRODUCT RE-ORDERS	
Actors	– Warehouse manager – Supplier or distribution centre
Procedure Steps	– Emission of the automatic report – Manual review and modification – Send order to the supplier or distribution centre
Product Flows	– N/A
Information Flows	– Stock levels – Forecasted sales – Estimated delivery time – Related product characteristics – e.g. expected life – Orders
Level of Automatism	– High: orders are generated automatically, although a manual check and adjustment is performed
Decision Points	– Products and quantity to reorder
Contingency Plans	– None
Supporting Assets	– Information systems (IMS, OS, SS)

Use Case diagram for the product reorder procedure under the current situation (non-Auto-ID-enhanced):

Figure 2

USE CASE DIAGRAM FOR REORDER PROCEDURE



Main flow of events

M.1. Warehouse manager
- M.1.1. Emit reorders report from OS
- M.1.2. Review report
- M.1.3. Send reorders advices to distribution centre or suppliers

M.2. Supplier or distribution centre
  M.2.1. Pick and send the shipment
  M.2.2. If product items are not available, notify warehouse manager
M.3. Warehouse manager
  M.3.1. For unavailable products, find a substitute and reorder

2.1.2. Product Receipt and Put-away

Once products are reordered or ordered for the first time, they are eventually received by the store. Trucks are expected to arrive on schedule as the logistics and distribution process is organised centrally and notified in advance to the warehouse manager. As opposed to direct deliveries from suppliers, when shipments come from the distribution centre there is no compulsory product revision either for product quantity or damaged products. Goods are verified only in extreme cases such as visible damage or evident differences. Product items usually come in mixed pallets where the content is known by the LDS for it is electronically sent in advance. These mixed pallets are broken down in product lines which are then usually mixed up again by product type at case level and then transported and stored in the backroom. For example, all sodas are stored together so picking up and replenishment becomes easier. Every product type has its predefined location, and, for simplicity, in some stores the backroom layout is a carbon-copy of the store's one. Proper product put-away is important as it guarantees appropriate storage and recover, perfect rotation and avoid product temporary or permanent loses.

The product receipt process is supported by the following information systems:

– **OS (introduced above):** this system informs of pending orders and their expected contents, allowing for order traceability and verification in the receipt process.

– **The Logistics and Distribution system (LDS):** supports internal shipments between deposits and stores, aiming at optimising transport operations. Its master files include deposits, trucks and stores, and its transactions come from internal delivery procedures and supply chain (SC) systems. In supporting the receipt and put-away process, the LDS holds all delivering transactions and their associated actors such as trucks, warehouses, stores, bill of ladings, etc; and provides information about shipments such as expected time, products, quantity etc. This system is primarily a supporting system as it provides real-time information for goods shipment, receipt etc.

– **The IMS (introduced above):** this system provides the location information for the put-away process, if any; or receives it in case of ad-hoc storing decisions.

The product receipt and put-away process has the following characteristics:

Table 2: Product receipt and put-away characteristics

PRODUCT RECEIPT AND PUT-AWAY	
Actors	– Carrier – Warehouse manager – Warehouse employees – normally assigned to specific sections or product lines
Procedure Steps	– Unload the truck – Mark the shipment as received in the computer – If necessary, check the products for right products, product quantity and defective products – Break pallets out and re-group goods by product type – Store these groups in wagons

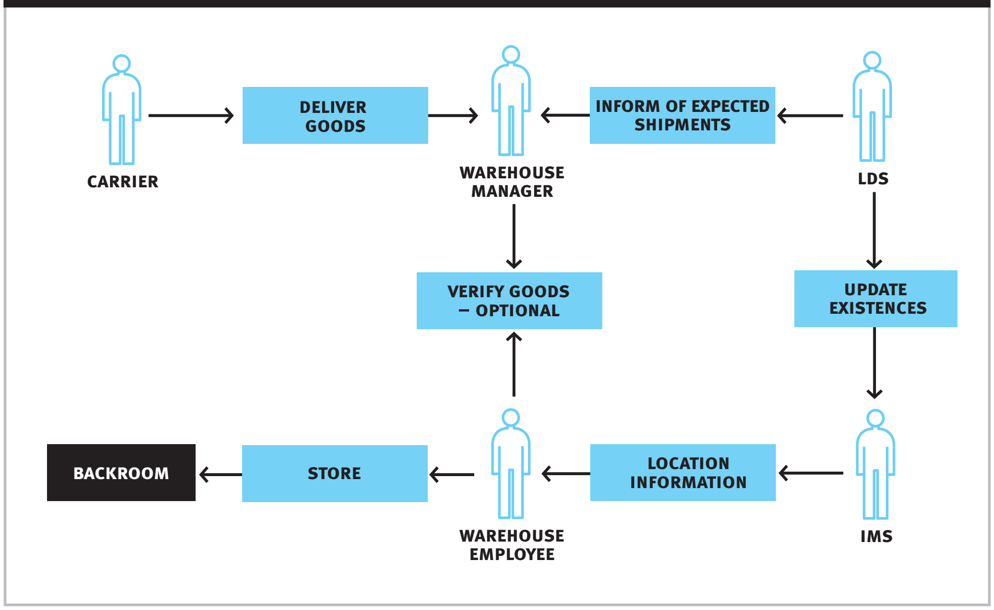
Continuation of Table 2

PRODUCT RECEIPT AND PUT-AWAY	
Procedure Steps	– Decide the product location or query it from the IMS – Move goods – Stack/store product items – Inform the IMS of any ad-hoc location or temporary or permanent location modification
Product Flows	– Goods come from the supplier or distribution centre to either: 1. The dock (usual case), and then to the backroom 2. Directly to the shelf (some specific products)
Information Flows	– Bill of Lading – Report with expected shipments – Receipt confirmation – Stock levels – Product location
Level of Automatism	– Medium: computers have all the pertinent information, though the product receipt and put-away steps are manual. In the latter, most of the product location information is based on employees' experience and knowledge
Decision Points	– Storage location when decided ad-hoc
Contingency Plans	– Track the truck if the order has not arrived – Generate a new order in extreme cases – Store goods in a temporary location
Supporting Assets	– Information systems – Trolleys, wagons, lift trucks, weight scale – Warehouse racks, shelf

Use Case diagram for the product receipt process under the current situation (non-Auto-ID-enhanced):

Figure 3

USE CASE DIAGRAM FOR THE PRODUCT RECEIPT AND PUT-AWAY PROCESS



Main flow of events

M.1. Carrier
- M.1.1. Transports and unloads goods at the store

M.2. Warehouse manager
- M.2.1. Accepts goods
- M.2.2. Verifies goods (optional)
- M.2.3. Registers reception into the LDS

M.3. Warehouse manager
- M.3.1. Checks undelivered orders
- M.3.2. Notifies carriers, suppliers or distribution centre managers in case of missing shipments

M.4. Warehouse employee
- M.4.1. Queries the IMS for a location where to store the incoming product items, or
- M.4.2. Uses his or her experience to move and store the goods
- M.4.3. Informs the system of any selected temporary storage location
- M.4.4. In case of direct replenishment, transports goods to the shelf

2.1.3. Product Recount and Manual Quantity Adjustment

The product recount procedure has two main approaches. First, a legally-required full annual recount is performed during which the store completely stops operations. Second, some products are counted periodically. The latter is triggered by different events:

1. The system shows zero or negative stock
2. Abnormal levels of theft or shrinkage are detected
3. Unscheduled disruptions to delivery
4. Need to check the status of new products
5. Product is showing abnormally slow turnover
6. A visual inspection reveals low stock levels

The recount procedure involves the manual count of both the backroom and shelf stock levels and in many cases a portable device is used to scan the corresponding barcode and enter the product quantity.

The main systems supporting the count procedures are:

- **IMS (introduced above):** provides location information to the counting procedures.

- **The LDS (introduced above):** reports received goods and keeps the inventory updated.

- **The point of sale system (POS):** support selling and return procedures. Among the master files it hosts are the product, tills, cashier and special offers catalogues. The main transactions it supports are sales and returns, registering lists of goods, payments, loyalty cards and cash. These transactions come primarily from tills and most of their input data is bar-code generated. In the recount procedure, the POS reports every item sold at till point and keeps the inventory updated. The POS system is a tracing and supporting system as it supports real-time sales by providing the right price and performing payment transactions and it traces all sales to allow future sales forecasts, product returns and keeps inventory levels updated.

