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AUTO-ID CENTRE

REPORT

Assessing the benefits of Auto-ID Technology in the Consumer Goods Industry

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EXECUTIVE SUMMARY

This Manufacturing Engineering Masters project was conducted in conjunction with the Auto-ID Centre at MIT, established in 1999, and also recently established in Cambridge. The Centre is investigating issues associated with developing a ubiquitous electronic product coding environment to extend current bar coding technologies in use in many industrial, retail and commercial environments.

Auto-ID technology is briefly described in section 2 of the report, with a comparison of what is available today to what will be available in the near future.

The two main objectives of this project were:

1. Scope the main applications and benefits of an improved Automatic Identification and Data Collection (AIDC) system for manufacturing companies in the consumer goods industry, with quantification of short-term benefits where possible
2. Propose a methodology that could be followed by future benefits studies

A number of benefit areas have been identified, with a description of current situation, auto-id technology application, and the information required for its evaluation. Some information was gathered and benefits evaluated for Unilever Bestfoods UK. Gillette's UK operations were also briefly studied towards the end of the project. Due to company confidentiality, this version of the report does not contain quantification of any benefits.

The most significant short-term benefits in the case studies were seen through:

- Improved On-Shelf Availability (reducing out-of-stocks)
- Automated proof of delivery (eliminating invoice adjustments)
- Improved security of products (reducing shrinkage in the supply chain)

A methodology has been proposed for future benefit studies and additional recommendations have been made, which should reduce the time required for the completion of a benefits study.

Some of the main concerns among manufacturing companies have been identified and next steps suggested for the Auto-ID Centre.

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Biography

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Vivek Agarwal is a student at Trinity College, Cambridge, UK from where he is doing a Bachelors and Masters in Manufacturing Engineering, graduating in June 2001. Vivek lives in India and did his primary schooling there from St.Xavier's, Calcutta and Mayo College, Ajmer. He then went to England for his A Levels and University education. As part of his studies at Cambridge, Vivek is doing a 7-week Long Project with the Auto-ID Center at MIT. His aim is to analyse the potential costs and benefits of Auto-ID for manufacturing companies in the consumer goods industry, and will be focusing on Unilever. In his free time Vivek enjoys playing sports such as Squash and Cricket.

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1. INTRODUCTION

1.1. Project Background and Objectives

Supply Chain Management (SCM) is thought to be fuelling the rebirth of the Industrial Age by reducing costs, improving service, enhancing revenues, and empowering both the providers and users of products and services. However, the success of SCM as a vehicle for improved productivity and improved return on investments often overshadows the fundamental components that make SCM a reality. One of these components is the barcode, which is a form of Automatic Identification and Data Collection (AIDC).

More advanced systems of AIDC in development offer the potential for increased functionality and an opportunity to obtain continuous, accurate and real time information. The Auto-ID Centre at MIT, established in 1999, is developing one such system – a ubiquitous electronic product coding environment that extend current bar coding technologies in use in many industrial, retail and commercial environments. It has a mission to merge the physical world with the information world – to bring bits and atoms together to form one seamless network, using the very latest advances in technologies including, electromagnetic identification, computer modelling, and networking.

It is important for such developments in technology to have input from its users, including retailers and manufacturers. In order to get added involvement from them, the applications and benefits from improved AIDC need to be established. Benefits to the retailers were identified and evaluated by an MIT team consisting of Yun Kang, Sanjay Sarma and three Harvard Business School students. This project supplements the study by evaluating the benefits to manufacturers.

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1.2. Project Deliverables

The deliverables of the project are suitable for both the Auto-ID Centre, and manufacturing companies willing to implement an improved AIDC system.

The main deliverables are:

- Identification of the main benefits from Auto-ID to manufacturing companies
- Quantification of some of these short-term benefits for case study companies
- Methodology for further benefits studies for/within manufacturing companies

In addition, supplementary deliverable are:

- Useful sources of information (publications and organisations)
- List of industry and organisation contacts for further projects

Note that due to company confidentiality, this version of the report does not contain quantification of any benefits.

1.3. Project Approach and Timing

The approach to the project was split into the following six main stages.

1. **Scope Project:** prepare Project Brief, identifying the objectives, suggested approach and timing of the project.

2. **Understand Auto-ID:** visit Auto-ID Centre at MIT to understand the technology, meet the team and understand the development of the retailer benefits case.

3. **Scope Applications:** develop initial hypotheses on the immediate applications of Auto-ID based on brainstorming, research, and interviews.

4. V**isit Sites & Collect Data:** identify key areas of short-term savings through site visits, and initiate efforts to collect data from case study companies.

5. **Evaluate Benefits:** analyse the data collected to determine the magnitude of the key financial benefits for the case study companies.

6. **Consolidate, Report and Present:** bring together research and analysis during the project, prepare report, and present to the Auto-ID consortium and to Unilever.

Some of these stages overlapped each other and the Gantt chart in Table 1 below gives an indication of how the eight-week duration of the project was split. A detailed Timetable can be found in Appendix 7.1.

Table 1: Gantt Chart for Project

WEEK	1	2	3	4	5	6	7	8
Dates from	26/3	30/4	07/5	14/5	21/5	28/5	04/6	11/6
Dates to	30/3	04/5	11/5	18/5	25/5	01/5	08/6	15/6
1. Scope Project								
2. Understand Auto-ID								
3. Scope Applications								
4. Visit Sites & Collect Data								
5. Evaluate Benefits								
6. Consolidate, Report & Present								

An over-riding theme throughout the length of the project was to collate opinions from a number of sources. In addition to extensive Internet research, a number of interviews were conducted with:

- Potential manufacturing users (Unilever and Gillette)
- Potential logistics user (Tibbett and Britten)
- Organisation with interest in Auto-ID (Integrated Product Intelligence)
- Organisation with interest in grocery (Institute for Grocery Distribution)

A number of visits were also made either to witness operations of the case study companies, or to meet company personnel:

- Unilever head office in Crawley (twice)
- Unilever ambient distribution centre in Peterborough
- Gillette production centre in Isleworth
- Gillette pack centre and warehouse in Hemel Hempstead

The contact list of all personnel interviewed can be found in Appendix 7.2, 7.3 and 7.4 .

Notes from non-confidential meetings with personnel from independent organisations are included in Appendix 7.5. A day-visit was made to the Institute of Grocery Distributors (IGD) in Watford to use their information resources and meet analysts. Notes from this visit are included in Appendix 7.6.

Though the project approach and timing outlined above were followed, there was one unforeseen change. At the start of the project, the scope of the study was limited to one case study – Unilever. However, mounting interest from Gillette led to its addition to the project in week six. This pressurised resources towards the final stages of the project, but allowed testing the methodology proposed for further benefits studies (outlined in section 4).

1.4. Project Report Outline

This report has been structured into a number of sections in order to aid the reader and to make it easy to customise the report for its different users, taking into account confidentiality issues. A brief description of each section included in this version of the report is given below:

Section 2
outlines the Auto-ID technology, and compares the functionality of what is available today to what should be available in the near future.

Section 3
forms the core of the report, outlining the main benefits of improved AIDC to manufacturing companies. Each benefit area starts with a description of the current situation and then describes the application of Auto-ID and the resulting benefits. Due to company confidentiality, the benefits quantified for the case study companies cannot be included here.

Section 4
outlines the factors to be considered in a benefits study and proposes a methodology for future benefits studies. Additional recommendations have been made, which should reduce the time required for the completion of a benefits study.

Section 5
highlights some of the main concerns among manufacturing companies, and recommends next steps for the Auto-ID Centre.

Section 6
outlines the conclusions from this project.

Section 7
contains the appendices. Only those appendices that are necessary for the completion of the document are included, along with those that enable it to become a better hand-over document.

