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AUTO-ID CENTRE

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Auto-ID Use Case: Food Manufacturing Company Distribution

Karl Prince, Humberto Morán, Duncan McFarlane

AUTO-ID CENTRE INSTITUTE FOR MANUFACTURING, UNIVERSITY OF CAMBRIDGE, MILL LANE, CAMBRIDGE, CB2 1RX, UNITED KINGDOM

ABSTRACT

This Use Case study investigates the distribution division of a company, Food Manufacturing Company (FMC), focusing on the potential impact an Auto-ID implementation may have on process and systems. While the use case takes a broad look at the different processes within distribution, of particular concern for FMC Distribution (FMCD) is the final process in which goods are placed onto trailers for transportation. An Auto-ID implementation solution for this concern is detailed as a possible pilot. The analysis is based on interviews and discussions held with FMCD staff, utilising a Use Case approach that entails:

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

Based on the analysis of any potential impact on processes and systems, the study concludes that opportunities exist to promote initial implementations of Auto-ID technologies. While Auto-ID may be considered disruptive it is possible to envisage an incremental approach for implementation strategies. Importantly, it should be remembered that Auto-ID implementations, particularly initial ones, would have to be executed within the constraints of existing processes and systems.

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Auto-ID Use Case: Food Manufacturing Company Distribution

Biographies

Karl Prince
PhD Candidate

Karl Prince is a PhD candidate at the Judge Institute of Management, University of Cambridge. His current research is focused on understanding the development and spread of new technologies such as Auto-ID. Karl has a background in electrical engineering having worked in the telecommunications, scientific research and financial services sectors of South Africa. He completed a Bachelor of Science degree in Engineering (1993) and a Master of Science degree in Engineering (1996) at the University of Cape Town (South Africa), his research focusing on control systems. He also completed an MBA at the University of Cape Town in 2001.

Humberto J. Morán
Senior Research Associate

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.

Duncan McFarlane
Research Director Europe

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

This document presents the analysis and results of an industrial application of the "Use Case Approach" proposed by the Auto-ID Centre (Morán et all, June 2003). The aim is to determine the impact of Auto-ID implementations on existing processes and information systems, and demonstrate relevant implementation possibilities. This report presents the tracking of inventory within FMC Distribution (FMCD) as a Use Case for Auto-ID technology. The distribution environment is a logistically complex one, with large numbers of products moving through warehousing systems from manufacturers to customers. The business has to keep track of what enters the warehouse as well as ensuring that the correct products reach the correct customers within scheduled delivery times. Furthermore, every movement of product is accompanied by information, whether it is product information, storage location information or customer order information. Making sure that the flow of goods to customers is well organised is a vital and complex service that could benefit from improvements in efficiency.

The industrial study was conducted through interviews with relevant personnel within FMCD. The analysis is based on the methodology prescribed by the Use Case approach and includes the following steps:

1. Finding representative Use Cases for process improvement – in terms of current processes, issues, and implementation possibilities. This first step involved interviewing employees in charge of Auto-ID adoptions and business innovation in general, and employees performing daily operational procedures related to handling, storing and distribution of goods. Some Auto-ID implementation possibilities were identified by considering different technologies and configurations.

2. Contrasting their associated processes 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 in their related information systems. The supporting transactions and data currently performed or stored by the current information systems were identifying by interviewing the relevant personnel.

1.1. Acknowledgements

We would like to acknowledge the support of the FMC personnel who agreed to give of their time to complete this use case study.

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 (BIICAG) activities. Combining both theoretical research and industrial developments, the group's aims include:

- Identifying the impact of Auto-ID on business information and industrial control systems.
- Developing frameworks, models and methodologies to deal with this impact.
- Providing sound integration alternatives.

The BIICAG 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 Case development and their impact on existing technology for business automation.

This research is also part of the Auto-ID Software Action Group (SAG), tasked with setting standards and legal frameworks for Auto-ID software development. The SAG proposes the development of specific Use Cases as a way of identifying technical requirements for the Savant and Auto-ID interfaces with business information systems.

1.2.2. Previous Research

This paper includes ideas from previous papers: Timothy Milne and Amit Goyal's "Track and Trace Shipping and Verify Receiving Use Case" (Auto-ID Centre – April 2003, still unpublished when this one was written), Timothy Milne's "Sub Group and Use Case Focus Group Methodology" (Auto-ID Centre – November 2002), Duncan McFarlane's "Auto-ID Based Control – An Overview" (Auto-ID Centre – January 2002), and "The Intelligent Product Driven Supply Chain" (Auto-ID Centre – January 2002, see references for list of authors), 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 the last ones and an example use case – "Methodologies for integrating Auto-ID Data with existing Business Information Systems", Auto-ID Centre, November 2002 (see references for list of authors).

The research documented in this paper closely follows the steps and methodology suggested by the "Use Case Approach for Determining the Impact of Auto-ID Implementations on Business Information Systems" (Morán et all, June 2003). This approach also served to support other similar studies, such as the one documented in "Auto-ID Use Case: improving inventory visibility in a retail company – impact on existing procedures and information systems" (Morán et all, September 2003); "Auto-ID Use Case: improving handling and tracing of rework pieces in a leading manufacturing company – impact on existing procedures and information systems" (Morán et all, September 2003); and "Auto-ID Use Case: Improving Differential Item Pricing in a Retail Company – impact on existing procedures and information systems" (Morán et all, September 2003).

1.3. Use Case Characteristics

The competitive advantage for distribution and logistics businesses lays in attempting to reduce costs, particularly labour costs, while at the same time improving customer service and efficiency through increased throughput and greater accuracy. In attempting to overcome these challenges, the industry has already invested considerably in technologies such as warehouse management systems and material handling automation. And yet manufacturers and retailers still experience errors in receiving, picking and shipping of goods. Human error, increasing volumes of products, limited product visibility and real-time information are the major causes for these issues faced within distribution centres. The Auto-ID technology is said to be a solution to these problems, offering improved accuracy, real-time tracking and identification of products, increased throughput as well as the possibility of reduced labour costs.

This Use Case explains how the use of Auto-ID technology, within the distribution centre of a company, may improve the delivery process, and presents the potential impact on current procedures and installed information systems. Adhering to the classification proposed in the "Use Case Approach" White Paper, the Use Case is classified as a **Process Improvement Use Case**, as it focuses on specific operational areas of the organisation and proposes no significant changes in the current business model.

1.4. Document Structure

The current situation pertaining to the FMC Use Case is detailed in section 2, outlining:

- Processes to improve – actors, procedure steps, product and information flows, activities, level of automatism, decision points, contingency plans and supporting assets
- Limitations of the current technology
- Opportunities and issues to solve or improve
- Auto-ID capabilities enhancing the improvement
- Implementation decisions
- Potential benefits

In section 3 details concerning an Auto-ID implementation are presented:

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

2. USE CASE COMPONENTS

A Use Case is more than mere description of Auto-ID-enhanced procedures and the advantages gained. Beyond description, it requires a thorough analysis of the present situation, and a clear justification, in terms of business benefits, of the proposed solution. The Use Case is therefore framed within the business requirements and not justified solely on the basis of the technology. In this section the Use Case components are presented with the particular aim of providing an overview of the present situation, which may, in turn, highlight opportunities for Auto-ID implementation solutions.

2.1. Processes for Potential Improvement

While the basic principle of the distribution business may appear simple i.e. receive goods, store them and deliver them to customers, it is in fact a complex operation. Complexity arises from the large quantity and variety of products that are received from various sources, different storage requirements, varying customer orders for mixed product groupings, varying customer delivery schedules and even in some occasions different packaging and labelling requirements. It is imperative that information is kept on the products entering and being stored in the warehouses to ensure adequate supply, efficient stock rotation and product recalls if necessary, as well as correct deliveries to customers. Mistakes and failures do occur, and because of the value of the product itself as well as the value attached to customer service and branding issues, these can prove costly.