The main characteristics of this procedure are:

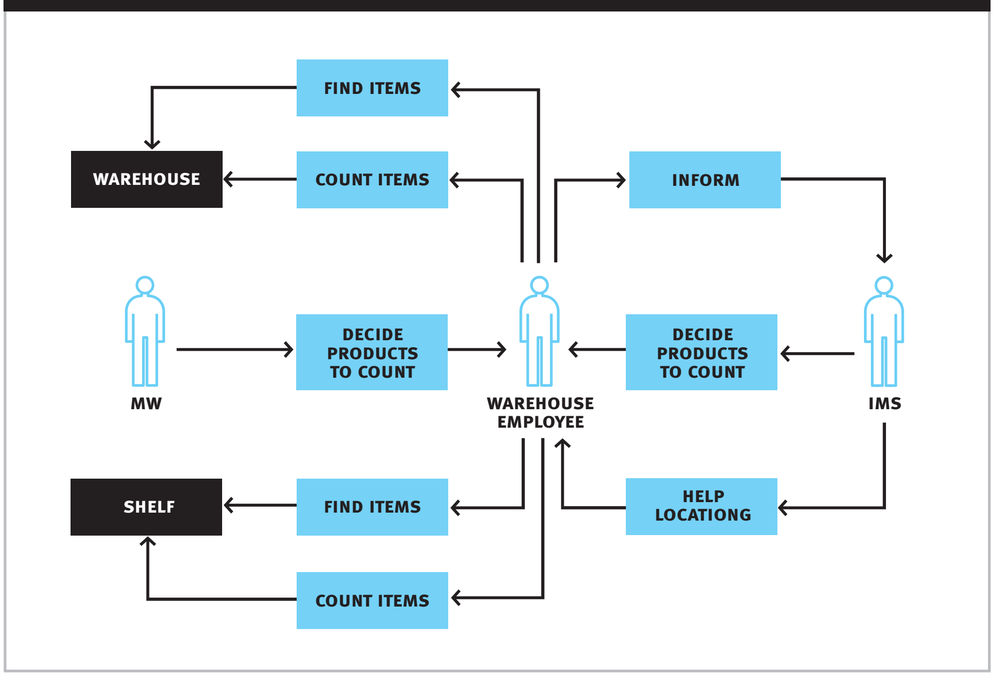
Table 3: Product recount characteristics

PRODUCT RECOUNT	
Actors	– Warehouse manager – Warehouse employees (normally assigned to specific sections or type of products)
Procedure Steps	– Decide what products to count – Find the product in the backroom – Count stock levels – Find the product on the shelf – Count stock levels – Inform the system
Product Flows	– None
Information Flows	– Low: most of the product location information is based on employees experience and knowledge, and the counting procedure is mostly manual
Level of Automatism	– High: orders are generated automatically, although a manual check and adjustment is performed
Decision Points	– Products to recount (manual and automatic decision)
Contingency Plans	– None
Supporting Assets	– Information systems – PDA to scan products' barcodes and enter quantity

Use Case diagram for the product recount procedure under the current situation (non-Auto-ID-enhanced):

Figure 4

USE CASE DIAGRAM FOR THE PRODUCT RECOUNT PROCEDURE



Main flow of events

M.1. Warehouse manager
  M.1.1. Decides which products to recount by visual inspection
M.2. Warehouse employee
  M.2.1. Prints the computerised report defining the products to recount, or
  M.2.2. Gets the information from the Warehouse manager
  M.2.3. Gets the product location information from the IMS or his or her own knowledge
  M.2.4. Finds and count the items in the backroom
  M.2.5. Finds and count the items on the shelf
  M.2.6. Adjust the inventory levels in the IMS

2.1.4. Shelf Replenishment – Normal, Direct and One-touch

Moving products from the backroom to the shelf is a complex procedure. First, it involves detecting and counting or estimating the number of required product items. Second, it requires finding the product items in the backroom. And third, because in some cases items picked up in excess must be moved back to the backroom (action known as reverse replenishment). Depending on the available information and level of coordination with suppliers, this procedure also branches out to three approaches:

– The "normal" approach in which the required number of items are not exactly known but roughly estimated, so more than the required product items are often transported and some consequently require post-reverse replenishment.

– The "direct" approach in which product items are never stored in the backroom, but go straight to their corresponding place on the shelf. In this case the accurate replenishment quantity should be reflected in the order to suppliers or distribution centre, and reverse replenishment only happens in case of mistakes.

– The "one-touch" approach in which only the required product items are moved so reverse replenishment is avoided.

The systems supporting the shelf replenishment process are:

– **LDS (introduced above):** notifies when a shipment has arrived for direct replenishment.

– **POS (introduced above):** reports on sales, helping estimating shelf levels.

– **IMS (introduced above):** keeps track of the item stocks in both the backroom and shelf – though this information is fairly unreliable given the high product mobility, shrinkage etc.

The main characteristics of the replenishment procedure are:

Table 4: Shelf replenishment procedure characteristics

SHELF REPLENISHMENT	
Actors	– Replenishment employees – Store manager
Procedure Steps	– Determine which products to replenish, and, if possible, how many of them – Find the products in the backroom and fill the replenishment wagon – Find the location in the store and move goods – Replenish

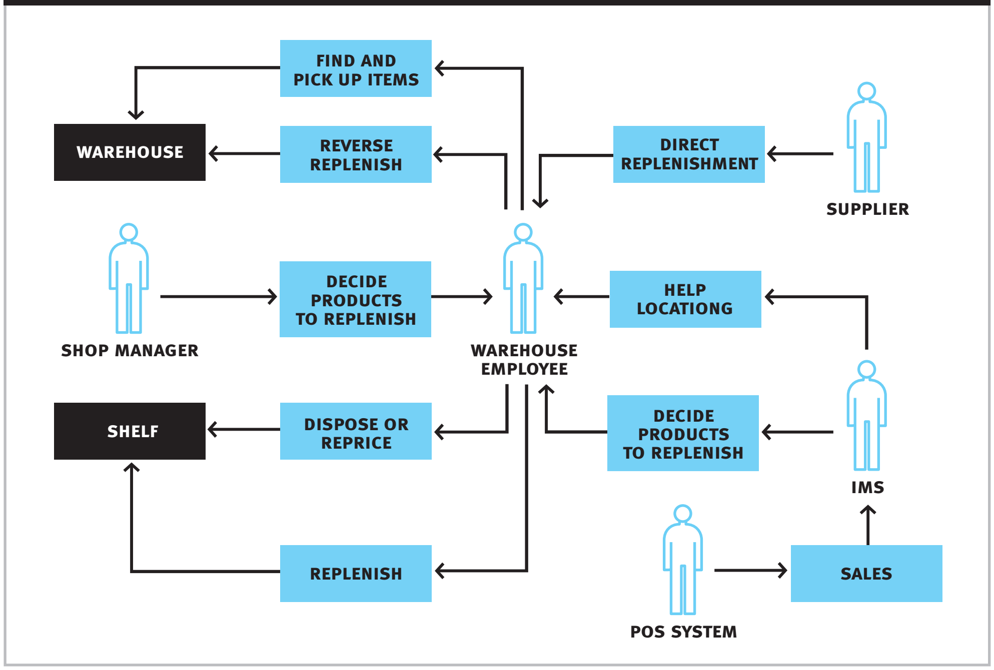
Continuation of Table 4

SHELF REPLENISHMENT	
Procedure Steps	– Remove expired or damaged product items – If any, move excess, expired or damaged product items to the backroom – Alternatively, reduce price of expired or damaged product items: mark and/or move to an special zone – Inform the system about the movement of goods
Product Flows	– From the backroom to the shelf – From the shelf to the backroom – reverse replenishment
Information Flows	– Products to replenish – type and quantity – Number of product items effectively replenished – Number of product items moved back to the backroom – Number of product items discarded or reduced
Level of Automatism	– Medium: the system orders scheduled replenishments or unscheduled ones in case of high sales. Nevertheless, finding and replenishing products is still a manual process. Moreover, the information result of the replenishment is not always fed back into the inventory management system
Decision Points	– Products and number of items to replenish – Items to reverse-replenish – Items to reduce or discard
Contingency Plans	– None
Supporting Assets	– Information systems – PDA to scan products' barcodes and enter quantity – Replenishment wagon – Warehouse and shelf space

Use Case diagram for the shelf replenishment procedure under the current situation (non-Auto-ID-enhanced):

Figure 5

USE CASE DIAGRAM FOR THE PRODUCT RECOUNT PROCEDURE



Main flow of events

M.1. Shop manager
 M.1.1. Decides products to replenish
M.2. IMS and POS systems
 M.2.1. Decide products to replenish based on stock levels and sales
 M.2.2. IMS provides location information
M.3. Supplier
 M.3.1. Provides goods for direct replenishment
M.4. Warehouse employee
 M.4.1. Finds goods in the backroom
 M.4.2. Fills replenishment wagons and trolleys
 M.4.3. Transport goods to the store
 M.4.4. Finds products' location on the shelves
 M.4.5. Inspects contents and discards old or damaged product items
 M.4.6. Reduces price of products about to expire
 M.4.7. Replenish
 M.4.8. Moves excess product items back to the warehouse

2.1.5. Reverse Logistics

Sometimes, defective or expired product items must be sent back to suppliers. This also applies to electronic goods returned by customers due to legal regulations. The reverse logistic process requires temporarily storing in-transit, to-return goods in the backroom, which must not be mixed up or confused with those in the forward logistics (goods to sell). As long as these goods retain their electronic tags after the point of sale, which is not granted due to privacy concerns related to Auto-ID, these tags may be used to improve the visibility of goods in the reverse supply chain. The reverse logistics process is complex as there are many sources of returned goods (pre or post-sale). These goods follow different tracks depending on the product type. Their movement also involves third parties. This retail company sends all its returned electronic goods to an intermediary, who collates and sorts returns from a region and passes them onto suppliers.

The main supporting systems for the reverse logistics procedure are:

– **POS (introduced above):** provides sales-time information about the returned goods such as price, customer, sales date etc.

– **Customer service desk system (CDS):** registers returning information such as customer, return motive, date, and product condition etc. Although the CDS system supports the returning process, it is essentially a tracing system as it registers the returning information in order to support other process steps such as supplier-level reverse logistics.

– **IMS (introduced above):** increase or decrease the goods existence following their movements – incremented as returned from customers, decremented as returned to suppliers.

– **LDS (introduced above):** coordinates product deliveries from the distribution centre with returns in order to minimise transport costs due to reverse logistics activities.