2. AUTO-ID TECHNOLOGY

2.1. Introduction to Section

Just as one need not know the technicalities of a mobile phone or a personal computer to use it, it is not necessary to know the technicalities to understand the principles, considerations and potential for using new forms of Automatic Identification (Auto-ID). However, a little technical appreciation can provide advantage in determining capabilities and restrictions. This section provides a flavour to the technology on which the benefits case is being presented. It starts with a brief description of the background to Auto-ID and the main principles involved. It then goes on to describe Radio Frequency Identification (RFID) systems, which are poised to become the Auto-ID system of choice. A comparison is then made between RFID and the traditional barcodes, in order to see where the main benefits of RFID stem from. The concept of intelligent products is introduced, and the issue of cost brought up.

2.2. Basics of Auto-ID

Auto-ID systems have become commonplace in access control and security applications, in industries requiring the tracking of products through the supply chain or manufacturing process, and in industries requiring the identification of products at the point of sale or point of service.

Included under the automatic identification umbrella are the following technologies:

- Bar Code
- Optical Character Recognition
- Radio Frequency ID
- Machine Vision
- Magnetic Stripe
- Smart Cards
- Touch Memory
- Voice Data Entry
- Radio Frequency Data Communications (RFDC)

All code-reading systems for automatic identification share the following features:

- There is a product, part, component, package, pallet, tote box, barrel, etc. Accurate identification of this item, while moving into or through production, warehousing, or the distribution pipeline, will contribute to the benefits case.

- A label, tag or coding device is affixed to the item so that it can be automatically read to identify what the item is, where it came from, where or to whom it is going, or whatever else might be needed by the user.

- An automatic or hand-held bar code reader, optical character reader, magnetic stripe reader, vision system, or radio frequency interrogator will read the code, validate it, and convert the content into system-meaningful control and information output.

- The code reader transmits the output to networked PC's, mini-computers, relays, solenoids, microprocessors, programmable controllers, diverters, counters, video displays, horns, bells, whistles, etc. for data manipulation or communication.

Perhaps the most widely recognised Auto-ID system is the barcode system developed in the 1970s, which also accounts for the biggest share of the worldwide Auto-ID market. Other technologies have gained acceptance in those applications where they provide the better solution. An important point to note is that users generally find that the technologies are more complementary than competitive. More recently, Radio Frequency Identification (RFID) technologies have begun to find greater use in automatic identification, and these are explored further in the following section.

2.3. Radio Frequency ID

Radio Frequency Identification (RFID) systems are poised to become the Auto-ID system of choice for all applications requiring the automated identification of people, animals, or objects. RFID systems are relatively new in Automatic Identification and Data Collection (AIDC), but these systems are already in use in many diverse applications including access control systems, livestock management systems, automated toll collection systems, theft-prevention systems, and automated production systems. Recent advances in RFID technologies have reduced the system costs to the point where RFID systems may be used in consumable applications such as grocery product identification.

RFID is being seen as a radical means of enhancing data handling processes, complimentary in many ways to other data capture technologies such as bar coding. A range of devices and associated systems are available to satisfy an even broader range of applications. Despite this diversity, the principles upon which they are based are quite straightforward, even though the technology and technicalities concerning the way in which they operate can be quite sophisticated.

The transponders (tags) typically consist of an electronic microchip that stores data and a coupling element, such as a coiled antenna, used to communicate via radio frequency waves. Transponders may be either active or passive – active transponders have an on-tag power supply (such as a battery) while passive transponders obtain all their power from the interrogation signal of the transceiver. The transceivers (tag readers) typically consist of a radio frequency module, a control unit, and a coupling element to interrogate electronic tags via radio frequency waves for information stored on them; this information can range from static identification numbers to user-written data to tag-sensory data. The transceivers can communicate their received data to the data processing subsystem via a fitted interface.

The use of radio frequencies for communication with transponders allows RFID tag readers to read passive RFID tags at small to medium distances and active RFID tags at small to large distances even when the electronic tags are located in a hostile environment and are obscured from view. The basic components of an RFID system combine in essentially the same manner for all applications and variations of RFID systems. All objects to be sensed are physically tagged with transponders. The type of tag used and the data stored on the tag varies from application to application.

Transceivers are strategically placed to interrogate tags where their data is required. For example, an RFID access control system locates its tag readers at the entry points to the secure area. The transceivers continually emit an interrogation signal, which forms an interrogation zone within which the transponders may be read. The actual size of the interrogation zone is a function of the transceiver and transponder characteristics. In general, the greater the interrogation signal power and the higher the interrogation signal frequency, the larger the interrogation zone. Sending power to the transponders is usually the bottleneck in achieving large read range with passive tags. Active tags do not suffer from this drawback and therefore typically have larger read ranges than an otherwise equivalent passive tag.

For more details on the technology, refer to the information sources in Appendix 7.7, or contact the Auto-ID Centre.

The following section analyses what makes RFID an improved AIDC system compared to barcodes. It serves the purpose of convincing sceptics on the potential within RFID, and should motivate further benefits studies within companies.

2.4. Improvement from Barcodes

Bar codes are cheap, reliable, relatively easy to produce, and can be put in the hands of shippers easily. Far exceeding initial expectations, five billion codes are scanned every day in 140 countries. But even as retailers tip their hats to the barcode's success, few deny that a more sophisticated kind of tagging would be a great improvement.

Some of the reasons for this view are described below:

– Barcodes identify only classes of products, not individual items, whereas a digital numbering scheme built into a tag has the capacity to identify every single manufactured item that is currently made and sold.

– Barcodes have to be deliberately scanned at specific orientations (establishing line of sight) whereas tags need only be within a reader's range. Tags can therefore be read in bulk very rapidly (offering virtually simultaneous reading of the contents of, say, a stockroom or shopping trolley).

– Barcodes do not work if the symbol becomes damaged; tags can withstand chemical and heat environments that would destroy traditional barcode labels.

– Barcodes contain static information that cannot be updated unless the user reprints the code; tags potentially have read-write capability.

– Compared to barcodes, tags can potentially contain a greater amount of data.

By replacing barcodes with tags, companies will be able to monitor product movement continually, from manufacture to disposal, in real-time. Eventually shoppers will bypass checkout counters altogether, as their tagged purchases are automatically debited to their accounts on their way out the door.

However, there is no denying that barcode technology is more mature than RFID, which gives significant comfort value to some users. The race between smart labels and bar code labels, at the moment, is a little like a contest between a submarine and a bicycle [Bert Moore, June 1999]. The submarine is not much of a threat on dry land, and the bike is not going to be very useful in the ocean. In other words, it is less a contest between technologies than it is a difference between visions of the total logistics and distribution process.

The development of such tags could enable the concept of intelligent products, which is introduced in the following section.

2.5. Intelligent Products

According to an Auto-ID board meeting presentation in Florida in February 2001, the intelligent product is a physical and/or information based representation of intellectual property which:

– possesses a unique identification
– is capable of communicating effectively with its environment
– can retain or store data about itself
– deploys a language to display its features, production requirements etc.
– is capable of participating in or making decisions relevant to its own destiny

Three intelligent systems under consideration in the manufacturing environment are defined below:

– Intelligent Resource: machining/transporting device that can negotiate its own tasks, schedule, manage and execute them

– Intelligent Product: software entity representing the description of the product, how it should be made (recipe) and to be able to identify possible production routes

– Intelligent Order: software and physical entity representing the products required and customer requirement, and capable of negotiating with different manufacturing processes via intra/internet

The application of universal electronic product coding (EPC) to manufactured items will enable each product to carry its own unique 'messages' around with it in the form of an embedded chip. For example, an order for mixed variety of pasta from a retailer could 'tell' a production line how to make and package it, a carton of spaghetti could 'tell' a truck to deliver it, 'tell' a shop that it had been bought, and then 'tell' a microwave how to cook it.

Until recently, it was generally believed that accurate tracking and management of individual goods produced by volume manufacturing was beyond existing technology. However, the application of smart tagging and Internet technologies in conjunction with intelligent agents – software objects capable of reasoning and interactive communication with similar objects – has the potential to make an 'intelligent' and fully traceable product a low cost reality within the next few years.