The general processes involving product receipt, storage and shipping in the distribution centre are:

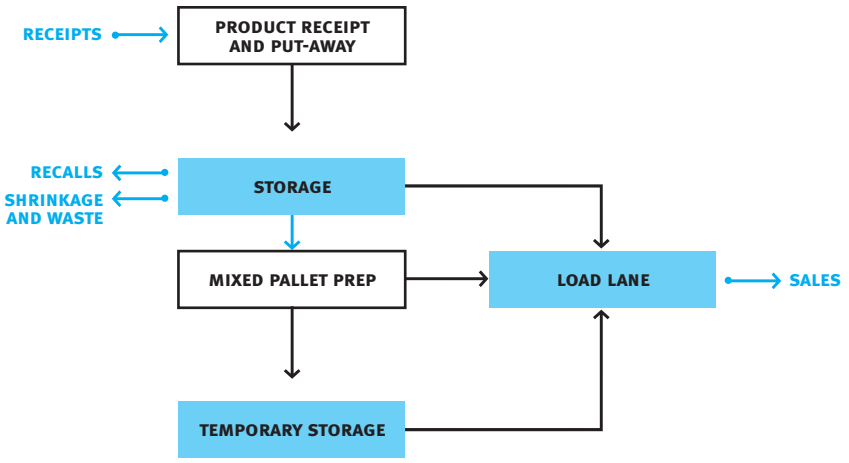
Product receipt and put-away: once goods arrive they are verified and checked, and then stored in the correct locations (pallets vary in height and have to be stored in suitable locations).

Mixed pallet preparation: some of the full pallets are placed in the mixed pallet preparation storage area. It is here that mixed pallets are prepared as per customer orders. Completed mixed pallets are placed in temporary storage or transferred directly to a load lane.

Shipping: full pallets and prepared mixed pallets are placed in the relevant load lane as per scheduling. Pallets are then verified and transferred from load lane to trailer.
The following diagram represents the product flows:

Figure 1

PRODUCT FLOWS



Auto-ID could be used to assist with the operational processes. The focus for FMCD, in particular, is the shifting of goods from the load lane to the delivery trailer.

This study focuses on three of the major information systems within FMCD used to support the processes aforementioned i.e. the Warehouse Management System (WMS), the Middleware (MW) and the Enterprise Resource Planning system (ERP). The WMS is the basic system supporting operational processes. The MW is an integration layer between the WMS and ERP, transferring data between the two systems. In some cases it interacts directly with operators and other smaller information systems, in turn passing the information either to the WMS or ERP. The ERP is used as an overview system for operational concerns, containing only higher-level information with much of the operational detail filtered out.

2.1.1. Product Receipt and Put-away

Goods are delivered to the FMCD from FMC factories in either specialised or traditional trailers.
The specialised trailers are from specific, limited locations and allow for the automated unloading of pallets using an airlift system. Pallets from other sites are manually unloaded. Pallets consist of single product lines. All pallets carry bar code information that is scanned to verify the receipt and matched against the pre-advised delivery information received from factories (see use case diagram and main flow of events for handling exceptions). The pallets are also checked for conforming to physical characteristics e.g. leaning goods on pallets, damaged wrapping (this will include height and weight checks in future). Any pallets not conforming to physical parameters are moved to an area for checking by FMCD employees. Pallets that are successfully entered into the system are moved into appropriate storage areas as part of the put-away process. There are two types of storage areas: an automated storage area and manual storage. The put-away process is important as product rotation is vital for moving goods in timely fashion to customers. The product receipt process is supported by the following information systems:

- **WMS:** Performs verification of the goods received, checking against pre-advise information of expected shipments. Also determines location information for the put-away process.
- **MW – a middleware layer**: is the main link between the WMS and ERP. Updates WMS on pre-advise of expected shipments, updates ERP on goods received, and also contains the location information of stored pallets.
- **ERP:** Contains the pre-advice of expected shipments, updating MW, and therefore the WMS, of what shipment data to expect.

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

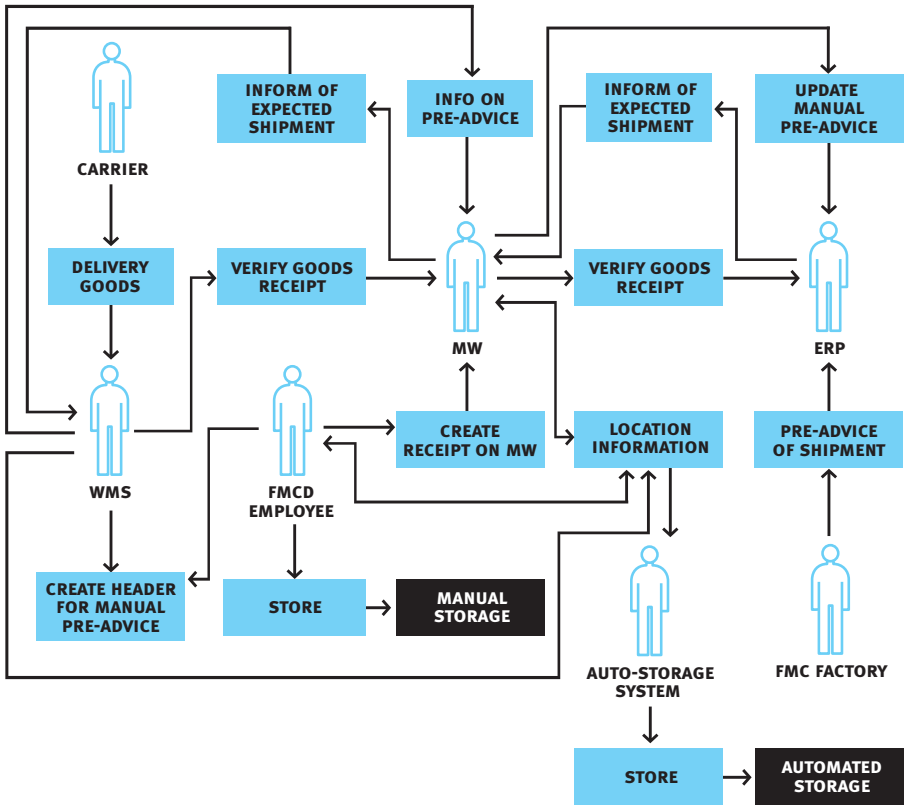
Table 1: Product receipt and put-away process characteristics

PRODUCT RECEIPT AND PUT-AWAY PROCESS	
Actors Procedure	– FMC factory – Carrier – FMCD employees
Procedure Steps	– Unload the trailer – Mark the shipment as received in the computer – Check the pallets for height, weight, damage – Decide on storage location/load lane assignment – Move pallets to storage location/load lane – Store pallets
Product Flows	– Goods come from various factories to distribution centre to be stored in automated or manual storage areas
Information Flows	– Bill of Lading – Report with expected shipments – Receipt confirmation – Product location
Level of Automation	– Medium: computers have all the pertinent information. The product receipt and put-away steps can be either automated or manual, depending on type of trailer and storage location.
Decision Points	– Storage location
Contingency Plans	– Track the truck if the order has not arrived – Generate a new pre-advice if original does not exist in system – Store goods in a temporary location
Supporting Assets	– Information systems – Fork-lift trucks, weight/height scale – Warehouse racks

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

Figure 2

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



Main flow of events

M.1. FMC factory
- M.1.1. Pre-advise distribution centre of shipment.

M.2. Carrier
- M.2.1. Transport and unload goods at distribution centre.

M.3. ERP
- M.3.1. Inform MW of expected shipment.

M.4. MW
- M.4.1. Inform WMS of expected shipment.

M.5. WMS
- M.5.1. Verify receipt of goods.
- M.5.2. Update MW.