The reverse logistics procedure has the following characteristics:

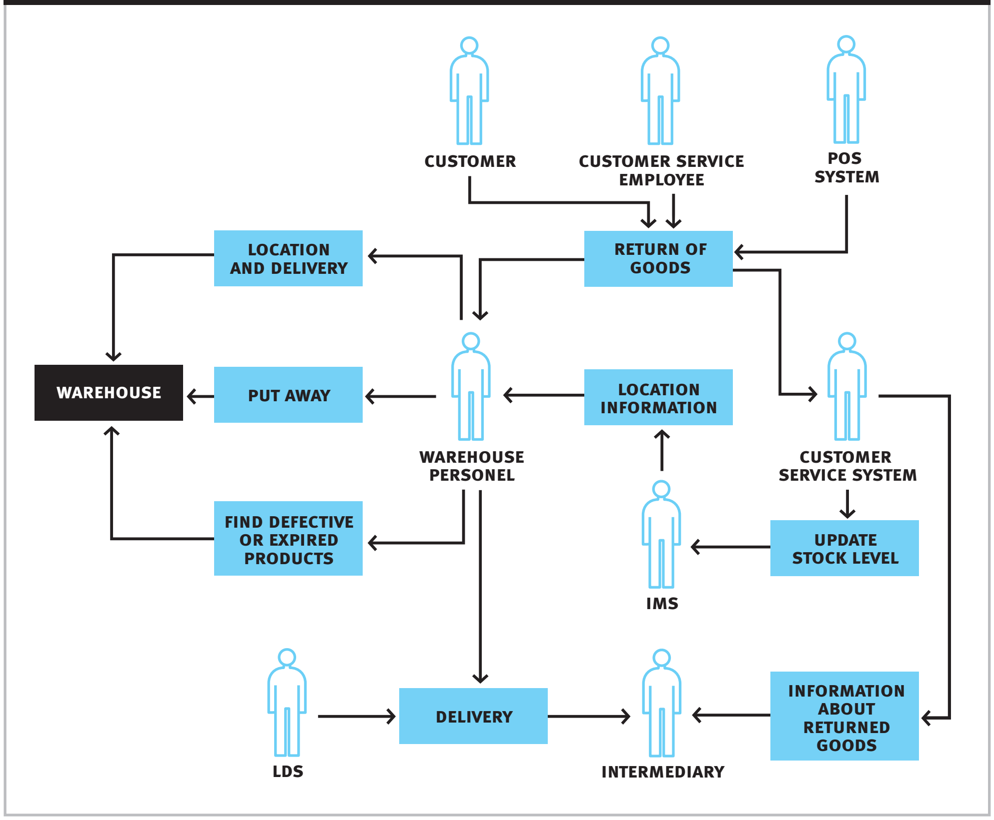
Table 5: Reverse logistics procedure characteristics

REVERSE LOGISTICS	
Actors	– Customer – Cashier – Store manager – Warehouse manager – Logistics and distribution manager – Intermediary – Suppliers
Procedure Steps	– Receive and register returned products from customers – Label and put away products in the backroom – Reuse products if possible – no legal regulations, non food etc. – Schedule the transportation of returned goods to intermediary – Find the products in the backroom – Ship the products to the intermediary
Product Flows	– From customer to store – From customer service desk to backroom – From backroom to truck, and then to intermediary – From intermediary to suppliers
Information Flows	– Product type, amount refund, reason to return, purchasing information – date, amount paid, customer name and id, etc. – Location of goods within the backroom – Shipment information
Level of Automatism	– High: the whole process is supported by existing information systems
Decision Points	– Whether to receive the good from customers or not – Amount to refund – Product re-selling if possible – Product disposal if necessary – Location to store the goods within the backroom
Contingency Plans	– None
Supporting Assets	– Information systems – Wagons and trolleys to move goods – Warehouse space – Trucks

Use Case diagram for the reverse logistics procedure under the current situation (non-Auto-ID-enhanced):

Figure 6

USE CASE DIAGRAM FOR THE REVERSE LOGISTICS PROCEDURE



Main flow of events

M.1. Customer
- M.1.2. Returns goods

M.2. POS system
- M.2.1. Provides information about the product origin and selling transaction

M.3. Customer service employee
- M.3.1. Decides whether to accept the good or not
- M.3.2. Refunds the money
- M.3.3. Register the transaction
- M.3.4. Temporarily stores the good

M.4. IMS
- M.4.1 Provides location information to store the product

M.5. Warehouse employee
- M.5.1. Decides whether the item is re-saleable or not
- M.5.2. Stores the good according

M.6. LDS
- M.6.1. Support the reverse shipment procedure

M.7. Intermediary
- M.7.1 Gets the returned non re-saleable goods and negotiates with suppliers

2.2. Limitations of Current Technology

The current technology available limits the possibilities of the aforementioned processes. Some of these limitations are:

Identifying products and product items is a costly and cumbersome process: the only current technology available to identify products and product groups in the aforementioned processes is the barcode. Pallets, cases, and product lines can be identified by their barcodes. However, scanning all products or product cases would involve the manual break down and reassembly of pallets in the receipt and put-away process. This is a slow, costly, and cumbersome process. Scanning products in the backroom and shelf in order to support the other processes also involves high manual intervention and the manipulation of goods. Consequently, most of the aforementioned processes do not make use of the identifying methods (except perhaps at the pallet level) and use alternate information sources to support decisions and operations. For example, the receipt and put-away process assumes correct delivery, unload, and put-away. The system also reflects what is expected to happen and not what really happens, which in some cases are different. In other words, checkpoints within the processes aiming at conciliating reality and expectations are distant and sparse. This makes the information about on stocks inaccurate and somehow unreliable. For example, shrinkage between the distribution centre and stores is significant, however the scarce and distant intermediate checkpoints make it almost impossible to uncover where, why, and to what extent the problem occurs.

Static existence and status checks are impossible to achieve: barcodes also require manual intervention, otherwise they are meaningless. Whenever a product item remains static and not accessed, for example when stored in the backroom, future processes concerning it must rely on historic information. That is, products are tracked as long as they are involved in an ongoing and active process. This implicit marriage between item tracking and operational business processes has three consequences: first, processes relying on product existence or status may fail if the situation changes while the product items where static – e.g. uncontrolled stock failure in an extreme shrinkage situation. Second, additional processes or process steps are required to ensure sound business operations – e.g. constant product recounts or verifications. Finally, the whole process is more vulnerable to mistakes: any errors upstream the process chain affecting the product location, status or related information will be more difficult to identify and prevent, and is more likely to have a negative impact on the subsequent processes – e.g. inability to find originally misplaced goods when it comes to replenishment.

Item level identification information does not exist: some business processes require individual item identification or at least a higher identification granularity than product type. An example of this is batches of products with the same “best before” date. Although for many products this information is available through barcodes, the same limitations above apply to processes aiming at using this information to improve operations that require manual intervention and breaking-down of pallets etc. A good example of these improvements is perfect inventory rotation where products are processed in strict “best before date” order to minimise waste due to product expiration.

2.3. Opportunities and Issues to Solve or Improve

Shrinkage detection and reduction: improving inventory visibility provides enough intermediate check-points to determine the primary causes of shrinkage. Based on this information, a company is able to draw possible solutions to the shrinkage phenomenon. Tracking down causes of shrinkage also allows assigning specific responsibilities for both moving and static goods, as well as incentives to reduce these causes. Reducing shrinkage is important in reducing costs. Furthermore, stolen goods may also be a source of unfair competition as many of these goods find their way to competitors’ stores at significant lower cost.

Perfect rotation enabling: current information systems, reports, and business analysis tools assume perfect rotation; that is, that goods move in the same order within the supply chain and overtaking does not takes place. However, it is clear that this is not the current reality. Improving inventory visibility helps achieve perfect rotation as products with earlier "best before" date are easily found and replenished. Achieving perfect rotation is important as it directly impacts product quality and the level of waste, as explained below.

Reduction of waste: improving inventory visibility reduces waste for three reasons. First, an imperfect rotation is always a source of waste as some goods reach their expiration date not because of the lack of customer demand, but merely because these goods were left behind in the replenishment process. Second, some lost items get damaged or left out of season or fashion. Lastly, because more returned goods would be resold or recycled if more information about them were available. Reducing waste is important not only because of the cost reduction it involves, but also due to environmental concerns and regulations.

Reduction of manual intervention: the automation of item tracking and tracing procedures reduces the need for human work, intervention, and knowledge. For example, many location decisions rely on the handler's experience. Human intervention is costly for many reasons: first, employees make mistakes; second, their availability is reduced to their working hours: holidays and resting hours rest productivity and availability to their experience and knowledge; third, humans generate other sort of requirements and related costs due to safety concerns, need of trust, etc. Finally, the cost of the workforce is expensive and subject to many complex legal regulations.

Reduction of stock failures: under the current system and as explained in the reorder process, reconciliation between real and expected stock levels only happens in extreme cases such as zero or negative stock, abnormal turnover, visual inspection etc. Under this approach some stock-outs seem unavoidable. Improving the inventory visibility decreases stock failures. This is important since it improves customer service thus reinforcing the brand and allows making a more efficient use of shelf space. An empty shelf is an idle asset.

One-touch replenishment enabling: this replenishment approach involves knowing exactly how much shelf space is available for replenishment. Improving inventory visibility on the shelf helps determine the number of goods to be picked from the backroom without worrying about bringing them back because of the lack of shelf space. Enabling a one-touch replenishment approach also reduces replenishment costs and helps in achieving perfect rotation as chaos is reduced in the backroom.