2.6. Cost of Tagging

The main area of focus for a number of technology vendors is further reduction of the cost of tagging.

The cost to a manufacturing firm would include:

- Cost of the tag itself
- Cost of applying tags to products
- Cost of purchasing and installing tag readers in factories and/or warehouses
- Systems integration costs
- Cost of training and reorganisation
- Cost of implementing application solutions

Though cost of tagging is currently one of the main barriers to immediate implementation of auto-id technology, it is not considered in further detail in this report. The justification for this lies in the fact that these costs are continuously reducing.

3. AUTO-ID BENEFITS CASE

3.1. Introduction to Section

It is generally agreed that the main benefits from Auto-ID are downstream in the supply chain, i.e. to the retailers. This is mainly because of the increased complexity of dealing with individual products rather than cases or pallets. However, tagging does provide a range of benefits to manufacturers, even when done at the product level. This section of the report investigates some of the main benefits from product level tagging to manufacturers. It aims to convince manufacturers that there is not just prognosis but also feasibility in the trend towards tagging.

Clearly, different companies will benefit from different applications – some may find a significant improvement in sales through improving on-shelf availability while others may find cost savings from reducing shrinkage. An attempt has been made to be comprehensive in the coverage of the short-term benefits. However, depth of understanding was achieved only for those benefit areas seen to be significant in the case study companies. Some benefit areas may have been overlooked, either deliberately because of their insignificance, or unknowingly because they were not encountered in the two case studies or in the personal experience of the author.

For each benefit area, the current situation is described first, followed by the potential Auto-ID application and benefits. To aid companies wishing to evaluate the benefits themselves, and to support future studies by the Auto-ID Centre, each benefit area includes the information required for its evaluation. This information is usually specified at the plant or warehouse level, in which case multi-site companies would need to either gather data for each site, or aggregate numbers appropriately. Some of the benefits identified are easily quantifiable, and an attempt has been made to evaluate the main ones for the case study companies. There are also some benefits that cannot be quantified, but have been included in the report (section 3.11) for completeness, and in order to guide future studies in this area. Due to company confidentiality, the benefits quantified for Unilever and Gillette cannot be included in this report.

Before a review of the benefits is put forward, it should be noted that barcodes are extensively used in both Unilever and Gillette. The Auto-ID infrastructure could be extended to these companies with the help of barcodes, but only to a limited extent. Barcodes allow visibility only to the product level whereas tagging would allow visibility to the item level, giving major additional benefits. Companies with no Auto-ID system currently in place would see benefits of an even larger magnitude, and may even see other benefits not identified here.

3.2. Overview of Benefits

The objective of supply chain management activities is to meet customer demand for guaranteed delivery of high quality, low cost, customised products with minimal lead-time. The attempt is to improve responsiveness, understand customer demand, intelligently control the manufacturing process, and align together the objectives of all partners in the supply chain. To achieve this objective, companies need to have visibility into the entire supply chain of transaction and planning systems – of its own plans as well as those of its suppliers and customers. Also, the company should be flexible enough that it can adjust, rebuild and re-optimise plans in real-time, to take care of unexpected events taking place in the supply chain.

Such effective management of the supply chain as a whole as well as within each participating supply chain company depends on timely, reliable and accurate information accompanying product and merchandise as it is sorted, stored, picked, transported and kept secure.

To achieve real time visibility of information we need:

- Real-time data acquisition methods
- Conversion of acquired data into relevant information: using standardised, secure representation
- Instantaneous access to this information

Tagging would enable continuous, accurate and real time information on products, providing an unprecedented level of visibility in the supply chain. It can therefore play an important role by enabling goals such as Efficient Consumer Response (ECR) and Collaborative Planning Forecasting and Replenishment (CPFR).

Table 2 below summarises the main benefits to manufacturing companies from improved forms of Auto-ID.

Table 2: Overview of Benefits

SUPPLY CHAIN AGILITY	REVENUE GENERATION	COST REDUCTION
– Complete visibility and traceability of products – More responsive production – Reduced order cycle times – Delivery in mixed pallets – Improving forecast accuracy	– Improved On-Shelf Availability – Mass Customisation – Frequent new product introductions	– Automated proof of delivery – Improved security of products – Eliminating stock verification – Incorporating shelf-life of products – Reducing inventory levels (& warehousing requirements)

The focus of this project is on the short-term and quantifiable benefits, which inevitably come through cost reduction and revenue generation. Improved supply chain agility may contribute towards cost reduction; for example improved forecast accuracy could lead to reduced inventory levels. The remainder of this section details potential short-term benefits.

3.3. Improving On-Shelf Availability

The financial benefit from improved on-shelf availability was found to be very significant, hence it is discussed in considerable detail compared to other benefits.

3.3.1. Current Situation

Level of Out-of-Stock (OOS)

Industry standards on the current levels of OOS were collated from independent studies, and have been summarised in Table 3 below.

Table 3: Out-of-Stock Levels

STUDY DETAILS	AVERAGE LEVEL	PEAK LEVEL
ANDERSEN CONSULTING, 1996	8.2%	15.0%
ROLAND BERGER, 1999	5.0%	17.5%
ECR FRANCE, 2000	10.9%	15.0%

There is general agreement that the problem of OOS is getting bigger. Evidence from ECR Europe and other sources shows worldwide increased interest in addressing the issues surrounding OOS. New products are being introduced to the marketplace, increasing the competition for retail shelf space and the likelihood of items being OOS. Personnel costs are rising and it becomes more difficult to 'throw more bodies' against the problem, a solution that has been utilised by retailers that are known for keeping their OOS levels to a minimum.

Root Causes of OOS

The Andersen Consulting study claims that 73 percent of the OOS problem is related to inadequate ordering processes (promoted item forecasting and ordering account for 19 percent of this). In most cases, store personnel are unaware of a current or potential out-of-stock and consequently do not

place an order. The study also claims that in only 8 percent of the instances is the OOS a result of having the product at the store (backroom inventory) and not on the shelf. However, other studies have assigned a much greater portion of shelf OOS responsibility to either warehouse and/or back-room replenishment. For example, a recent study by P&G Disco-Ahold claims that 37 percent of OOS occurred when the product was actually in the store.

Consumer Behaviour

To accurately evaluate the potential benefit to the manufacturer from improving shelf availability, it is important to understand the consumer behaviour when faced with an OOS situation. Some of the reactions, such as leaving the store and continuing elsewhere, only impact the retailer and not the manufacturer, as consumers still purchase the brand. Others, such as buying another brand in the same store, would impact the manufacturer more than the retailer. Note that some allowance also needs to be made for the fact that consumers may switch between two brands from the same manufacturer, in which case the negative impact would be marginal, coming only from a shift towards a lower priced item.

Current Initiatives to Improve On-Shelf Availability

A number of initiatives have been launched (in addition to tagging) to address the issue of on-shelf availability. These are briefly evaluated below:

COLLABORATIVE PLANNING:
to involve suppliers in the forecasting and planning processes. This is a useful tool, but one still needs accurate data from the shelf and the backroom, which can be provided by tagging. Moreover, there is insufficient provision for unplanned and unforeseen events, and the 'last 50 yards' would still be a problem.

STORE-READY PACKAGING:
use of 'one touch' product presentations to make it easy for stores personnel to convey fast movers from back to store. An example is the 'wheeled dolly' used to transport 2 litre bottles of soft drinks. This is a good means of implementation, but does not address the root causes of OOS.

SMART PACKAGING:
flexible solutions to allow stores to pick by aisle or by category. This is an innovative idea but the benefits from it will only be marginal.

THIRD PARTY LOGISTICS:
outsourcing shelf replenishment, giving advantages in areas such as replenishment during busy hours. Again, this does not address the root causes of OOS.

INCREASE LABOUR:
'throw more bodies' against the problem. However, personnel and training costs are rising, and people (especially untrained part-timers who do the restocking) do make mistakes.