M.6. MW
- M.6.1. Update ERP on verification of receipt of goods.

M.7. WMS
- M.7.1. Determine location information for pallets, updating MW.

M.8. Automated storage system
  M.8.1. Store pallets in automated storage area.
M.9. FMCD employee
  M.9.1. Store pallets in manual storage areas.
  M.9.2. In case of direct distribution, place pallets in appropriate load lane.

If pre-advice for shipments do not exist, the following events take place:

M.1. FMCD employee
  M.1.1. Create header on WMS.
  M.1.2. Create receipt on MW.
M.2. MW
  M.2.1. Update ERP on manual pre-advice.

Process continues from M.5 in the previous list.

2.1.2. Mixed Pallet Preparation

Mixed pallet preparation is the result of an order from a customer that results in more than one product line being placed on a single pallet. When customers place an order an FMCD employee assembles the orders into loads with the assistance of software as well as calculating delivery schedules for the various loads. The WMS then calculates how many full pallets, consisting of a single product line, are required for an order as well as how many pallets will have to be made up of mixed product lines. The mixed pallets are prepared by FMCD employees, who select the appropriate products from the picking face. This picking face is replenished as necessary in a separate process. During the picking process the FMCD employee scans the appropriate bar codes of the picking face and enters the quantity of product removed and placed on the mixed pallet. On completion of the picking, location information is provided to the FMCD employee, resulting in the mixed pallet either being placed in temporary storage or being moved directly into a load lane. The movement of full pallets is described as part of the shipping process.

The mixed pallet preparation process is supported by the following information systems:

- **WMS:** calculates and generates the appropriate pallet mixes for orders, passing them on to FMCD employees. The WMS also provides location information for completed mixed pallets.
- **MW:** passes order information to FMCD employees, who calculate load schedules, after which MW passes order details to the WMS.
- **ERP:** customer orders are updated in ERP and information is then passed onto MW.
- **Other:** other software systems utilised include a Load Scheduling System for assembling pallets into load schedules.

The mixed pallet preparation process has the following characteristics:

Table 2: Product receipt and put-away process characteristics

PRODUCT RECEIPT AND PUT-AWAY PROCESS	
Actors Procedure	– Customer – FMC employees – call centre personnel – FMCD employees
Procedure Steps	– Customer places order – Orders finalised and updated in ERP, MW and WMS – Pallets (for full and mixed) are calculated and generated with location information – FMCD employee picks mixed pallets – Mixed pallets are temporarily stored or placed in load lane (see shipping)

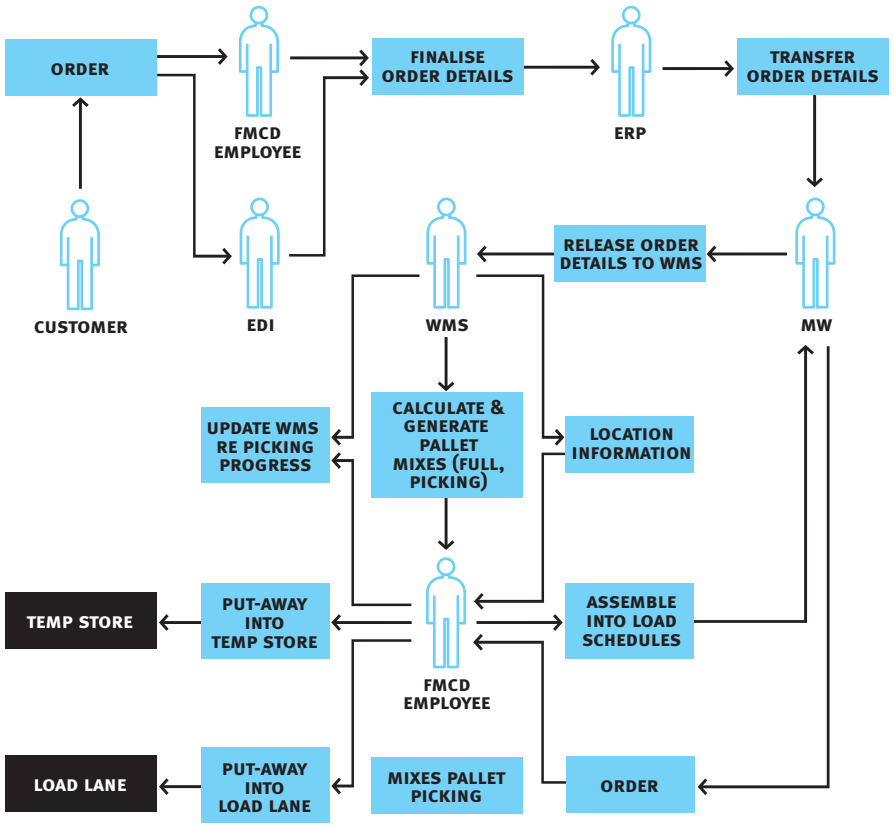
Continuation of Table 2

PRODUCT RECEIPT AND PUT-AWAY PROCESS	
Product flows	– From storage to load lane. – From load lane to trailer. – From trailer to customer product receipt areas.
Information Flows	– Mixed pallet compositions. – Product location – picking source/storage location. – Tracking of product quantities in picking face. – Load scheduling.
Level of Automation	– Low: picking is done manually, assisted by information systems
Decision Points	– Calculating mixed and full pallets for orders. – Determining product locations in picking face. – Determining temporary storage location for mixed pallets or load lane assignment (see shipping).
Contingency Plans	– None
Supporting Assets	– Information systems – Fork-lift trucks and computers/scanners to identify pallets picked from as well as temporary storage location for mixed pallets

Use Case diagram for the mixed pallet preparation 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. Customer
  M.1.1. Order goods using EDI/telephone.
M.2. FMC employee
  M.2.1. Finalise order details on ERP.
M.3. EDI
  M.3.1. Finalise order details on ERP.
M.4. ERP
  M.4.1. Transfer order details to MW.
M.5. FMCD employee
  M.5.1. Assemble orders into loads.
  M.5.2. Schedule loads for transportation to customers.
  M.5.3. Release order details to MW.
M.6. MW
  M.6.1. Release order details to WMS.
M.7. WMS
  M.7.1. Calculate and generate pallet mixes.
M.8. FMCD employee
  M.8.1. Perform mixed pallet picking.
  M.8.2. Update WMS on picking progress.
  M.8.3. Obtain location information from WMS for completed pallets.
  M.8.4. Label completed mixed pallets with bar codes.
  M.8.5. Place prepared mixed pallets either in temporary storage or load lane.

2.1.3. Shipping

Once load schedules have been determined (see mixed pallet preparation process), FMCD employees place full and mixed pallets in the appropriate load lanes. Full pallets are removed manually from the manual storage areas to the appropriate load lanes and automatically from the automated storage area onto an output spur. Pallets are moved manually from the output spur to appropriate load lanes. Occasionally pallets may be moved directly from receipt to load lanes without being stored – this is a manual process. Mixed pallets are either moved from a temporary storage location into a load lane or may be placed in the load lane directly after picking – again, this is a manual process. While pallets are in the load lane, the bar code labels are scanned. This scan marks the pallets as having passed through a door and loaded onto a trailer even though they have not. After a variable time period, pallets are moved from the load lane onto the trailer. As the pallets are loaded an FMCD employee completes a manual despatch of the goods through WMS and a further manual despatch of the goods in ERP. In particular cases, an automated pre-advice of delivery may be generated. The driver of the trailer (may be either an FMCD employee or a third party) delivers the goods to the customer, completing the appropriate paperwork required. The driver also phones in confirmation of the delivery to an FMCD employee, who then updates the appropriate information systems.