Improvement of product recalls: improving inventory visibility allows finding, picking, and shipping recalled product items either from the backroom or the shelf. Product recalls are important as they involve massive movement of goods and must be done properly to avoid legal consequences or brand damaging.

2.4. Auto-ID Capabilities Enhancing the Use Case

The main Auto-ID capabilities that enhance the Use Case are:

1. Tracking and identification capabilities in order to improve the product reorder, receipt and put-away, re-count, and replenishment processes. The ability to know where a product item is stored and what product items are on an arriving pallet makes Auto-ID a remarkable technology to improve inventory visibility in order to enable perfect rotation and one-touch replenishment; reduce shrinkage, waste and stock failures; and ease product recalls.

2. Tracing capabilities in order to improve the reverse logistic process. Having the possibility of tracing back a returned product notably enhances the returning procedure. First, the actual origin of the product can be easily determined. Second, knowing some technical or legal aspects of the product item may enable or ease reselling, recycling, or negotiating refunds with suppliers. Finally, the returning process itself at the customer services desk will benefit from detailed selling, customer, and product information such as paid price or date of acquisition.

3. Inter-organisational capabilities in order to improve the put-away and replenishment processes. One important piece of information enhancing these processes is the "best before" or "expiration" date. Other valuable inputs include storage conditions such as refrigeration temperature, maximum stack levels etc. Auto-ID inter-organisational capabilities will help sharing this information between suppliers and retailers. This can be used to support storing and picking decisions in the put-away and replenishment processes.

The following table summarises the relationship between current processes, opportunities and issues to solve, and the Auto-ID capabilities leveraging these opportunities:

Table 6: Processes and Auto-ID capabilities leveraging them

	REORDER	RECEIPT AND PUT-AWAY	RECOUNT	REPLENISHMENT	REVERSE LOGISTICS
Shrinkage Reduction and Detection	Tracking	Tracking	Tracking	Tracking	Tracking
Enabling Perfect Rotation	Tracking, tracing & inter-org	Tracking & inter-org		Tracking & inter-org	
Reduction of Waste		Tracking & inter-org	Tracking	Tracking & inter-org	Tracing & inter-org
Reduction of Manual Intervention		Tracking	Tracking	Tracking	
Reduction of Stock Failures	Tracing	Tracking	Tracking	Tracking	
Enabling One-touch Replenishment	Tracking			Tracking	
Improvement of Recalls			Tracking		Tracking, tracing & inter-org

2.5. Implementation

2.5.1. Implementation Pre-requirements

The key implementation requirements include the efficient organisation of stock around the store. The backrooms in many stores are not organised in any notable method. If smart shelves are introduced into this system for certain products, stock will have to be stacked carefully and methodically. Many products arrive from suppliers in cages that can be taken straight to the shopfloor to replenish shelves so that not all products need to be shelved in the storeroom.

Use of the zoning method would require an efficient referencing system to be in place so that staff can understand how products are being referenced as well as find products quickly.

Some of the most important technical requirements:

Reader and Savant™ Filters and counters: in the scanning and capture of EPC™ in this use case, it is assumed that groups of EPC™ may be summarized as aggregate counts of items. This will reduce the burden on the system by eliminating superfluous data; the theory of filtered counts is outlined in the background document entitled Standard Reader/Savant™ API, Filters & Counters being prepared by the Auto-ID Software Action Group.

Inventory comparisons and alerts: the Inventory Management system should be able to compare aggregated count readings from the Savant™ with the store's inventory requirements as inputted by the user. For example, the stock control manager should be able to input an inventory level that indicates a low inventory level. When the reading from the Savant™ reaches this number, an alert needs to be sent to the ordering system or shop floor, depending on where the stock out is about to occur.

Queries: an interface is needed to allow queries to be made relating to product details (e.g. finding the price, location, name, supplier details of a product on the shelf). This interface must also be present on handheld devices to provide full functionality.

Exits and entrances reading configuration: for this configuration to work, the readers need to be able to tell which direction products are moving in so that the system can tell whether a product is entering or leaving a room. A way of working around this technology requirement is to have two readers at each door or a complementary technology such as electronic eyes, allowing interpolation of direction.

Scan reliability: 100% scanning accuracy needs to be guaranteed, especially in security applications. The 'exits and entrances' configuration assumes that products at item level can be read when they are being moved passed readers at varying speeds.

Refresh Rate: an important requirement of the system is the ability to complete an entire scan of all products quickly so that there is minimal probability that products will be moved during the scan, reducing the scan accuracy. This requires fast data processing speeds.

2.5.2. Implementation Alternatives

There is more than one implementation possibility when using Auto-ID to improve inventory visibility in the backroom and shelf. First, there are two main approaches for contents needing to be controlled in a confined space. The first approach is a static one where fixed readers on shelves, aisles, or hand-held readers continuously or periodically monitor stocks. The second approach is dynamic where there are readers in every door for access control item movements and update an inventory log. It is clear to see that the dynamic approach offers some cost benefits as few readers are required. However, it fails to verify static stocks, as barcodes do, see 2.2. Moreover, a dynamic approach is believed to be less reliable as read failures can occur and extra hardware and software is required to reliably determine the direction of movement (for example, are products entering or leaving the place?). Second, for controlling stocks, tags can be put at different levels: pallets, cases, products etc. Different approaches will bring different benefits to different processes such as pallet-level tagging clearly benefits the receipt process, and product-level tagging clearly benefits the replenishment one. The challenge is to find a common approach leveraging advantages in all of the related processes. Third, the level of integration possibilities with existing technology clearly conditions the possibilities. For example, an automatic product recount via Auto-ID will be really worth it as long as it sends the results directly to the IMS. Finally, there are other implementation decisions conditioning immediate and future possibilities, such as tag and reader type, refreshment rate, antennae and reader coverage etc.

In a nutshell, the main implementation decisions depend on the following combinations:

Table 7

IMPLEMENTATION DECISIONS	
Location of Readers	doors / shelf / mobile (wireless handheld devices)
Level of Tagging	pallet / case / product
Type of Tags	active / passive
Granularity of Coverage	time (refresh rate) – fast / medium / slow space – small / medium / large
Integration with Installed IS	none / loose / tight

It is clear that some combinations such as mobile readers with a small and slow coverage do not make sense. We will also disregard using active tags as it seems that their advantages do not outweigh the price difference for most applications.

Having reviewed all combinations, this paper proposes the following implementation approaches:

a) Low cost alternative (dynamic).
- Fixed readers in all doors with large coverage and fast refresh rate
- Mobile readers with medium coverage and fast refresh rate
- Pallet and case level tagging
- Loose integration via batch files

Under this approach, only pallets and cases will be tagged and tracked with Auto-ID. This will allow to improve the reorder, receipt and put-away, and replenishment picking from the backroom. Backroom stocks will be controlled by means of mobile readers in product recounts, put-away, and item finding steps of the aforementioned processes. The reordering process will benefit from more accurate information on real stocks. This alternative would not allow for one-touch replenishment as individual product item stocks on shelves will not be available via Auto-ID. Similarly, this approach will not allow for improvements in the reverse logistics process because product item identification is not available.

b) Medium cost alternative (dynamic for the backroom and static for the shelves).
- Fixed readers in backroom’s doors with large coverage and fast refresh rate.
- Mobile readers for the backroom with medium coverage and fast refresh rate.
- Smart shelves for the store with low refresh rate.
- Pallet, case and product level tagging.
- Loose integration via batch files.

This approach combines the advantages mentioned previously with better information on shelf stocks in order to improve the replenishment process. The characteristics are similar, although this approach positively allows for one-touch replenishment and improvements in the reverse logistics process because it offers product-level tagging. Nevertheless, a loose integration with existing information systems would definitely condition or limit these improvements since some procedure steps in the replenishment and reverse logistics process require on-the-fly information that asks for online IS coupling.

c) High cost alternative (static).
   - Fixed readers in docks with large coverage and fast refresh rate.
   - Smart shelves in both the backroom and store.
   - Pallet, case and product level tagging.
   - Tight online integration.

This approach is the most sophisticated but expensive. It eliminates the need for mobile readers (wireless handheld devices) and their associated manual procedures, and combines the advantages of dynamic and static models. Its tight IS coupling also allows supporting on-the-fly operational decisions such as storing locations etc.

2.6. Potential Benefits

In relation with the improvement opportunities, the main benefits that result from increased inventory visibility are:

Productivity increase: increased inventory visibility helps utilise warehouse facilities and assets. An improved inventory visibility translates into lower total stocks as safety stocks needs are reduced. Reorders will also be more accurate and reflect real selling needs. The following improvement opportunities directly or indirectly help increase productivity: **shrink detection and reduction** as less stock and warehouse space will be required for normal operations; **reduction of stock failures** for the number of empty shelves will be reduced; one-touch replenishment enabling as employees will minimise trips between the store and the backroom and transport only the required product items; and **improvement of product recalls** for less employees and supporting assets will be required to find and dispose the requested items. The productivity increase result from all these improvement opportunities can be easily valued using cost/benefits analysis, as long as the inputs are known. For example, the reduction in manual work required by one-touch replenishment as opposed to normal replenishment can be easily found by measuring current workforce requirements in the reverse replenishment process. Valuing this reduction in terms of money is as straightforward as workforce cost is normally well known by companies.