3.3.2. Auto-ID Application & Benefits

The two most important root causes to be addressed are the ordering process and the backroom-to-shelf replenishment process. The ability to provide the necessary solutions lies in the ability to capture the behaviour of each SKU at each location through tagging. Readers can provide accurate data on shelf and backroom availability, as well as timing and location of incoming deliveries. Tags can then trigger an alarm to inform the store personnel of a re-ordering or replenishment that needs to take place. Tagging can therefore allow us to capture approximately 80 percent of the potential benefits from improving on-shelf availability (as the two causes account for approximately this proportion of OOS). The most important

and tangible benefit from improving shelf availability is increased sales, on average about 2 to 3 percent [Roland Berger]. Other benefits include better service, and improved chances of brand loyalty.

3.3.3. Information Required for Evaluation

Current level of OOS for the company's products.
Note that different products will have different OOS rates and an allowance must be made for that if an average figure is to be used for the whole company. Relevance of figures collected by the company itself is higher as the right brands would be studied.

Level of brand loyalty amongst consumers.
This would help in establishing whether the likely reaction of the consumer when faced with an OOS situation would be different from a 'typical' behaviour.

Current sales level of the product.
This would enable converting the percent figure to actual revenue gains. Only sales made to retailers that are in a position to adopt tagging in the short-term should be measured.

Profit margin on the increased sales.
The margin would be higher than normal since all the overhead costs are already apportioned to the current level of sales.

3.4. Mass Customisation

3.4.1. Current Situation

With changes in society, there is an increased demand for customised products. However, manufacturing companies have been reluctant to mass customise, especially on high volume situations, mainly because of the changeover times and costs involved, and the decrease in machine utilisation rates. For example, changing the proportions of chemicals to produce a customised fragrance may require operator involvement, either to set the level of each chemical or specify pre-set levels. The machine may need to be on stand-by while this change occurs. Companies are also discouraged from mass customisation due to the logistical complexity involved downstream in the supply chain.

3.4.2. Auto-ID Application & Benefits

In an automated production context, it is envisaged that from very early in its life each product will have unique product identification. This will carry information not only on the specification of the final product required but also (assuming there is the capacity for a large amount of identification information) details of how a standard machine cell would have to be configured to produce the product. In this instance such standard cells would become highly flexible with the ability to reconfigure on the demand of products arriving, enabling mass customisation. With Auto-ID tagging of products, the downstream complexity of logistics would also be reduced, enabling mass customisation of deliveries. The biggest benefit from mass customisation would be an increase in sales, both from the new market opportunity as well as at the expense of competitors.

3.4.3. Information Required for Evaluation

The benefits from mass customisation are not easy to evaluate, as the following information is required:

- Current demand for mass customised products that is yet unmet, in order to establish new market opportunity.
- Share of this market that can be captured, enabling estimation of sales growth.
- Premium on price that can be charged for mass customised products.
- Therefore potential increase in revenue from increased sales and prices.

3.5. Automating Proof of Delivery (PoD)

3.5.1. Current Situation

When products are delivered from the manufacturer to the retailer, a proof of delivery is required to legalise the transfer of ownership of the products. Currently this is done manually, which leaves room for error. There is often discrepancy between what the manufacturers say they have sent and what the retailers say they have received. This may lead to invoice adjustments, to correct the invoice from what manufacturers believed they sent to what retailers believe they received. More often that not the mistake is at the retailer's end, so the manufacturer ends up providing free products to retailers. This is thought to be the case due to the relatively high accuracy levels of current Warehouse Management Systems. Therefore, manufacturers may know that they have sent the product, but do not receive payment, as there is no concrete way of proving delivery apart from what the retailer has signed for.

3.5.2. Auto-ID Application & Benefits

Using tagging, the process of obtaining proof of delivery can be automated, eliminating manual errors. Products can simply be passed through tag readers at the retailers rather than have to be manually checked and counted. The manufacturer would not just save on the cost of products unpaid for, but also on the man-hours spent on processing and negotiating the claims from the retailers.

3.5.3. Information Required for Evaluation

- Average level of invoice adjustments in a year.
- Number of people employed (and salaries paid) to investigate claims and negotiate with retailers.
- Average annual expenditure on external help (e.g. lawyers) taken for the settlements.
- Extra cost of speeding delivery of stock required to complete order.

3.6. Improving Security of Products

3.6.1. Current Situation

Barcode technology offers no protection from theft. EAS tags are used in some applications such as CDs and clothing, but require labour intervention for insertion and removal. Some industries also face a threat of products from counterfeiters riding on the back of the original producers, who would have invested millions in product design, development, and marketing.

3.6.2. Auto-ID Application & Benefits

The capability to quantify and locate all inventory using tagging has positive implications for the integrity and security of the supply chain and for combating retail theft, returns fraud and counterfeiting. Auto-ID offers protection from theft for all items. On one hand the level of theft can be reduced, as readers could warn personnel of any attempted theft in the vicinity. In addition, stolen products (which are often found in the black market or shipping docks) can be identified and the correct ownership restored. Note that there have been instances where companies have stumbled upon stolen products in some instances but been unable to prove their ownership. RFID can also be used for product authentication, defeating counterfeiting operations and hence increasing hard financial gains in sales (eliminating losses).

3.6.3. Information Required for Evaluation

- Current level of physical shrinkage in the manufacturer's supply chain (i.e. where manufacturer has ownership of product).
- Root causes of the shrinkage (e.g. theft, damage, loss, etc.)
- Realistic level to which shrinkage can be reduced, even with complete visibility and traceability of products in the supply chain.

3.7. Eliminating Stock Verification

3.7.1. Current Situation

Manually conducted physical stock checks take place at most manufacturers' warehouses. This is to ensure a level of accuracy between what the system claims there is in the warehouse and what is actually there. 'Paper shrinkage' may occur when a product is physically in the warehouse but the system is unaware of it. This generally occurs due to incorrect manual entry of data. An inventory record that reports inventories are higher than actual can result in stockouts and, perhaps, work stoppages.

Verification is also generally required when products come from the factory to the manufacturer's warehouse. Since manufacturers are mostly dealing with bulk pallets, the verification at receiving is not a lengthy process. However, manufacturers often have to break pallets for picking, in order to send mixed pallets to retailers. The verification required at this level could be fairly time consuming as operators would have to ensure they pick the right quantity of cases, and may be required to enter the remaining number of cases into the system for cross-checking. Picking activity is considered to be the bottleneck in the warehouse, and there is increasing pressure from the shift towards cross docking. Marginal savings in time could therefore be quite beneficial.

3.7.2. Auto-ID Application & Benefits

Products can simply be passed through tag readers and the stock verification can be automated, speeding up the process and eliminating manual effort. Automated operation also eliminates errors in scanning and labelling. The activity of taking stock checks can be eliminated as the system can give continuous, accurate and real-time information on what you have, how much of it you have, and where you have it. The effort behind internal audits can be drastically reduced. The main benefit would be the re-deployment or reduction in labour expenses. The picking activity in warehouses could also be eased through tagging, as pickers would not have to spend time specifying what they have picked.

3.7.3. Information Required for Evaluation

- Number of personnel employed for the purpose of stock checks and their annual salaries. Note that there may be a person in each shift.
- Average number of man-hours spent on each stock-check (assuming personnel not dedicated to stock checking), wage rates, and frequency of stock checks.
- Number of 'inspectors' employed to ensure barcodes are scanned when products are moved. Annual wages of these personnel.
- Proportion of picking time spent in verification of what has been picked or what is left in the picking bay. Man-hours and wage rates for pickers.
- Work stoppages caused due to incorrect inventory levels.