The shipping process is supported by the following information systems:

- **WMS:** provides location information for pallets to be placed in load lane. Goods are despatched manually in the WMS, which in turn updates MW.
- **MW:** updates ERP of delivery of goods.
- **ERP:** is informed, manually, of despatch of goods as well as delivery of goods. May, for certain customers, generate pre-advice of delivery. Billing will be completed in ERP after delivery confirmation.

The shipping process has the following characteristics:

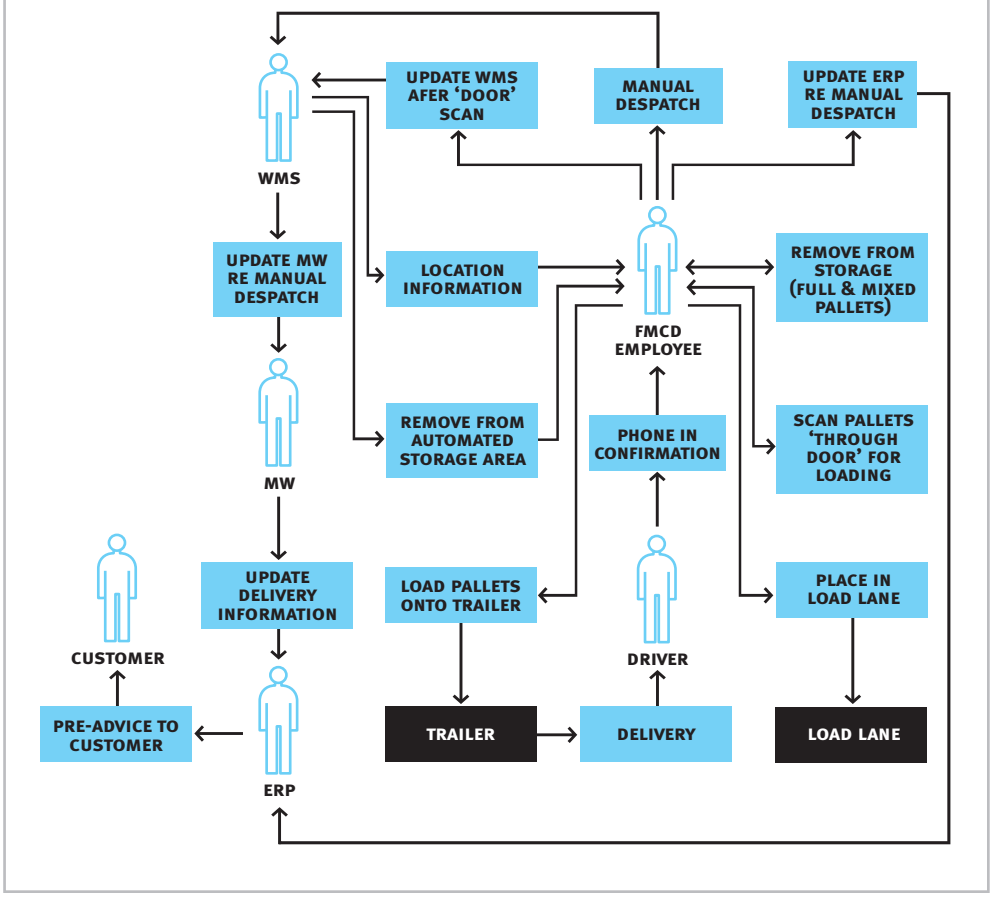
Table 3: Shipping process characteristics

SHIPPING PROCESS	
Actors Procedure	– FMCD employees – Driver – Customer
Procedure Steps	– Remove appropriate pallets from automated and manual loading areas (including mixed pallets) for scheduled loads. – Place pallets in load lane. – Scan pallets as if having passed through door while still in load lane. – Load pallets onto trailer. A: – FMCD employee manually despatches load on system. – Pre-advice is created by ERP for certain clients B: – Driver delivers load. – Driver phones in confirmation of delivery. – FMCD employee updates system re delivery confirmation.
Product Flows	– From storage to load lane. – From load lane to trailer. – From trailer to customer product receipt areas.
Information Flows	– Pallets to remove from storage. – Load lane for scheduled loads.
Level of Automation	– Low – Medium: mix of manual and automated removal from storage. Placing into load lanes and information scanning thereafter is all manual. Delivery confirmation is handled manually and most pre-advice is generated manually – there are exceptions such as in the case of Sainsbury's.
Decision Points	– System driven.
Contingency Plans	– None
Supporting Assets	– Information systems. – Bar code scanning equipment. – Trailer.

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

Figure 4

USE CASE DIAGRAM FOR THE SHIPPING PROCESS



Main flow of events

M.1. WMS
- M.1.1. Provide location information for pallets for loads to be marshalled.

M.2. Automated storage system
- M.2.1. Automated removal of pallets from automated storage area.

M.3. FMCD employee
- M.3.1. Remove pallets from manual storage areas.
- M.3.2. Place pallets, including those from automated storage area, into load lane.
- M.3.3. Scan pallets in load lane as having passed through door – bar code representing door is kept in a handheld file.
- M.3.4. Load pallets into trailer.
- M.3.5. Manually despatch load in WMS (which in turn updates MW) and ERP

M.4. Driver
- M.4.1. Deliver goods to customer.
- M.4.2. Phone in delivery confirmation to FMCD employee.

M.5. FMCD employee
- M.5.1. Update MW system re delivery confirmation.

2.2. Limitations of Current Technology

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

Identifying products is a costly and cumbersome process: the only current technology available to identify products in the aforementioned processes is the bar code. However, scanning pallets held in storage or in transit would be a slow, costly and cumbersome process, since pallets can be stored in places inaccessible for physical scanning e.g. scanning pallets in a trailer would be impractical as it would difficult to achieve the line of sight needed. For example, if a pallet is misplaced, or some of the product on a pallet is missing, it would be very difficult to find out where and how the discrepancy has occurred as well as how severe the problem could be. Using a line-of-sight scanning procedure can also be a repetitive, monotonous task that a workforce would not consider ideal e.g. scanning pallets through doorways.

Static existence and status checks are impossible to achieve: bar codes must be physical scanned by employees in order to provide information. Whenever a product item remains static and not accessed, e.g. while remaining in storage, future processes concerning it must rely on historic information exposing a lack of continuity between information representing the physical situation and the physical situation itself. That is, products are tracked as long as they are involved in an ongoing and active process. The link between item tracking and operational business processes has three consequences:

1. Processes relying on product existence or status may fail if the situation changes while the product items are static.

2. Additional processes or process steps are required to ensure sound business operations – e.g. constant product recounts or verifications.

3. The whole process is more vulnerable to mistakes: any upstream errors in 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 preparing loads or making product recalls.

2.3. Opportunities and Issues to Solve or Improve

Delivery load tracking: in order to avert industrial relations issues, it has been necessary to alter processes to accommodate the workforce. The particular process referred to is the scanning of pallets before they pass through a door onto a trailer while they are in a load lane and marking them on the information systems as already having passed through the door. In the intervening time between scanning and loading it is possible for a pallet to be moved or simply forgotten after the loading process if loaders are pressed for time. An automated tracking capability would allow the precise tracking of pallets through the door as well as matching the load progress with the predetermined load so that pallets are not forgotten. It is therefore unnecessary to alter process steps to accommodate the workforce demands. A more accurate tracking of goods delivered should also provide much needed information in dealing with dispute resolution processes between the distribution warehouse and customers.

Reducing manual intervention: the automation of item tracking and tracing procedures should reduce the need for human labour, intervention and knowledge. One advantage of a more automated process is the capability of handling mundane and repetitive tasks, such as the scanning of pallets through doors onto trailers. Humans also have the following limitations: they may make mistakes, particularly under stressful or tiring conditions, they have limited working periods i.e. they cannot work continuously, and

they generate further related costs e.g. health and safety concerns, management costs etc. Labour is also relatively expensive, subject to complex legal regulations, as well as industrial relations issues, especially as regards a unionised workforce.