Cost reduction: it comes from various improvement opportunities. **Shrinkage detection and reduction** as costs consequence of lost goods will be reduced; **perfect rotation enabling** whereby expired product waste is reduced; **reduction of waste** which allows for saving not only the cost of disposed products but also that of disposing procedures; **reduction of manual intervention** which may be expensive; and **improvement of product recalls** which will require far less resources to be performed as requested products will be easily identified and found. Valuing these benefits in terms of money is a straightforward cost/benefit analysis in some cases such as reduction of shrinkage, however, a more complex one in others where the inputs are not known such as reduction of waste result from perfect rotation for waste may result from both lack of customer demand and product left-behind. In the latter, some stochastic valuation techniques may be necessary.

Service improvement: these benefits are the result of improvement opportunities in **enabling perfect rotation** as customers will find fresher products on the shelves and **reduction of stock failures** result from improved shelf stock visibility. The organisation will also be able to provide a better product return service as more and more accurate information will be available at the customer service desk. Valuing the benefits of service improvement is trickier and sometimes impossible to do. Customers visit the supermarkets for a variety of reasons: proximity, attraction, habit, loyalty programs, cost, availability of products etc. The latter affects their decision, although it is almost impossible to find to what degree.

Strategic value: finally, the Auto-ID infrastructure has strategic value as long as it can be used for other applications, either immediately or in the future. For example, readers in shelves could be used to gather information on consumer behaviour for marketing purposes, and tags on products could be used to provide customers with detailed information about the product item. Strategic value can be estimated in terms of money by using complex financial formulae as real options or the like, but that is out of the reach of the current paper.

3. ASSESSING THE IMPLEMENTATION IMPACT

3.1. Identifying the Affected Systems and Related Data and Transactions

In this section we will identify the impact of Auto-ID on the described procedures in a retail company and related information systems. This impact is found by relating the decision points in procedures with the information affecting those decisions and related transactions, as well as the information flows from the procedures to the supporting information systems. Table 8 summarises the analysis:

3.2 Data flow, Sources and Destinations

Figure 7 shows a representation of the data flows and the effects of the data on the current inventory management system. Each data transaction gives rise to a status change.

Figure 7

DATA AND PROCESS TRANSACTIONS IN CURRENT RETAIL SYSTEM

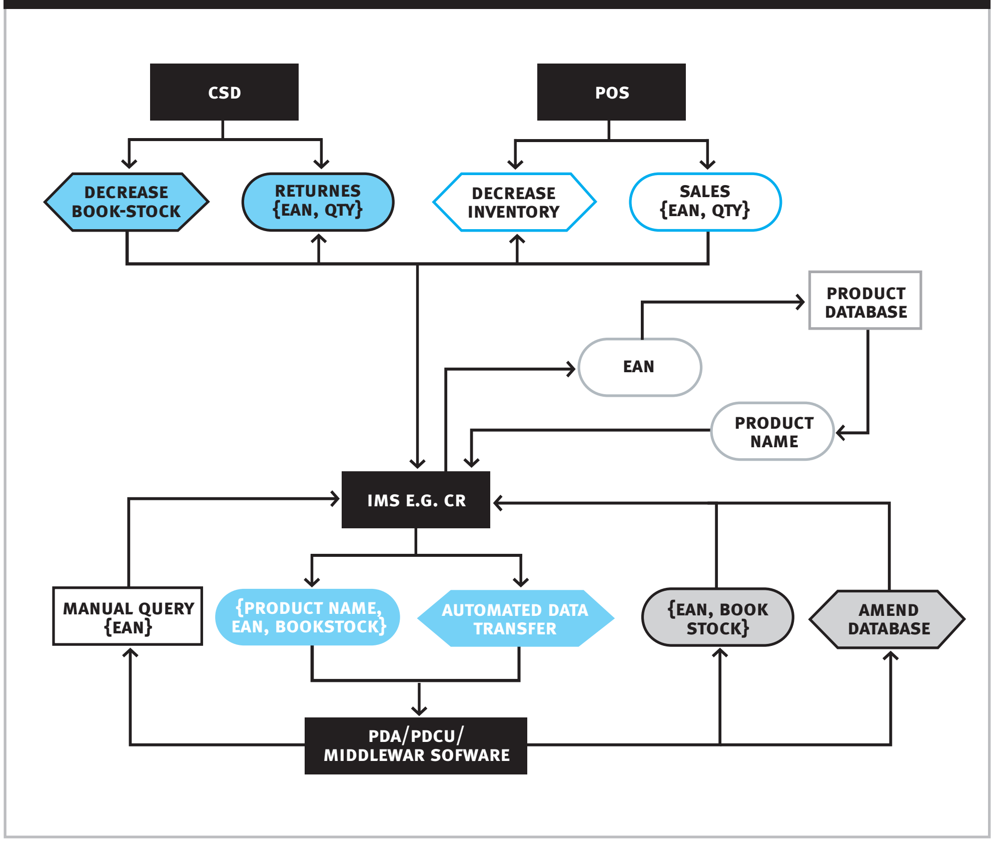


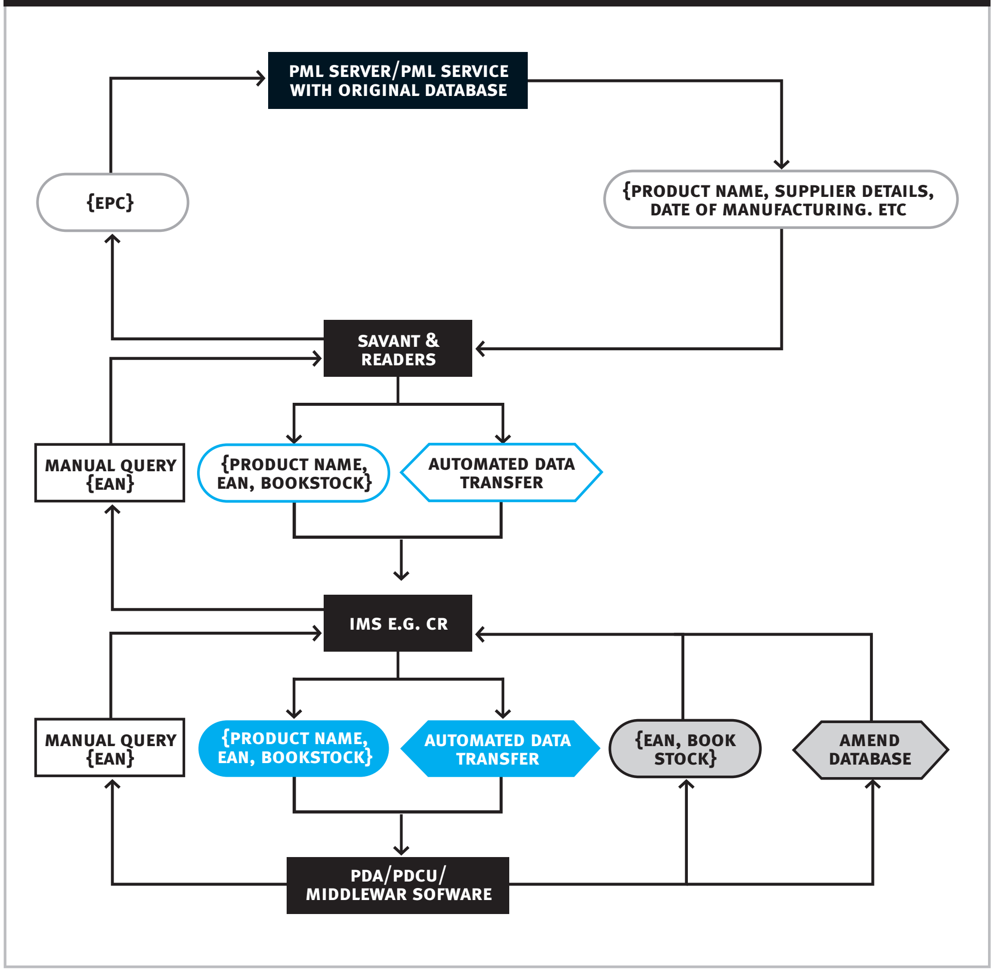
Table 6: Process steps, supporting IS transactions and generated transactions

	Procedures	Re-ordering	Receipt and Put-away			Recount			Shelf Replenishment			Reverse Logistics			
SYSTEM	**DECISIONS TRANS-ACTION**	**WHAT TO ORDER?**	**ORDER HAS BEEN RECEIVED**	**IS THE ORDER ACCEPTED?**	**WHERE TO STORE PRODUCTS?**	**WHAT TO RECOUNT?**	**WHERE TO FIND PRODUCTS?**	**HOW MANY PRODUCTS FOUND?**	**WHAT TO REPLENISH?**	**WHERE TO FIND PRODUCTS?**	**WHAT TO DISPOSE OR MOVE BACK?**	**HOW MUCH TO REFUND?**	**RETURN INFO**	**RESELL RETURNED GOODS**	**WHAT TO DO WITH THE GOODS?**
OS	**Reordering**	← Products & prod. qty to reorder													
	Acceptance			← Verificatn info											
	Order receipt		↑ Order number							↑ Direct replenishment orders					
IMS	**Reordering report**	↑ Products & qty to reorder													
	Location by product line or type				↑ Location info		↑ Location info			↑ Location info					↑ Location info
	Products with 0 or negative stock report					↑ Products to recount									
	Quantity adjustment			← Number of items				← Number of items			← Disposed items			← Number of items	
LDS	**Shipment**		← Order number						↑ Direct replenishment orders						← Items to transport back
SS	**Forecast**	↑ Expected sales													
POS	**Selling report by product**					↑ Products with abnormal turnover			↑ Recent Sales						
	Selling transaction details											↑ Price at the selling date			
CDS													Return details		

Figure 8 shows a representation of the data flows in an Auto-ID enabled system. The Savant™ and reader have replaced the POS and CSD.