3.8. Incorporating Shelf-life of Products

3.8.1. Current Situation

A number of times manufacturers are unable to maintain stock rotation to avoid expiry, or rejection due to insufficient shelf life remaining. Manufacturers attempting the 'first in first out' (FIFO) rule fail mostly due to unawareness of where the oldest stock is located, leaving operators no choice but to utilise stock most easily available. Operators are not actively aware of any products that may be approaching their best before date, and at best are able to pull out regular reports from the system to find such products. There are also some products, e.g. crisps, which require an incubation period to allow the flavours to mature. One needs to avoid the situation where these products are sent too early to the retailers, i.e. in a state 'unfit' for consumption.

3.8.2. Auto-ID Application & Benefits

Tagging of products can enable FIFO, as there can be complete visibility of the location of the oldest stock. Tagging of products could warn the operators if they are sending products to the retailers too early, in a state 'unfit' for consumption. If the wrong stock is being sent out, the tags could send an alarm to the operators. Tags on products could also warn operators if any products are approaching the end of their shelf life and need to be shipped soon. This should lead to fewer rejections based on insufficient shelf life.

3.8.3. Information Required for Evaluation

- Manufacturing and holding cost for the products rejected annually due to insufficient shelf life remaining.
- Handling cost involved in the rejection of these products (cost of labour, transportation etc.)

3.9. Reducing Inventory Levels

This benefit area has proved to be the most difficult to convince to manufacturers, and is potentially very significant, so it is considered in some detail.

3.9.1. Current Situation

The level of inventory in the manufacturer's supply chain is linked to the accuracy of forecasts and the order cycle times, as shown in Figure 1 below.

Figure 1: Root Causes for High Inventory

LEVEL OF INVENTORY IN THE SUPPLY CHAIN			
Uncertainty of Future demand	Poor Accuracy of Forecast	High Variability in Orders	High Level of Inventory for Manufacturer
Poor Knowledge of Current Demand	Poor Accuracy of Forecast	High Variability in Orders	High Level of Inventory for Manufacturer
Retailers Unwilling to Hold Inventory	Short Order Cycle Times	High Variability in Delivery Lead Time	High Level of Inventory to for Manufacturer

The figure demonstrates that inventory needs to be held at the manufacturer's warehouses to safeguard against uncertainties in the orders placed by customers, and the order delivery lead time.

Order Cycle Time

Order cycle times are often confused with order lead times. The latter is the period of time between when the retailer places the order and when the manufacturer delivers it. However, the order cycle time is the period of time between when the retailer places the order and when the manufacturer is able to produce and deliver it. This is what truly determines the level of inventory in the system. Some companies decide on a minimum level of inventory required in the system to guarantee a certain service level to the retailer. However, using safety stocks and safety lead times increases inventory and the real problems are not addressed. By reducing the response time from the plant, this level can be lowered.

Forecast Accuracy

Most consumer goods manufacturers produce to stock based on forecasts. The accuracy of these forecasts can be of great significance since large variations one way or the other could lead to out

of stocks or excessive inventory. Given this situation manufacturers need to work towards improving their forecasting, with a move from hypothesis-based planning to demand-driven forecasting.
The requirement of good information is unchallenged, as most companies realise 'crap in leads to crap out'. Promotions are the most difficult element within forecasting. When consumers themselves cannot predict whether or not they would purchase an item on promotion, how could the retailers or manufacturers? It has therefore become increasingly important to have accurate visibility into the demand of the products on promotion in order to be able to make appropriate changes in the supply chain to ensure good on-shelf availability without excessive inventory.

EPOS Data
Manufacturers have started utilising Electronic Point of Sale (EPOS) data and advanced forecasting software in order to improve forecast accuracy. However, EPOS data lacks integrity – for example, a check-out-till person may not differentiate between two flavours of yoghurt, scanning the sale of all the flavours bought by the consumer under one.

Bullwhip Effect
The bullwhip effect occurs when the demand order variability in the supply chain is amplified as demand moves up the supply chain. Excessive inventory can be caused by distorted information from one end of the supply chain to the other. Other inefficiencies include poor customer service, lost revenues, misguided capacity plans, inactive transportation, and missed production schedules. There are cycles of excessive inventory and severe backlogs.

In a supply chain for a typical consumer product, even when consumer sales do not seem to vary much, there is pronounced variability in the retailers' orders. For example, P&G found that even products (diapers) that are consumed at a steady rate have amplified demand order variability as they moved up in the supply chain.

The four main causes of the bullwhip effect are

a) demand forecast updating,
b) order batching,
c) price fluctuation, and
d) rationing and shortage gaming.

Each of these four forces in concert with the chain's infrastructure and the order managers' rational decision making create the bullwhip effect.

Efficient Consumer Response (ECR)
In the past few years, the ECR initiative has tried to redefine how the grocery supply chain should work. One motivation for the initiative was the excessive amount of inventory in the supply chain. Distorted information has led every entity in the supply chain – the plant warehouse, a manufacturer's shuttle warehouse, a manufacturer's market warehouse, a distributor's central warehouse, the distributor's regional warehouses, and the retail store's storage space – to stockpile because of the high degree of demand uncertainties and variabilities. Effectively, the more nodes there are in the supply chain, the more inventory there will be.

3.9.2. Auto-ID Application & Benefits
It is strongly speculated that Auto-ID can enable inventory to be substituted by information.
This can be done by

– Reducing order cycle times (effect on inventory proven by the beer game) through better information flow, i.e. reducing the non value-adding content of the order cycle time.

- Enabling the improvement of forecast accuracy through better and quicker information on current demand patterns
- Understanding promotions better through visibility of consumer behaviour
- Reducing variability in ordering (thus lower safety stock)
- Increasing speed and accuracy of planning
- Increasing flexibility in responding to unexpected demand
- Enabling JIT strategies, such as produce-to-demand vs. produce-to-forecast
- Controlling the bullwhip effect by co-ordinating information and planning along the supply chain through information and product visibility
- Increasing the accuracy of information. In general, the higher the accuracy of the inventory, the lower the level of buffer stocks that needs to be held
- Enabling a shift from make-to-ship or make-to-pack towards make-to-order

Tighter stock control leads to lower inventory investment, faster order turnaround, improved resource utilisation, and reduced costs. In addition to inventory reduction there may also be supplementary benefits from improved information on the inventory. For example, manufacturers would have better knowledge of where the inventory needs to be delivered, reducing the level of inter-site movement of products.

3.9.3. Information Required for Evaluation

- An estimate of the percentage reduction in inventory levels from Auto-ID. This would vary between companies depending on efficiency of their current systems.
- Cost of capital tied up in inventory. Note that reduction of capital tied up will be a one-time gain.
- Storage costs for inventory. Note that depending on the level of inventory reduction, manufacturers may be able to eliminate third-party storage, and even reduce the number of warehouses they have. Manufacturers may even be able to provide third-party storage to other companies.
- Cost of inter-site transportation and handling of inventory.

3.10. Benefits from Component Tagging

3.10.1. Current Situation

Work In Progress (WIP)

For some manufacturers, WIP is a big inventory cost. For example, electronics manufacturers can have a large WIP of expensive components. Lack of visibility in their supply chains requires them to keep minimum stock levels to guarantee certain service levels. Moreover, WIP tracking ensures the right product is sent to the right customer.

Reverse Logistics

Some manufacturers have to manage difficult processes associated with product recalls and dealing with returned merchandise that needs to be re-integrated into the forward supply chain operation. Reworks are also a source of considerable problem in some industries. Manufacturers need to be able to accurately establish the faulty component, say in a computer, and go through a lengthy process of not just finding and replacing the part but also determining whether it was from a bad batch of parts (in order to determine who was at fault).

3.10.2. Auto-ID Application & Benefits

Component tagging eases the task of identification of parts. WIP can be easily tracked giving visibility that can reduce its required stock levels. More effective solutions to the intractable problems associated with reverse supply chain logistics can also be implemented. Note that component tagging would be cost-effective only for certain applications such as in automotive, aerospace and electronics.