Improving product recalls: product recalls are important as they can involve large movements of products, and must be done properly to avoid legal consequences or damage to brand. Improving inventory visibility would allow more efficient identification and removal of recalled product items within the storage and picking face areas of the distribution warehouse.

2.4. Auto-ID Capabilities Enhancing the Use Case

The main Auto-ID capabilities enhancing the Use Case are:

1. Tracking and identification capabilities to improve the shipping process. Being able to ensure that a particular load assignment has been completely loaded onto delivery trailers would limit delivery errors.

2. Inter-organisational capabilities to improve the dispute resolution aspects of the shipping process. Auto-ID inter-organisational capabilities would assist in sharing information between customers and the distributor, aiding in any dispute resolution processes should products be misplaced or disappear during the shipping process.

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

Table 4: Auto-ID capabilities enabling opportunities for improvement

	RECEIPT AND PUT-AWAY	MIXED PALLET PREPARATION	SHIPPING
Delivery load tracking			Tracking, tracing and inter-org
Reduction of manual intervention	Tracking	Tracking	Tracking
Improvement of recalls			Tracking, tracing and inter-org

2.5. Implementation

2.5.1. Implementation Pre-requirements

Installing a new system that has potential to change work processes can be met with resistance by the workforce. It is a concern for FMCD that, if they attempt to use an Auto-ID solution, the question of tagging is addressed. Should the pallets or cases be tagged at the factory, or should they be tagged on arrival at the distribution centre? In either case, agreement will have to be gained from the workforce for new process steps to include retagging (besides the bar code tags) each of the pallets.

Some of the most important technical requirements:

Scan reliability: 100% scanning accuracy needs to be guaranteed, especially in the loading process. Failure to accurately identify when pallets have been loaded onto the trailer will result in the same problems being faced by FMCD.

Refresh Rate: an important requirement of the system will be ensuring that pallets of products will be able to be scanned at varying rates. The system should, therefore, be able to scan pallets passing through a doorway simultaneously or in quick succession. This may require fast data processing speeds.

2.5.2. Implementation Alternatives

There are a number of ways to implement Auto-ID to assist at FMCD. The most basic implementation will be needed to solve the particular problem with the loading steps of the shipping process. But this is a limited application and may not highlight further benefits of using Auto-ID. Extending the use of Auto-ID to further processes could yield further benefits but at the cost of tighter integration with existing systems. There are also a number of implementation decisions affecting the choice of infrastructure for each implementation. These main implementation decisions depend on the characteristics of the technologies available e.g. tag and reader type, refresh rates for updating, reader/antennae coverage. See Table 5 for further details.

Table 5: Technology characteristics

TECHNOLOGY CHARACTERISTICS	
Location of readers	doors / storage bays / mobile
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

Some combinations of these characteristics are of little advantage e.g. consider that mobile readers with small coverage areas capable of slow refresh rates would not be an ideal combination. Active vs. passive tags: while active tags cost more and are physically larger in size than passive tags, it may be that their advantage of larger coverage areas and ability to carry more data could be needed for some applications e.g. low volume use for identifying pallets in inaccessible areas such as trailers, or having storage and product information directly available on receipt of a pallet. However, the implementations suggested in this study utilise passive tags. Below are the three implementation approaches proposed, based on low, medium and high cost considerations:

a. Low cost implementation.
   - Fixed readers in loading doors with medium coverage and medium refresh rate.
   - Pallet level tagging.
   - Basic (loose) integration with installed IS.

The low cost alternative aims to simply replace the existing process with an Auto-ID approach. Pallets awaiting loading in load lanes may simply be tagged by FMCD employees, replacing the artificial ‘scan through door’ step of the shipping process. As pallets are moved onto the trailer through the loading door they are ‘scanned through door’, with the reader replacing the original bar code scan. This implementation will lead to the accurate monitoring of pallets onto trailers but cannot prevent trailers from being left behind. The problem lies in the process itself, where employees are able to manually despatch a load even though the system reports an error. What the implementation will provide is the certainty that a pallet has indeed been left behind and not simply been missed during the scanning step. The implementation will also provide an opportunity to study the Auto-ID technology in a working environment with minimal impact to existing systems and processes.

b. Medium cost implementation.
   - Fixed readers in loading doors with medium coverage and medium refresh rate.
   - Mobile readers in trailer doorways, smaller coverage and slower refresh rate.
   - Pallet level tagging.
   - Loose integration via batch files.

This implementation option is an extension of the previous solution to include pallet removal from trailers. The information obtained will be valuable in expediting any dispute resolutions resulting from missing pallets. Besides being able to confirm that FMCD has loaded pallets onto the trailer, FMCD will have data to confirm the offloading of pallets from the trailer. Coupled with trailer tracking systems, used as anti-theft measures, it should be possible to ascertain the geographic position of offloading.

This implementation solution may be extended to an inter-organisational system were FMCD customers to install readers on their receipt side, confirming the actual delivery.

c. High cost implementation.
   - Fixed readers in specified doorways and storage bays with medium coverage and medium refresh rate.
   - Mobile readers in trailer doorways, human driven forklifts (smaller coverage areas and slower refresh rates) and automated cranes (larger coverage areas and fast refresh rates).
   - Pallet, case level tagging.
   - Tight online integration.

This implementation is the most sophisticated and expensive approach. The implementation does mean, however, that each case and pallet can be accounted for. This is especially effective in the picking area where removal of individual cases from the picking face is monitored automatically without the requirement for bar code scanning. The correct composition for each of the mixed pallets can also be confirmed without human intervention. Readers in storage cranes and forklifts can be used in conjunction with existing storage system software, confirming and providing accurate location information and aiding in more flexible operational decision making. The use of Auto-ID will eliminate the need for bar code scanning steps in processes and will essentially be done on the fly.

2.6. Potential Benefits

The major benefits to be gained from the aforementioned implementation proposals are listed below.

Service improvement: these benefits are the result of the improvements in the shipping process. More accurate information as to the loading of trailers will provide customers with confidence that not only have the correct loads been delivered but also any disputes that may arise can be dealt with correctly. The value of such a service improvement may be difficult to quantify but it should be clear that there would be less opportunity for damage to brand and reputation occurring due to lost deliveries.

Productivity increase: with the high-cost implementation proposal there are opportunities to increase productivity. There should be less need for explicit bar code scanning steps, more optimal storage decisions can be made and these can be done on a real-time basis. More effective product recall procedures can be introduced since locating products will be less cumbersome. The low and medium cost implementation proposals offer more effective dispute resolution procedures. More information will be available and the accuracy of the information should be improved. The use of technology may also allow for the introduction of new procedures without a need for manual intervention e.g. consider that scanning a pallet through a doorway was not welcomed by the workforce and procedures had to be

amended in an artificial manner to accommodate the workforce and limit industrial relations tensions. The value due to productivity increases mentioned should be measurable using usual cost/benefit analyses, provided all the inputs are known.

Cost reduction: the minimum point for cost reduction would include the reduction of investigation costs to settle disputes arising from missing deliveries. Related to this is the opportunity to assist in determining causes for missing deliveries e.g. if theft is identified there is a possible cost-saving in combating losses due to theft. Increased Auto-ID integration could lead to further benefits including the reduction of manual intervention, improved product recall processes resulting in minimal waste. Again, cost/benefit analyses could be used to determine the value of cost reductions but it is also likely that more complex situations lacking input information will require more sophisticated stochastic valuation techniques.

Strategic value: the Auto-ID infrastructure proposed in the aforementioned implementations has further strategic value based on it use in other present-day or future applications. This strategic value can be estimated in monetary terms through the use of complex financial formulae in techniques such as real options. Such calculations are, however, beyond the scope of this paper.