Figure 8

DATA AND PROCESS TRANSACTIONS IN CURRENT RETAIL SYSTEM



3.3. New Operational Procedures with Auto-ID

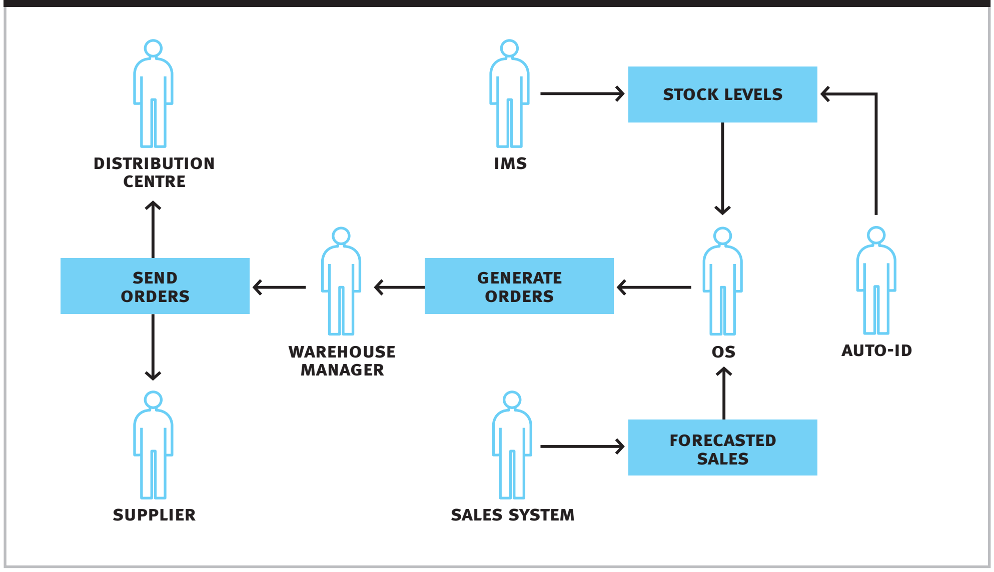
As table 8 shows, many transactions and pieces of data flowing between operational procedures and information systems deal with product location and cardinality – (how many products are there and where are they located?). A particularly significant case is the IMS, which stores information on product location information and quantity. It also supports the receipt and put-away, recount and replenishment processes. Auto-ID tracking and identification possibilities allow for easy product item location and counting. Depending on the implementation approach, complementary procedures may be necessary. Particularly, the use of wireless hand held devices – implementation approaches A and B – requires a frequent manual scan of stocks. This manual scan is believed to be easy, as it does not require neither line of sight nor pallet or stack disassembly. This new procedure requires a new report from the IMS with the suggested scanning pattern and target products. For this new report, the IMS will consider products with high turnover and special conditions such as negative or zero stock which are the same conditions triggering current product recounts, plus products that have not been scanned for a certain period.

The impact of Auto-ID on current procedures involves the inclusion of a new actor – Auto-ID infrastructure, which will provide information about product location and cardinality and get information directly from the physical world. This new actor was included in the Use Case diagrams to properly reflect the impact, as shown below. The respective procedure steps also reflect the extra or modified steps.

Reorder process: Auto-ID will provide valuable information on stocks. Although the main reorder process will not change dramatically, the fundamental reordering formula remains the same, having more precise information on current stock levels will end up in a more accurate and reliable reordering process. The following diagram shows how the new actor fits into the existing procedure.

Figure 9

USE CASE DIAGRAM FOR THE AUTO-ID-ENHANCED REORDER PROCEDURE



Main flow of events

IMPLEMENTATION ALTERNATIVES A AND B:

A.1. IMS
   A.1.1. Orders periodic product recounts using PDAs
A.2. Auto-ID
   A.2.1. Provides accurate existence information
A.3. Warehouse manager
   A.3.1. Issues reorder report
   A.3.2. Checks reorder report
   A.3.3. Sends reorders advices to distribution centre or suppliers
A.4. Supplier or distribution centre
   A.4.1. Picks and sends the shipment
   A.4.2. If product items are not available, notify warehouse manager

IMPLEMENTATION ALTERNATIVE C:

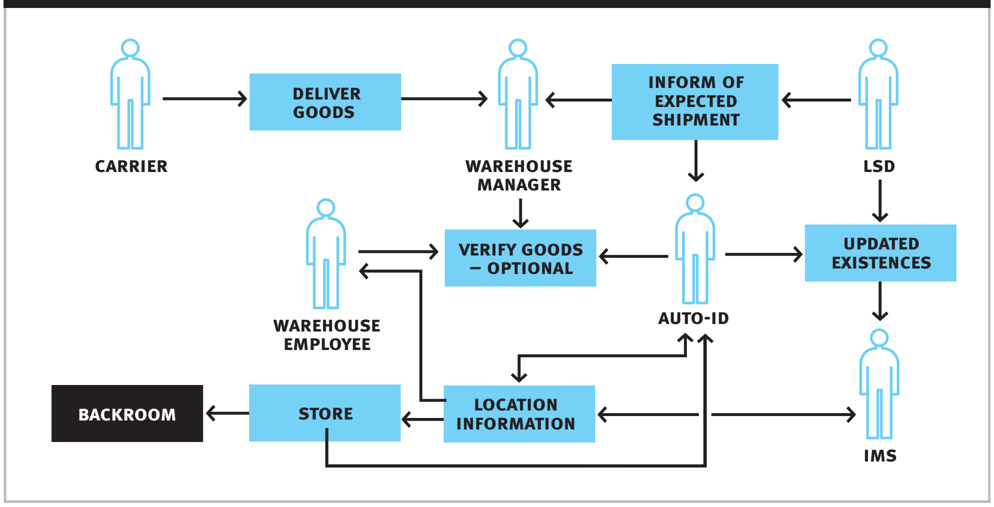
A.1. Auto-ID
   A.1.1. Provides accurate existence information
A.2. Warehouse manager
   A.2.1. Issues reorder report

A.2.2. Checks reorder report
A.2.3. Sends reorders advices to distribution centre or suppliers
A.3. Supplier or distribution centre
A.3.1. Picks and sends the shipment
A.3.2. If product items are not available, notify warehouse manager

Receipt and put-away: Auto-ID will provide and receive information about good reception and storage. That is, it can be used to automatically verify shipments at dock point – products and product quantity, although not quality; and provide pre or post-storage location information. That is, it can find free places within the backroom where to store goods, or track product location in case of ad-hoc storage decisions.

Figure 10

USE CASE DIAGRAM FOR THE AUTO-ID-ENHANCED RECEIPT AND PUT-AWAY PROCEDURE



Main flow of events

IMPLEMENTATION ALTERNATIVES A AND B:
A.1. Carrier
A.1.1. Transports and unload goods at the store
A.2. Warehouse manager
A.2.1. Accepts goods
A.3. Auto-ID
A.3.1. Verifies goods (quantity)
A.3.2. Registers delivery into the LDS
A.3.3. Updates stock levels in IMS
A.4. Warehouse manager
A.4.1. Checks undelivered orders
A.4.2. Notifies carriers, suppliers or distribution centre managers in case of missing shipments
A.5. IMS
A.5.1. Orders periodic product recounts using PDAs
A.6. Auto-ID
A.6.1. Supplies location information – free space in the backroom
A.7. Warehouse employee
A.7.1. Queries the IMS for a location where to store the incoming product items, or
A.7.2. Uses his or her experience to move and store the goods

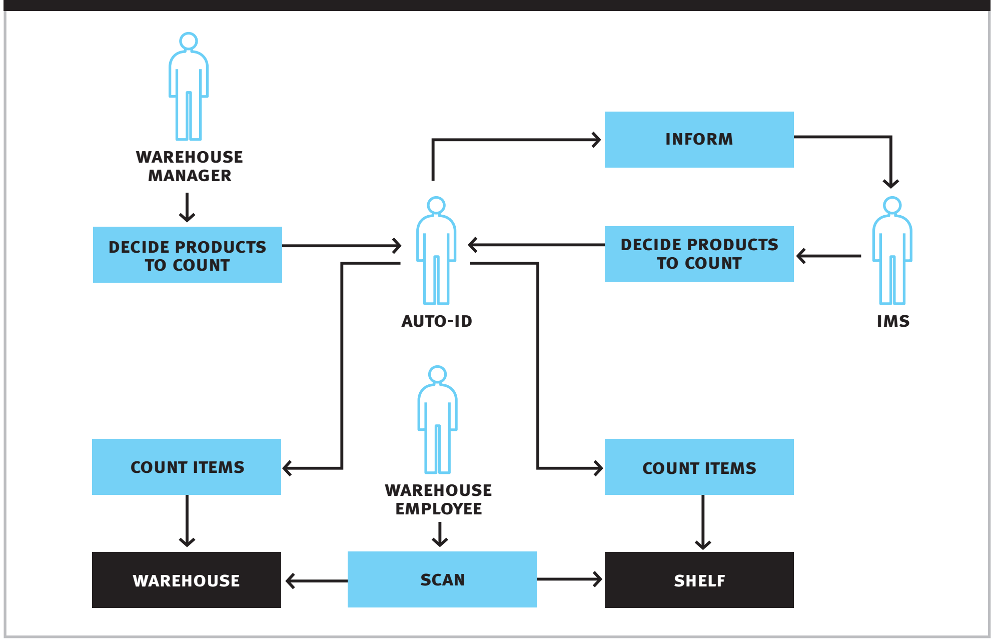
A.7.3. Informs the system of any selected temporary storage location
A.8. Auto-ID
A.8.1 Provides final location information to IMS