3.10.3. Information Required for Evaluation

- An estimate of the percentage reduction in WIP stock level if complete visibility is enabled, and the actual financial level of WIP in the system.
- Current levels of wrong deliveries of components or WIP to customers, and associated cost.
- Current average level of product recalls and the cost of handling and re-integration of products.
- Current average level of reworks and the cost of handling and re-integration of products.

3.11. Other Benefits

There are some other benefits that cannot be accurately quantified but have been included here to be comprehensive in presenting all the findings from the project. In some situations these benefits may bring competitive advantage while in others they may be an order-qualifying criteria.

Systems 'Integration'
Most manufacturers use different systems from their retailers and suppliers, and more often than not, have a variety of different systems within the company. Auto-ID can ease the pain of systems integration by allowing data to be maintained on the products themselves. The read/write or read-and-append feature of tags means the same label could hold shipper, customer and carrier data. The data would, obviously, have to be compatible with the existing systems. Auto-ID can therefore provide companies the benefits of integrated systems without the cost of standardising systems.

Consumer (Internet) Ordering
There is an increased trend towards Internet shopping. Though currently this is limited to people with computers, in future we may have active advertising on television, allowing us to order a product by simply clicking on an ad. We may also be able to shop at portals located in areas where people spend non value-adding time, e.g. while waiting for a train on a railway platform. With increased consumer ordering, one can envisage a scenario where consumers wish their picked orders to be delivered to their residence, office, or an outlet. These orders may be satisfied directly by manufacturers, in which case tagging would provide the visibility and traceability of the products required for better service to consumers (especially those who wish to track the location and delivery status of their products).

Automatic Reordering
There is continuing work on future white goods that may automate the reordering process. For example, a fridge could automatically reorder milk when existing stock depletes or goes out of date. Manufacturing companies would potentially benefit from being closer to the end consumer.

Active Management
The best decision-making is executed on the basis of feedback on events while, not after, they occur. To achieve greater productivity, contemporary systems must provide discipline and control that is based not only upon plans and performance goals, but also upon the dynamics of the actual operation. With tagging companies could monitor not just where their products are, but also what environments they are being put through. For example, a company can track the temperature at which a product is held throughout its distribution cycle. This level of visibility could enable 'active management' of products, so that alarms could be flagged to a lorry driver, the company head-office or the service provider, who could take actions to correct faults (e.g. products being stored at too high a temperature) before damage occurs. The companies would not only understand their supply chains better but also be in a position to actively manage it. Rerouting can also be done dynamically, if the need arose, simply by changing the data on the tag.

A checklist of benefits identified by Omron (vendor) and CEST (independent organisation) are included in Appendix 7.9 and 7.10.

4. PROPOSED METHODOLOGY

4.1. Introduction to Section

One of the key deliverables of this project is to act as a primer for future benefit studies. The type of information required for the evaluation of the benefits was included along with each benefit identified in section 3. This section attempts to fit that information required into the context of the overall study that would need to take place. Factors that need to be considered in a benefits study have been outlined and a methodology proposed for future benefits studies. The methodology amends some of the errors or misjudgements that may have taken place during the course of this project. Based on the experience from this project, recommendations have also been made to avoid potential problems. These should speed up the timeframe of the study.

4.2. Factors to Consider

There are a number of factors that a benefits study should consider. The questions that need to be addressed during a benefits study are outlined in Table 4 below, along with the reason for asking each question. The questions are tabulated in the order they should be addressed:

Table 4: Factors to Consider

QUESTION TO ASK	REASON FOR QUESTION
WHAT BUSINESS PROBLEMS ARE THE MOST SIGNIFICANT?	To ensure that time is not wasted on insignificant problems
IS THIS A COMMON PROBLEM FOR THIS CATEGORY OR BUSINESS?	To see if similar benefits can be found elsewhere
HOW CAN THE APPLICATION OF AUTO-ID OVERCOME THIS PROBLEM?	To ensure that Auto-ID is able to solve the problem
WHY SHOULD AUTO-ID BE THE PREFERRED SOLUTION OVER OTHERS?	To ensure there are no other obvious solutions that could be more easily applied to solve the problem
WHAT FINANCIAL BENEFITS CAN BE REALISED BY IMPLEMENTING THE APPLICATION?	To be able to evaluate the financial benefits
WHAT ADDITIONAL BENEFITS CAN THE USER COMPANY REALISE?	To identify other savings that may not be financially quantifiable
ARE THERE ANY EXTRA BENEFITS TO THE COMPANY NOT IDENTIFIED EARLIER?	To ensure any new benefit areas found in a case study company are added to a list of benefits so they are not missed in future studies

4.3. Suggested Methodology

The questions described above need to be addressed in a methodical manner. Figure 2 overleaf gives a methodology for benefits studies. The key tasks involved in the process are shown, along with enablers for these tasks. The general flow of the methodology is from top to bottom.

Figure 2: Methodology for Further Benefit Studies

KEY TASKS	ENABLERS
Ensure good understanding of Auto-ID technology	Papers, articles and web resources (see Information Sources in Appendix 7.7)
Consolidate previous work on Auto-ID benefits (internally and externally)	Meetings and workshops within company
Understand current supply chain of company and the main problems faced	Meetings with the prime contacts, or workshop
Focus down to product or plant/warehouse	Identification of most promising potential
Scope Auto-ID benefits from Auto-ID applications	Benefits list (see section 3) and meetings with company personnel
Identify information required from company	Example for summary of information required (see Appendix 7.11)
Collect data from plant/warehouse personnel	Site visits; meetings with warehouse, plant and head office personnel
Evaluate monetary value of benefits	Analysis on data collected
Conduct sanity check on numbers	Meetings with relevant company personnel
Present and/or report to company	Consolidation of collected material

4.4. Improvement Recommendations

Recommendations are made below to address some of the issues encountered during the project, such as a slow response speed for information.

- The acquisition of relevant data from the company could be slow and time-consuming. It is therefore recommended that two or more benefits studies be run concurrently so that overall productivity of the people conducting the study is higher.

- It is also important that the correct champion is identified within the company, who has the right contacts in all areas, and can tackle issues of sensitivity. Someone with a long history in the company is good for this purpose.

- The process is much faster if the correct contacts within the company are contacted. It is therefore worth spending some time in the beginning of the project to identify these contacts for each location/function to be studied.

- It is also recommended that if possible a workshop be held in the initial stages of the project. This has a number of advantages:
  - It ensures that relevant contacts are aware of the project and clear on the goals and timeframe (this would then not have to be repeated with each individual)
  - Any previous work done in the area can be identified and collected
  - The main business problems faced can be identified, with equal participation from each function of the organisation
  - Further visits and meetings can be fixed

5. CONCERNS AND NEXT STEPS

Some of the main concerns among manufacturing companies have been identified and collated below:

- Price/cost – capital equipment, consumables and maintenance
- Compatibility with existing numbering systems
- Ease of integration into existing data capture systems
- Harmonious co-existence with other data capture products, both similar (RFID) and dissimilar (barcodes)
- Standardisation of technology
- International operability of the products/systems
- Limited read range of passive tags
- Debate between use of read-only vs. read-write tags
- Security/privacy of information on tags

Manufacturing companies need the assurance that developments in technology are addressing these concerns. It is recommended that the Auto-ID Centre take active steps in either addressing the concerns, or encouraging debate in these areas. Some next steps are recommended below:

- Though the fixed and variable costs of the tags are decreasing with time (as a result of technological innovation) and will lower with volume production, an estimate of current costs would be beneficial.

- The scope of some of the benefits of Auto-ID fits more into industries other than grocery. It is advised that benefit studies be conducted in aerospace, automotive and/or electronics industries to get a idea of the savings from areas such as WIP tracking, as well as new areas of benefits overlooked in this project.

- Due to time and resource restrictions, the case studies undertaken in this project could not be extended beyond the UK. It is recommended that these studies be extended to Europe and America to ensure differences in supply chain are tackled.

- Though most of the benefits identified are a result of product-level tagging, a number of manufacturers are considering restricting the application of tagging (at least in the initial stages) to pallet-level tagging. The significance and feasibility of this should be analysed in an appropriate manner. Results from the different phases of the town test may be used for this purpose.