3. ASSESSING THE IMPLEMENTATION IMPACT

3.1. Identifying the affected systems and related data and transactions

In this section the impact of Auto-ID on the processes described previously are identified. This is determined by relating the decision points within these processes with the information affecting those decisions and related transactions, as well as the information flows from the processes to the supporting information systems. Table 6 summarises the analysis:

Table 6: Process steps, supporting IS transactions and generated

	PROCEDURES	RECEIPT AND PUT-AWAY			MIXED PALLET PREPARATION			SHIPPING			
SYSTEMS	**DECISIONS/ TRANSACTIONS**	**ORDER RECEIVED?**	**ORDER ACCEPTED/**	**WHERE TO STORE?**	**PALLET MIXES?**	**WHAT'S IN LOAD?**	**WHERE TO STORE/PLACE?**	**WHERE TO FIND PRODUCTS**	**TRAILER LOADED?**	**IS LOAD DISPATCHED**	**DELIVERY MADE?**
WMS	**Reordering**		↑								
	Order Acceptance		Verification info								
	Order Receipt	Pre-advice ←		↑			↑	↑			
	Location Info			Location info			Location info	Location info	← Location info		
	Pallet calculation for load				↑ Pallet mixes						
	Load Despatched									← Manual despatch	
MW	**Load Scheduling**					↑ Create load for order					
	Location Info			← Location Info			↑ Location Info				
	Order Acceptance		← Verification info								
	Order receipt	Pre-advice ←									
ERP	**Load Despatched**									← Manual despatch	
	Delivery confirmation										← Delivery info
	Verification	↑ Pre -advice	← Verification info								

3.2. Auto-ID Enabled Processes

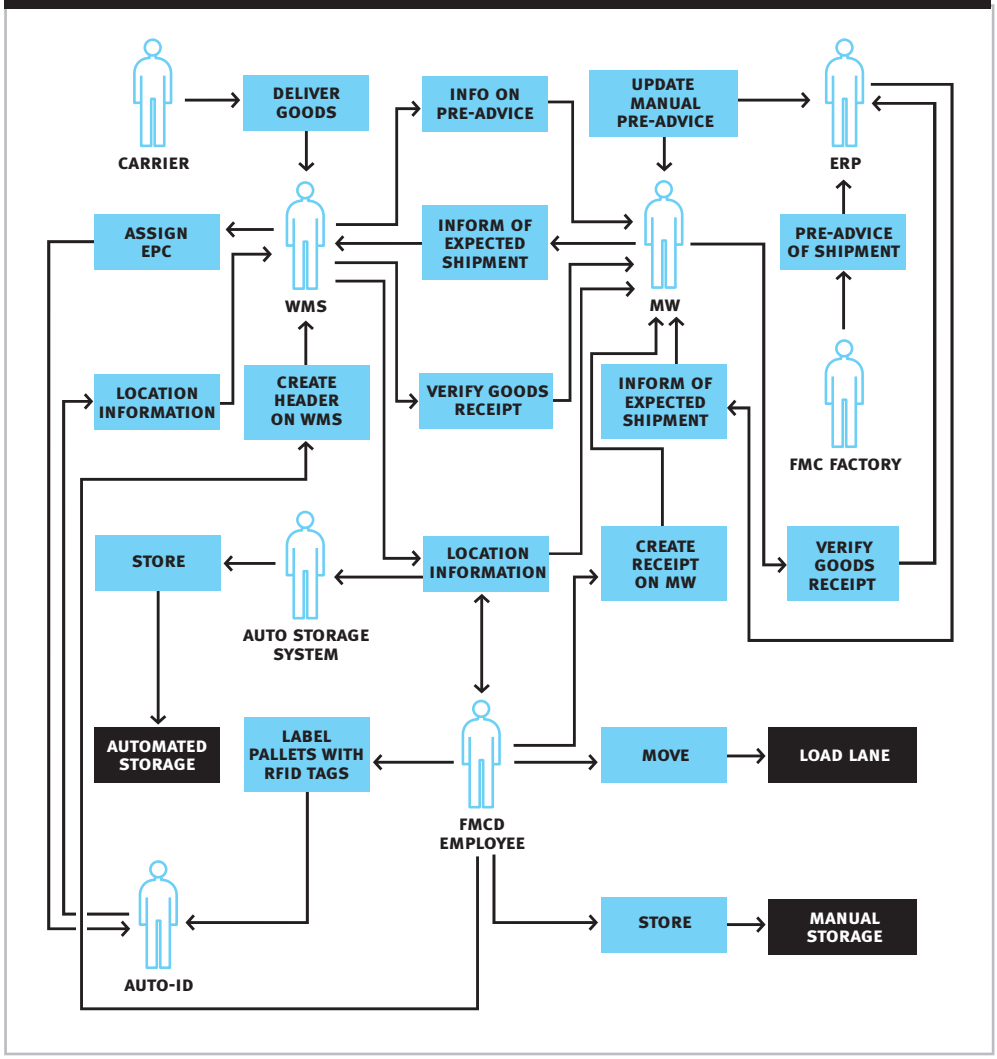
The impact of Auto-ID on current processes involves the inclusion of a new actor – Auto-ID infrastructure, which will provide information about product location and cardinality and get information directly from the physical world. This new actor is included in the Use Case diagrams to properly reflect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

3.2.1. Receipt and Put-away Process

There are no Auto-ID capabilities required in both implementation A and B, and the process remains the same. In implementation C, it is envisaged that Auto-ID is an integral part of the operation. A note: if RFID tags are to be used within the distribution business, there is no guarantee that the pallet tagging will be done by the manufacturing business. It would be prudent therefore, to assume that, initially at least, tagging will need to be done in-house. This requires the existing information systems to still perform the necessary verification of receipt. Auto-ID will provide the storage location information and track products if misplaced in manual storage areas. The expansion of Auto-ID infrastructure to the reception process should prove prudent should intra-organisational Auto-ID implementations occur. The use of Auto-ID could then be expanded to include the acceptance and verification of receipts.

Figure 5

USE CASE DIAGRAM FOR THE SHIPPING PROCESS



Main flow of events

IMPLEMENTATION ALTERNATIVES A AND B: Unchanged
IMPLEMENTATION ALTERNATIVE C: Assuming pallets arrive without RFID tags and associated EPC.

M.1. FMC factory
  M.1.1. Pre-advise distribution centre of shipment.
M.2. Carrier
  M.2.1. Transport and unload goods at distribution centre.
M.3. ERP
  M.3.1. Inform MW of expected shipment.
M.4. MW
  M.4.1. Inform WMS of expected shipment.
M.5. WMS
  M.5.1. Verify receipt of goods.
  M.5.2. Assign EPC to pallets.
  M.5.3. Update MW.
M.6. FMCD employee/labelling system
  M.6.1. Label pallets with RFID tags.
M.7. MW
  M.7.1. Update ERP on verification of receipt of goods.
M.8. Auto-ID
  M.8.1. Determines storage destination location information for pallets.
  M.8.2. Update WMS and MW.
M.9. Automated storage system
  M.9.1. Store pallets in High Bay.
M.10. FMCD employee
  M.10.1. Store pallets in manual storage areas.
  M.10.2. In case of direct distribution, place pallets in appropriate load lane.
M.11. Auto-ID
  M.11.1. Provide final storage location information

If pre-advice for shipments do not exist, the following events take place:

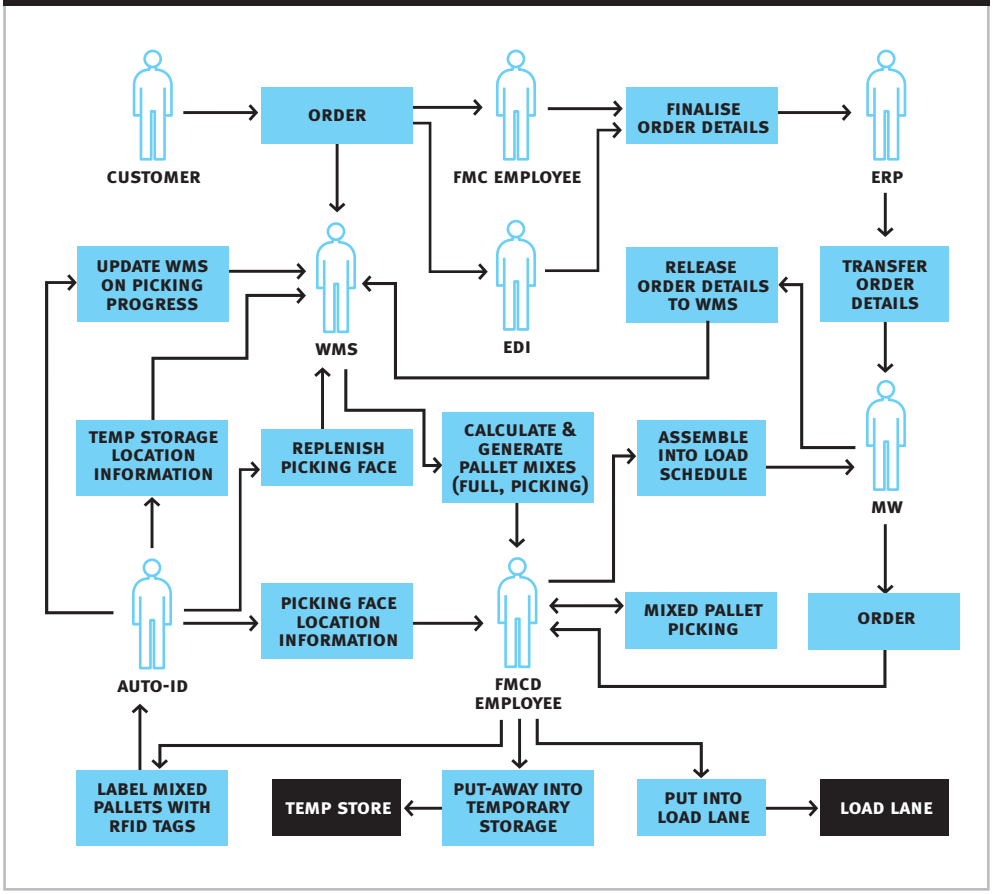
M.3. FMCD employee
  M.3.1. Create header on WMS.
  M.3.2. Create receipt on MW.
M.4. MW
  M.4.1. Update ERP on manual pre-advice.

3.2.2. Mixed Pallet Preparation Process

For the low and medium cost implementations the basic mixed pallet preparation process remains the same except for the need to assign EPC's to pallets when the loads are scheduled and the tagging of completed mixed pallets. For the high cost implementation only the mixed pallets require assignment of an EPC, as all full pallets will have been tagged on receipt. The picking of cases from the picking face will be enhanced, as employees will not need to scan the product and location for updating. Also, location information for refreshing picking face and storing mixed pallets may be automated by Auto-ID e.g. mixed pallets can be placed in any available storage bay without the requisite scanning of the bay location and pallet. The Use Case diagram for the updated process for implementation C is shown below.

Figure 6

USE CASE DIAGRAM FOR THE AUTO-ID-ENHANCED MIXED PALLET PREPARATION PROCESS



Main flow of events

IMPLEMENTATION OPTION A AND B:

M.1. Customer

M.1.1. Order goods using EDI/telephone.

M.2. FMC employee

M.2.1. Finalise order details on ERP.

M.3. EDI

M.3.1. Finalise order details on ERP.

M.4. ERP

M.4.1. Transfer order details to MW.

M.5. FMCD employee

M.5.1. Assemble orders into loads.

M.5.2. Schedule loads for transportation to customers.

M.5.3. Release order details to MW.

M.6. MW

M.6.1. Release order details to WMS.

M.7. WMS

M.7.1. Calculate and generate pallet mixes.

M.7.2. Assign EPC codes for individual pallets in load.

M.8. FMCD employee

M.8.1. Perform mixed pallet picking.

M.8.2. Update WMS on picking progress.
M.8.3. Label completed mixed pallets with RFID tags.
M.8.4. Obtain location information from WMS for completed pallets.
M.8.5. Place prepared mixed pallets either in temporary storage or load lane.

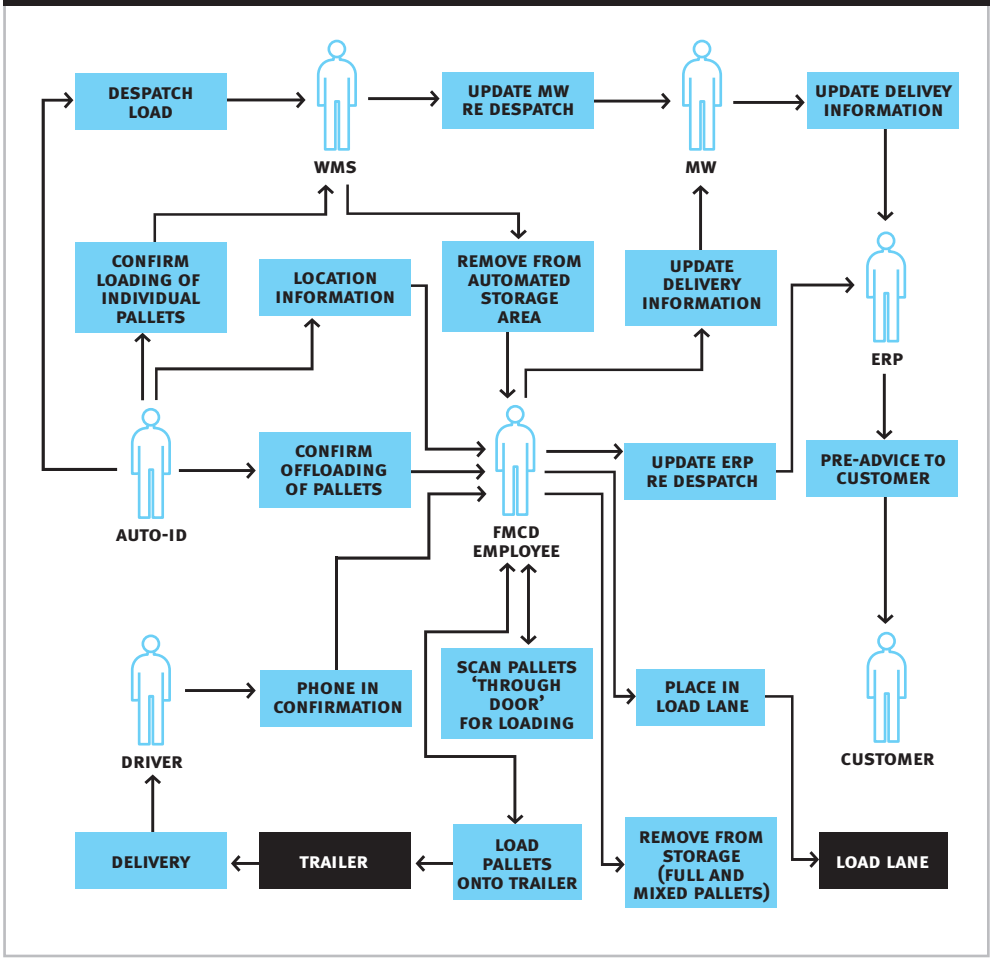
IMPLEMENTATION OPTION C:
M.1. Customer
M.1.1. Order goods using EDI/telephone.
M.2. FMC employee
M.2.1. Finalise order details on ERP.
M.3. EDI
M.3.1. Finalise order details on ERP.
M.4. ERP
M.4.1. Transfer order details to MW.
M.5. FMCD employee
M.5.1. Assemble orders into loads.
M.5.2. Schedule loads for transportation to customers.
M.5.3. Release order details to MW.
M.6. MW
M.6.1. Release order details to WMS.
M.7. WMS
M.7.1. Calculate and generate pallet mixes.
M.7.2. Assign EPC codes for mixed pallets in load (full pallets already have EPC's assigned to them).
M.8. Auto-ID
M.8.1. Provide location information for picking.
M.9. FMCD employee
M.9.1. Perform mixed pallet picking.
M.10. Auto-ID
M.10.1. Update WMS on picking progress.
M.10.2. Request picking face replenishment if required.
M.11. FMCD employee
M.11.1. Label completed mixed pallets with RFID tags.
M.11.2. Place prepared mixed pallets either in temporary storage or load lane.
M.12. Auto-ID
M.12.1. Hold location information for temporarily stored mixed pallets.