IMPLEMENTATION ALTERNATIVE C:
A.1. Carrier
A.1.1. Transports and unload goods at the store
A.2. Warehouse manager
A.2.1. Accepts goods
A.3. Auto-ID
A.3.1. Verifies goods (quantity)
A.3.2. Registers delivery into the LDS
A.3.3. Updates stock levels in IMS
A.4. Warehouse manager
A.4.1. Checks undelivered orders
A.4.2. Notifies carriers, suppliers or distribution centre managers in case of missing shipments
A.5. Auto-ID
A.5.1. Supplies location information – free space in the backroom
A.6. Warehouse employee
A.6.1. Queries the IMS for a location where to store the incoming product items, or
A.6.2. Uses his or her experience to move and store the goods
A.6.3. Informs the system of any selected temporary storage location
A.7. Auto-ID
A.7.1 Provides final location information to IMS

Recount: the Auto-ID infrastructure provides easy-to-use and reliable tools for product counting, either with fixed readers or mobile ones involving manual intervention. Mobile readers clearly have an advantage over barcodes as they do not need line of sight and, therefore, using them does not involve product handling in the process. Including Auto-ID into the recount process brings a significant change in the Use Case diagram:

Figure 11

USE CASE DIAGRAM FOR THE AUTO-ID-ENHANCED RECEIPT AND PUT-AWAY PROCEDURE



The warehouse employee intervention depends on the implementation approach. The diagram reflects the situation for A, whereas approach B does not require scanning of the shelf, and approach C does not require scanning at all – the "warehouse employee" actor completely disappears.

Main flow of events

IMPLEMENTATION ALTERNATIVE A:
A.1. Warehouse manager
  A.1.1. Decides products to recount by visual inspection
A.2. IMS
  A.2.1. Decides products to recount and zones to scan
A.3. Warehouse employee
  A.3.1. Scans the selected zones in both the backroom and store shelves
A.4. Auto-ID
  A.4.1. Counts items tracked by the PDA
  A.4.2. Adjust the inventory levels in the IMS

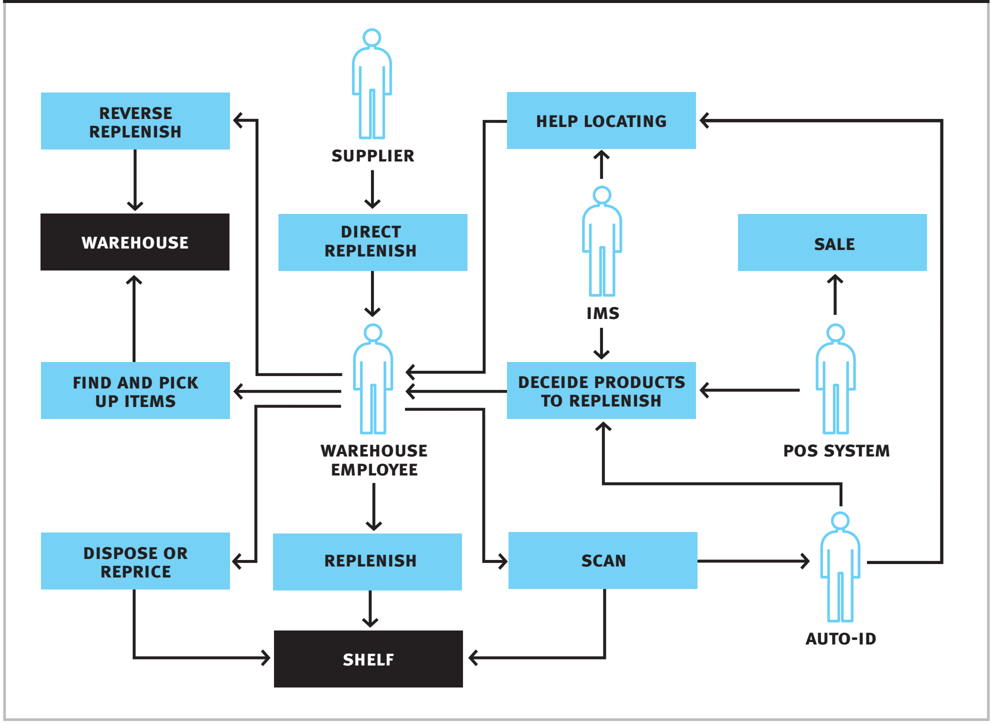
IMPLEMENTATION ALTERNATIVE B:
A.1. Warehouse manager
  A.1.1. Decides products to recount by visual inspection
A.2. IMS
  A.2.1. Decides products to recount and zones to scan
A.3. Warehouse employee
  A.3.1. Scans the selected zones both the backroom
A.4. Auto-ID
  A.4.1. Counts items tracked by the PDA
  A.4.2. Finds and counts items on store shelves
  A.4.3. Adjusts the inventory levels in the IMS

IMPLEMENTATION ALTERNATIVE C:
A.1. Warehouse manager
  A.1.1. Decides products to recount by visual inspection
A.2. IMS
  A.2.1. Decides products to recount and zones to scan
A.3. Auto-ID
  A.3.1. Finds and counts items on backroom shelves
  A.3.2. Finds and counts items on store shelves
  A.3.3. Adjusts the inventory levels in the IMS

Replenishment: the replenishment process can benefit from Auto-ID as this technology provides accurate, constant, and reliable monitoring of stocks in both the backroom and store shelves, and trigger replenishment actions in case necessary. The use of mobile readers requires an additional pre-replenishment manual scan of the products on store shelves in case of the implementation alternative A. This may be cumbersome and costly. Using Auto-ID to support the replenishment process requires and additional actor – the Auto-ID infrastructure, which will provide location and quantity information. The following diagram shows the impact of Auto-ID in the replenishment procedure:

Figure 12

USE CASE DIAGRAM FOR THE AUTO-ID-ENHANCED REPLENISHMENT PROCEDURE



Main flow of events

Implementation alternative A:
A.1. IMS and POS
  A.1. Decide products to scan based on stock levels and sales
A.2. Warehouse employee
  A.2. Scans products on the shelves
A.3. Auto-ID
  A.3.1. Uses the PDA information to decide product to replenish and quantity
  A.3.2. Provides location information in both the backroom and shelves
A.4. Supplier
  A.4.1. Provides goods for direct replenishment
A.5. Warehouse employee
  A.5.1. Finds goods in the backroom
  A.5.2. Fills replenishment wagons and trolleys
  A.5.3. Transports goods to the store
  A.5.4. Finds products' location on the shelves
  A.5.5. Inspects contents and discards old or damaged product items
  A.5.6. Reduces price of products about to expire
  A.5.7. Replenishes

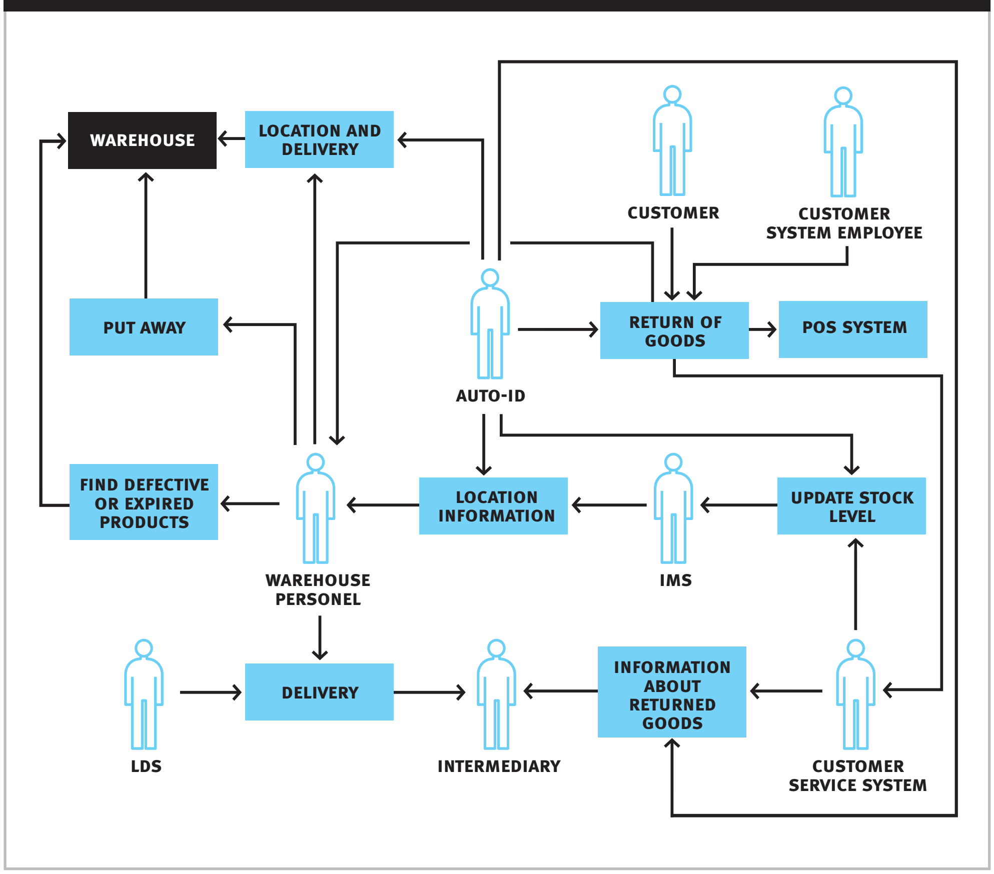
Implementation alternatives B and C:
A.1. Auto-ID
  A.1.1. Decides products to replenish based on on-shelf contents
  A.1.2. Provides location information in both the backroom and shelves
  A.1.3. Provides information about the exact quantity to replenish