- It is speculated that a number of the benefits from tagging could be achieved from selective tagging of products, either just promotional items, or a few products per tag. The feasibility of such statistical tagging should be explored further.

6. CONCLUSIONS

The following are the main conclusions from the project:

- Barcodes are currently used to amass significant amounts of data, but the data is difficult to collect, is not real-time, and cannot be easily analysed to improve productivity within a manufacturing company.

- Auto-ID technology has tremendous scope in extending the benefits of automatic identification and data collection.

- The main benefits for the case study companies (Unilever and Gillette) seem to be from improved on-shelf availability, automated proof of delivery, and increased security.

- The magnitude of benefits to manufacturing companies is lower than for retail companies due to less handling at the unit level.

- Benefits to manufacturing companies do not necessarily arise from their internal operations. For example, improved on-shelf availability will come through improved retailer operations, but will benefit manufacturers through improved sales.

- Information required for the evaluation of short-term benefits has been identified.

- A methodology for conducting further benefits studies for manufacturing companies has been proposed.

- Some of the main concerns among manufacturing companies have been identified and collated, along with recommended next steps for the Auto-ID Centre.

- Delay in implementation of Auto-ID may reduce the 'pot of gold', i.e. other technologies may improve current situation, reducing the potential benefit from Auto-ID.

7. APPENDICES

7.1. Project Timetable

Table 5: Project Timetable

OBJECT	DISCRIPTION	CONTACT	FROM	BY WHEN	STATUS
SCOPING STUDY	Initial scoping of the project and preparation of brief	Duncan, Kevin	26 March	30 March	Complete
UNDERSTAND TECHNOLOGY AND CURRENT POSITION	Understand WalMart case development	Yun	30 April	4 May	Complete
UNDERSTAND TECHNOLOGY AND CURRENT POSITION	Identify key contact points in company	Kevin, Duncan	N.A.	4 May	Complete
UNDERSTAND TECHNOLOGY AND CURRENT POSITION	Develop process of benefits identification	Yun	30 April	11 May	Complete
IDENTIFICATION OF BENEFITS	Develop initial list of applications/uses within the company, and possible (near term) benefit areas	Unilever	4 May	11 May	Complete
IDENTIFICATION OF BENEFITS	Visits to Unilever to collect basic data	Unilever	11 May	18 May	More Reqd.
EVALUATION OF BENEFITS	Prepare and send data request for performing quantification	Unilever	11 May	18 May	Complete
EVALUATION OF BENEFITS	Collect detailed data from Unilever	Unilever	18 May	1 June	More Reqd.
CONSOLIDATE, PRESENT & REPORT	Consolidate material and cover gaps (through further visits)	Unilever	23 May	8 June	Complete
CONSOLIDATE, PRESENT & REPORT	Present to Auto-ID Board	Unilever	N.A.	13, 14 June	Fixed
CONSOLIDATE, PRESENT & REPORT	Prepare project report	N.A.	11 June	13 June	Complete
CONSOLIDATE, PRESENT & REPORT	Present to Unilever	Kevin, Duncan	N.A.	15 June	Fixed

7.2. Contact List – Auto ID Center

Table 6: MIT Auto-ID Center Contact List

NAME	POSITION	ROOM
BRENDON LEWIS	PML Simulation: Distributed Modelling (PhD)	1–007
BROOKE PETERSON	Head of Communications	3–449f
CHING LAW	Tracking Server (PhD)	1–107
DAN ENGELS	Program Manager	3–449d
DAVID RODRIGUERA	Sanjay's Assistant	Bldg 35
DEBORAH MOORE	Local Networking	3–436
JIM WALDROP	Local Servers	3–436
JOE FOLEY	ONS (PhD)	3–436
KEVIN ASHTON	Director	3–449a
ROBIN KOH	Ex-Pepsi Co; P&G and Gillette cases	5–020
SANJAY SARMA	Associate Prof.; CAD/CAM; Manufacturing & Supply Chain	Bldg 35
SILVIO ALBANO	Program Manager for Town Tests	N.A.
STEPHEN HO	Warehouse Observability (PhD)	1–007
TIM MILNE	PhD: PML	1–007
TOM SCHARFELD	RF Physics	3–436
TRACY SKEETE	Administrator	3–449
YUN KANG	Supply Chain Integration (PhD); Business Cases	5–020

Table 7: Cambridge Auto-ID Centre Contact List

NAME	POSITION
ALAN THORNE	Program Manager
ALIA ZAHARUDIN	MET-II
CHIEN YAW	MET-II
DUNCAN MCFARLANE	Research Director, Cambridge Lab
JIN-LUNG CHIRN	PhD.
MENG-HAN KOUK	MET-II
NIRAV CHOKSHI	PhD: Holonic
STEVE HODGES	Senior Industrial Fellow
VIVEK AGARWAL	MET-II
YOON CHANG	Senior Industrial Fellow

7.3. Contact List – Unilever & Gillette

Table 8: Unilever Contact List

NAME	DEPARTMENT	LOCATION
ALEX RUMBLE	Customer Supply Chain Manager: Tesco	Crawley
BERND OLEJAK	Bestfoods Customer Service Centre	Rotterdam
CATHY DRISCOLL	Sales: Customer Supply Chain Sainsbury's/ Morrison	Crawley
CHRIS FIELDHOUSE	Michael's secretary	England
DAVID ANDERSON	Demand manager	Crawley
DAVID SCHWARZ	Logistics	Crawley
DONNCHA SCOLLARD	Director of Digital Futures Lab (main Auto-ID contact)	New Jersey
GRAHAM HOULDER	Foods Packaging	Vlaardingen
HELEN WINANDY	Finance (ECR cost model)	Crawley
HUGH CLARE	Production Engineering	Port Sunlight
JOSHUA GREEN	MSc Logistics & SCM	Port Sunlight
KATRINA WALSH	Sales: Customer Supply Chain Asda	Crawley
MAURA WELCH	Distribution	Peterborough
MICHAEL CLARK	Principal Technologist: Corporate Research (UK contact)	Bedford
NEIL GARLINGTON	Customer Management: e-solutions	Crawley
NICK PARTRIDGE	Graduate Trainee (was placed at Asda-Walmart)	Crawley
SANDRA YATES	Team Leader for Sy. Ch. Mgrs.	Crawley
SARAH BAXTER	Warehousing	Peterborough
SIMON CHANDLER	IT; Soup vending	Crawley
TOM LAWRENCE	Sales	Crawley
VIC BENNETT	Logistics: Distribution Ambient & Peterborough	Crawley

Table 9: Gillette Contact List

NAME	DEPARTMENT	LOCATION
ALISTAIR JOHNSTON	N.A	N.A
CHRIS STANLEY	Supply Chain – W/H	Hemel Hempstead
COLIN MATTHEWS	Warehousing	Hemel Hempstead
HANS JÜRGEN HAJEK	Supply Chain – DRP	Isleworth
JAMES WALKER	Production Supplies Manager	Isleworth
MICHAEL STELZER	Manager, Pack Centre	Hemel Hempstead
JEREMY DERBYSHIRE	Production	N.A
PETER NWOSU	Accounts	N.A

7.4. Contact List – Miscellaneous

Table 10: Miscellaneous Contact List

NAME	ORGANISATION
TARUN PATEL	IGD
PETER DAVEY	IGD
DR CAROL D. DANIEL	CEST
MARTIN SWERDLOW	IPI
JASON GARDINER	Tibbett & Britten UK

7.5. Non-Confidential Meeting Notes

When/Who
04/6 Martin Swerdlow (IPI)

Main Points
– Benefits seen in a number of areas, but not aware of any extensive study
– IPI working on some implementation projects in aerospace, paper, etc., but confidential
– Important to note that acceptance of barcodes is only 40% in industry (claimed by EAN)
– Metal and liquid environments pose trouble to passive tags; future may be in active tags
– Barcode and RFID are complementary not substitute technologies
– Growth has to be driven by the front end (users)