3.2.3. Shipping Process

The shipping process for implementation A highlights the focused use of Auto-ID to track pallets through a loading door onto a trailer. All other aspects of the process, including the manual despatch of loads, are left unaltered. Implementation B is an extension of implementation A in that the goods are now tracked off the trailer and the information used to corroborate the telephone delivery information provided by the driver. In implementation C the Auto-ID system is used to provide the location information for pallets to be placed in loads as well as ensuring that loads are complete before despatching them. The following diagram shows the impact of Auto-ID on the shipping procedure for implementation C:

Figure 7

USE CASE DIAGRAM FOR THE AUTO-ID-ENHANCED SHIPPING PROCESS



Main flow of events

IMPLEMENTATION OPTION A:

M.1. WMS

M.1.1. Provide location information for pallets for loads to be marshalled.

M.2. Automated storage system

M.2.1. Automated removal of pallets from automated storage area.

M.3. FMCD employee

M.3.1. Remove pallets from manual storage areas.

M.3.2. Place pallets, including those from automated storage area, into load lane.

M.3.3. Label full pallets with RFID tags

M.3.4. Load pallets onto trailer

M.4. Auto-ID

M.4.1. Confirm loading of each pallet

M.4.2. Confirm loading complete

M.5. FMCD Employee

M.5.1. Manually despatch load in WMS, MW and ERP

M.6. Driver
M.6.1. Deliver goods to customer.
M.6.2. Phone in delivery confirmation to FMCD employee.
M.7. FMCD employee
M.7.1. Update MW system re delivery confirmation.
IMPLEMENTATION OPTION B:
M.1. WMS
M.1.1. Provide location information for pallets for loads to be marshalled.
M.2. Automated storage system
M.2.1. Automated removal of pallets from automated storage area.
M.3. FMCD employee
M.3.1. Remove pallets from manual storage areas.
M.3.2. Place pallets, including those from automated storage area, into load lane.
M.3.3. Label full pallets with RFID tags
M.3.4. Load pallets onto trailer
M.4. Auto-ID
M.4.1. Confirm loading of each pallet
M.4.2. Confirm loading complete
M.5. FMCD Employee
M.5.1. Manually despatch load in WMS, MW and ERP
M.6. Driver
M.6.1. Deliver goods to customer.
M.6.2. Phone in delivery confirmation to FMCD employee.
M.7. Auto-ID
M.7.1. Confirm offloading of pallets.
M.8. FMCD employee
M.8.1. Corroborate and update MW system re delivery confirmation.

IMPLEMENTATION OPTION C:
M.1. WMS
M.1.1. Provide pallet EPC details for load to be marshalled.
M.2. Auto-ID
M.2.1. Provide location information for pallets, both automated and manual storage.
M.3. Automated storage system
M.3.1. Automated removal of pallets from automated storage area.
M.4. FMCD employee
M.4.1. Remove pallets from manual storage areas.
M.4.2. Place pallets, including those from automated storage area, into load lane.
M.4.3. Load pallets onto trailer
M.5. Auto-ID
M.5.1. Confirm loading of each pallet.
M.5.2. Confirm loading complete.
M.5.3. Despatch completed load.
M.6. Driver
M.6.1. Deliver goods to customer.
M.6.2. Phone in delivery confirmation to FMCD employee.
M.7. Auto-ID
M.7.1. Confirm offloading of pallets.
M.8. FMCD employee
M.8.1. Corroborate and update MW system re delivery confirmation.

3.3. Impact of Auto-ID Enhanced Processes on Existing Information Systems

3.3.1. Warehouse Management System (WMS)

The WMS will require the creation of a new entity, the EPC. In implementations A and B the EPC will only be related to the loading step of the shipping process. This will require a modified load transaction, replacing the existing transaction that uses the 'scan through door' step.

Trailer loaded transaction: includes EPC, order identification, date, time, loading dock, and delivery load status – whether the order was complete or not.

Implementation C will require both the above and the following entity, transactions and reports:

Pallet data entity: this new entity will store information about each pallet including EPC, expiration date, and location. It may also include storage information relevant e.g. height and weight of pallet – can be used to confirm measurements taken.

Order contents transaction: includes EPC, order identification, storage location, destination (loading bay) location.

Load despatch transaction: includes EPC, order identification, date, time, loading dock, delivery load status and despatch status.

Loading and delivery report: while delivery reports exist, this report will more accurately reflect the location of pallets between the loading bay and the customer. This report would crucially be able to identify whether or no loads were despatched in a complete state. Furthermore, offloading events can be corroborated with employee reports.

Misplaced pallets report: the WMS system can compare expected location with actual location and issue a detailed report of misplaced goods using Auto-ID generated data. This would be useful in determining the location of missing pallets for incomplete loads.

3.3.2. Middleware (MW)

The MW layer will require the EPC entity also, as it distributes information between the WMS and ERP. Specifically the offloading step of the shipping process will require the following transaction for implementations B and C:

Trailer offloaded transaction: it includes the EPC, order identification, date, time, and receipt status – whether the order was complete or not.

The following reports would provide detailed information that may be required:

Location information report: the MW would provide location information of pallets within the storage and loading areas, even in the event of misplacement. This report currently exists, but reflects only the last known theoretical location instead of the actual one. Through the use of Auto-ID, the MW could access its infrastructure to make this report more closely match the physical reality.

Delivery discrepancy report: details the information concerning pallets that made it onto trailers but were not offloaded as well as pallets that were part of a delivery load but were not loaded onto a trailer.

3.3.3. Enterprise Resource Planning system (ERP)

The ERP system does not contain the detail of the other systems and as such should not be affected in a major way for the implementations proposed. This is a consequence of the way in which the ERP system is currently utilised within FMC i.e. information is passed through the MW from the WMS with much of the detail filtered. Should detail be required, it would be possible for relevant reports and transactions to be created.

4. CONCLUSIONS

This study has highlighted that Auto-ID, while having benefits for organisations, has to work within the parameters already set in operation. Processes that are flawed e.g. altered to accommodate workforce demands, cannot necessarily be corrected by Auto-ID. An Auto-ID solution can however, provide some level of flexibility to allow for such situations. It is also possible to consider the use of Auto-ID without the drastic altering of original processes.

It is important to be aware of ongoing projects within companies as they consider applications of new technologies such as Auto-ID. Already FMC is well into a major global ERP project and chances of being able to alter the system at this stage to accommodate an Auto-ID application is not seen as feasible. Smaller trials designed to have minimum impact, especially on the information systems, are most likely to be more acceptable.

This study has shown that focusing on a particular issue of concern – in this case the loading of trailers – allows a less intrusive opportunity to consider a new technology. A low cost implementation proposal may not alter the operations of an organisation but allows exploration of the technology within the working environment. The basic implementations require an introduction of Auto-ID infrastructure and few changes to the information systems. Higher cost implementations could seek to expand on the basic proposal so as to provide an incremental growth path to broadening the use and capabilities of the new system. These require further investment in infrastructure and increased changes to information systems. Recognising the strategic value of an initial implementation should assist in justifying these further expansions.

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