A.2. Supplier
  A.2.1. Provides goods for direct replenishment
A.3. Warehouse employee
  A.3.1. Finds goods in the backroom
  A.3.2. Fills replenishment wagons and trolleys
  A.3.3. Transport goods to the store
  A.3.4. Finds products' location on the shelves
  A.3.5. Inspects contents and discards old or damaged product items
  A.3.6. Reduces price of products about to expire
  A.3.7. Replenishes

Reverse logistics: the reverse logistics process can be significantly changed by Auto-ID, as this technology impacts many of its steps and decisions. First, the Auto-ID tracing capabilities can be used to provide more accurate and reliable information about returned goods and support decisions in the customer services desk. Nevertheless, this would require extra support Auto-ID infrastructure at the POS to register item-specific selling information. This extra infrastructure has not been considered in the implementation possibilities as there is another Use Case for Auto-ID in retail selling covering it more in detail. Second, Auto-ID tracking and identification capabilities help storing and locating returned goods within the warehouse, and to automatically update stock levels for re-saleable products. Finally, Auto-ID can be used to support all the reverse logistics by tracing the delivery of items back to the intermediate or original suppliers and sending the relating information. The following Use Case diagram shows how the new "Auto-ID" actor impacts the reverse logistics procedure:

Figure 13

USE CASE DIAGRAM FOR THE AUTO-ID-ENHANCED REVERSE LOGISTICS PROCEDURE



Main flow of events

FOR ALL IMPLEMENTATION ALTERNATIVES:
A.1. Customer
A.1.2. Returns goods
A.2. Auto-ID
A.2.1. Provides tracing information about the good origin
A.3. POS system
A.3.1. Provides information about the selling transaction
A.4. Customer service employee
A.4.1. Decides whether to accept the good or not
A.4.2. Refunds the money
A.4.3. Register the transaction
A.4.4. Temporary stores the good
A.5. Auto-ID and IMS
A.5.1. Track temporary stored product
A.5.2. Provide location information to store the product
A.6. Warehouse employee
A.6.1. Decides whether the item is re-saleable or not
A.6.2. Stores the good according
A.7. LDS and Auto-ID
A.7.1. Support the reverse shipment procedure
A.8. Intermediary and Auto-ID
A.8.1. Gets the returned non re-saleable goods and negotiates with suppliers
A.8.2. Gets good's related information from Auto-ID (PML)

3.4. Impact of new Procedures on Existing Information Systems

3.4.1. Ordering System (OS)

This system will remain mostly unaffected by Auto-ID because the information is received from other systems such as the IMS (current stocks) and SS (sales forecast). Nevertheless, this system will include a new transaction coming from the Auto-ID world, which is the receipt acknowledge. That is, once products arrive to the supermarket, an automatic receipt acknowledgement is generated by Auto-ID and sent to both the OS and LDS systems.

Receipt acknowledgement transaction: it includes the order identification, date, time, receiving dock, identification of receiving employee, and receipt status and whether the order was complete or not.

3.4.2. Inventory Management System (IMS)

As opposed to the previous one, this system will be notably affected by Auto-ID, as it stores information on product location and stock levels, and receives product-related information from many other systems. One of the major impacts of Auto-ID on the IMS is that new entity granularity is required at product level: not only products and quantities should be stored, but also product items with their respective unique information such as "best before" date and particular location. The new detailed storage requirements are as follows:

Product items: this new entity will store information about every product item, "best before" date, location within the store or last location where tracked, and EPC™ code. Optionally, this entity may contain historic storage information such as refrigeration and handling conditions etc.

The IMS will also need to include new reports and transactions, as follows:

Products to scan: this new report lists all the products that should be re-counted for any of the reasons currently triggering the recount procedure as explained in section 2. It only applies to alternatives A and B where there is manual scanning of products on non-smart shelves.

Misplaced product items: based on Auto-ID-generated data, the IMS system can compare expected and real location and issue a detailed report of misplaced goods. This report applies to all implementation alternatives.

Location information: the IMS can provide operators with precise location information of goods within the backroom or shelves, even in case of product misplacement. This report currently exists, but reflect only theoretical location instead of the real one. If Auto-ID is available, the IMS could access its infrastructure to make this report closer to reality. This report applies to all implementation alternatives, though it will be more accurate for the ones using smart shelves.

Rotation quality: this new report will reflect the achieved level of perfect rotation per product during a specific period. That is, only products strictly replenished by "best before" date order where overtaking does not take place will get 100%, whereas the rest will get only a lower percentage based on the "fresher products/existence" rate for every registered movement of goods. Alternatively, this report may account for costs to compute a weighted average per product, and/or number of disposed or reduced products consequence of near expiration.

Stock failures: based on shelves' empty time and average product sales by season, day and period of the day; the system can estimate the number of stock failures and lost sales per product. This report will be more accurate in the implementation alternatives B and C, for they allow constant store shelf monitoring. Furthermore, this report may differentiate between stock-outs caused by faulty replenishment – existence of goods in the backroom but not on the shelf; from those caused by faulty reorder or excess sales – completely unavailable goods.

Product items in the reverse supply chain: this report will help identifying returned goods from those in sale. This will allow easily storing and finding these products in order to send them back to the reverse logistics intermediary or suppliers.

Quantity adjustment from Auto-ID: this new transaction will automatically adjust the number of items by using Auto-ID-generated tracking information. The data will be taken either directly from the smart shelves or from the mobile wireless devices (PDAs), so this transaction applies to all implementation alternatives.

Inter-organisational transactions:

Product item characteristics: using Auto-ID, the inventory management system may receive detailed product item information such as "best before date" or storing conditions. This will replace some current procedures in which this information is manually scanned using barcodes.

3.4.3. Logistics and Distribution System (LDS)

This system will also require an important modification to work with Auto-ID. It will require including a new entity – the item EPC™. This new entity will apply to all transactions involving the manipulation of goods: bill of ladings, orders, shipments, receipts, and verifications etc – all these transactions will include the EPC™ list of handled goods. Applying to all implementation alternatives, this item-level information allows the LDS issuing detailed product handling reports such as:

Receipt accuracy: comparing the expected receipt with the real one and calculating the weighted average cost will give a clear idea of the performance of logistics and distribution activities.

Product loses in logistics and distribution activities: a detailed list of product items that never made their way to the stores.

Rotation quality: by comparing the "best before" date of incoming products with that of stored products, the system may find erroneous LDS rotation failures such as receiving a product item older than those already in the warehouse – imperfect rotation in the logistics and distribution process.

Inter-system transactions:

Order receipt: as the order receipt process will have detailed product item information, the order receipt transaction may precisely reflect the received products to both the OS – for payment and accounting reasons, and the IMS – to update store stock levels. This may require inter-organisational transactions to include the EPC™ list of traded goods.

3.4.4. Sales System

This system remains unaffected.

3.4.5. Point of Sale System

This system remains mainly unaffected and the only exception not fully covered by this paper, is related to the changes required to gather item-specific selling information at the POS aiming at facilitating returning procedures. For example, keeping a list of all EPCs™ of goods sold in the selling transaction would help identifying the product item, customer, price and other details at the customer service desk in case of product return. This paper overlooks these changes for they are covered by another similar project.

3.4.6. Customer Desk System

This system will remain mainly unaffected, except for the fact that it will have to store the EPC™ of returned goods, as an alternative to the current unique barcode identification code for those items. The CDS may also get the returning information from the POS instead of from the operator when it comes to product returns, as long as the EPC™ is available. This will improve the returning process and provide it with accuracy and reliability.

4. CONCLUSIONS

One major finding of this study is that current information systems do not require significant changes to benefit from Auto-ID as we might think a priory. Furthermore, the impact of the adoption of this technology is more qualitative than quantitative, and most processes remain more or less the same but use and provide more accurate and reliable results and information. The main changes can be summarised as:

1. Expand entity granularity ranging from product type to product item in the inventory management system.

2. Add EPCs™ of related products to some of the current transactions such as product receipt and verification acknowledgement, sales registry, inventory adjustment, and bill of lading in the logistic and distribution, inventory management and point of sale systems.

3. Include a new operational procedure to perform a manual product scanning using wireless mobile readers. This would avoid having expensive fixed readers either in the backroom or shelves – implementation alternatives A and B.

4. Include new reports to give details on rotation quality; receipt accuracy; shrinkage by supply chain point such as distribution, receipt, put-away, backroom, replenishment, shelves; reverse supply chain performance; misplaced products; and stock failures.

5. Modify some transactions to get their information from different sources – product item information from Auto-ID inter-organisational transactions and location and verification information directly from the Auto-ID infrastructure.

As we can see, all these modifications are relatively superficial, and do not involve dramatic functionality changes or extensions except perhaps for the inventory management system. Moreover, not all these modifications are essential to Auto-ID implementations such as some reports such as the perfect rotation one.

The main conclusion of this study is that, although Auto-ID technology is a disruptive one, the nature and depth of impact in current procedures and information systems allow for incremental adoptions. That is, as long as early applications allow for extension and have strategic value, others can follow as the technology becomes cheaper and more reliable, and the organisation incorporates and accepts Auto-ID.

Moreover, it is clear to see that for some applications it is not necessary a radical substitution of the installed information systems to incorporate Auto-ID, but just adding simple functionality extensions and an integration middleware.

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