When/Who
07/6 Jason Gardiner (Tibbett & Britten)

Main Points
– RFID has three main functionalities over barcodes
– Can scan many tags simultaneously
– Can read and write on tags
– Don’t need line of sight
– Accuracy of information with tagging is very high
– The information is on the product itself, which has its advantages
– The main issues with the adoption of tagging are cost, integration and regulation
– Waitrose has tried some variations to RFID, namely audio and smell based technology
– The more nodes there are in any process the higher the benefits from tagging
– Tagging can enable active management as opposed to reactive management

7.6. Non-Confidential Visit Notes

When/Who

21st May, 2001, IGD, Letchmore Heath, Watford, Herts, WD25 8GD,
Closest station: Watford Junction www.igd.com; Tel: 01923 851 141

Meetings

TARUN PATEL
Senior product manager
– IGD not actively researching tagging
– An initiative was started with EAN but IGD not playing any further role in it
– EAN set up e-centre which is looking into tagging
– www.e-centre.org.uk; Tel: 020 7655 9000; Help line: 020 7655 9001
– Referred to Integrated Product Intelligence as doing some good work

PATER DAVEY
Business unit Manager supply chain
– Been at IGD only 2 months; prior experience in supply chain with retailers
– Part of working group on ECR Europe Out-o-Stock (OOS)
– Shared some presentations on OOS at recent convention in Glasgow, with some useful OOS data

Information Source (Library)

CONTACT: SHIRLEY
(Tel: 01923 851 927)
– Categorised library with articles, press cuttings and industry reports
– IGD publishes a number of reports – for synopses see:
– http://www.igd.com/homepage.asp?AreaID=30&SubAreaID=47&PageID=62
– No reports relating to tagging
– Some useful reports for Unilever
    – Guide to B2B exchanges (Why join an exchange? Do I have a choice? What services do they provide? What are the risks of not becoming involved? These are just some of the questions answered here)
    – Guide to E-commerce – Business to Consumer (Provides an impression of what business to consumer E-Commerce may hold for the future of the food and grocery market)
    – Account watch reports on a number of major retailers (good source of information for Customer Supply Chain Managers at Unilever)

7.7. Useful Information Sources

Table 11: Useful Sources of Information

AUTHOR	TITLE	DETAILS	RELEVANCE
ANDERSEN CONSULTING	The retail problem of out-of-stock merchandise	Study for Coca Cola	Out of Stock Study
BRUCE P	Barcode and EDI – "the right stuff" for consumer goods manufacturers	Automatic I.D. News, 14(4), pp 46–47, April 1998	Barcodes
FISHER M.L.	What is the right supply chain for your product?	HBR, Mar/Apr 1997	Supply Chain
JOSHI Y.V.	Information visibility and its effect on supply chain dynamics	Thesis in partial fulfillment for Master of Science from MIT	Supply Chain Management
LEE, PADMANABHAM & WHANG	The bullwhip effect in supply chains	Sloan Management Review, Cambridge, Spring 1997	Bullwhip
LINDAU AND LUMSDEN	The use of automatic data capture systems in inventory management	Intl. J. of Production Economics, Vol-59, pp 159–167, 1999	Inventory
MANAGEMENT HORIZONS	Supply Chain Integration - Retail Best Practice	N.A.	Supply Chain Management
MOORE BERT	Bar code or RFID: Which will win the high-speed sortation race?	Automatic I.D. News, 14(7), pp 29-30, June 1999	Barcode vs. RFID
SCHARFIELD, SARMA & ENGELS	Review of RFID technologies	To be published (Auto-ID Centre, MIT)	RFID technologies
SWAMIDASS P.M.	Bar code users and their performance	Unova Inc, July 1998	Barcodes
YAO AND CARLSON	The impact of real-time data communication on inventory management	Intl. J. of Production Economics, Vol-59, pp 213–219, 1999	Inventory

7.8. Useful Organisations

Table 12: Useful Organisations

ORGANISATION	LINK	COMMENTS
ACHIEVING SUPPLY CHAIN EXCELLENCE THROUGH TECHNOLOGY (ASCET)	www.ascet.org	Useful articles on Auto-ID and other supply chain technologies
AUTO-ID CENTRE, MIT	auto-id.mit.edu	Merging the physical world with the information world
AUTOMATIC IDENTIFICATION MANUFACTURERS (AIM)	www.aimglobal.org	Extensive information source on Auto-ID technology; some articles on applications of RFID
CENTRE FOR EXPLOITATION OF SCIENCE AND TECHNOLOGY (CEST)	www.cest.org	Set up to improve collaboration in industry
E-CENTRE UK	www.e-centre.org.uk	Up-to-date e-commerce developments in the UK
EUROPEAN ARTICLE NUMBER (EAN)	www.ean-int.org	Establishing global multi-industry system of identification and communication for products, services and locations based on internationally accepted and business led standards; developing the EAN-UCC system
INSTITUTE OF GROCERY DISTRIBUTORS (IGD)	www.igd.com	Good publications on logistics and distribution for the grocery industry; useful summaries on major retailers; library archives some good articles
INTEGRATED PRODUCT INTELLIGENCE (IPI)	www.ipi-uk.com	Consulting firm broken off from CEST
UNIFORM CODE COUNCIL (UCC)	www.uc-council.org	Serve the business needs of its member companies through the development of user-driven and user-tested standards and solutions

7.9. Checklist of RFID Benefits (OMRON)

Area: Manufacturing

BENEFIT

– Vital information can be encoded either directly onto products, or onto the containers that will transport the products through the supply chain. This information can include product identification codes, batch numbers, sell-by dates, destination codes, and also special instructions.

– Enables fast and accurate inventory management within a manufacturer's warehouse

– Provides significant benefits within the dispatch process

Area: Distribution

BENEFIT

– Distribution Centres are very bust environments that can benefit greatly from automated processes.

– Enable the accurate and efficient automatic bulk reading of products or containers, in oth the goods-in area, and also within the dispatch area

– Improved unloading and loading times of transportation vehicles

– Elimination of time consuming manual scanning associated with other identification systems such as barcodes

– Flexibility of being able to automatically update or change vital information contained within the RFID tags

Area: Corporate

BENEFIT

– Management of the supply chain is an increasingly important function for major retailers

– The ability to speed up, or delay, the shipment of goods from the point of manufacture to the retail point of sale, has become an essential operational function in efficiently matching supply and demand. To achieve this function, good quality and accurate data acquisition is required, without increasing costs or processing time within the distribution process.

– RFID can significantly improve data acquisition by providing efficient automatic bulk identification of products or containers at strategic points throughout the supply chain. It provides automatic and accurate real time information to corporate SCM software applications, and addresses the increasingly important issue of product traceability.

Source: Adapted from CEST web site information

7.10. Checklist of RFID Benefits (CEST)

1. **Benefit – Reduced inventory**
   From optimal product mixes, delivery frequencies and times

2. **Benefit – Improved productivity**
   Through JIT, information sharing and location data

3. **Benefit – Reduced fraud and increased security**
   As property can be tracked and access controlled

4. **Benefit – Better service**
   By fully informing the customer and adding value to products

5. **Benefit – Reduced direct labour and transport costs**
   Dynamic route planning, direct delivery and efficient packing

6. **Benefit – Improved asset management**
   Uniquely identify assets to reduce cost and manage asset lifecycle

7. **Benefit – Improved customer and supplier relationship**
   Web-enabled interfaces and transaction processing to improve efficiency and reduce labour costs

8. **Benefit – New business opportunities**
   From remote access and control of products and processes

7.11. Example for Summary of Information Required

General
- Details of any previous work done of RFID within the company
- Main contacts for supply chain, technology, accounts, production, warehousing
- Current supply chain of products
- Level of product traceability in the supply chain

Production
- Number of plants; their location; any product focus; outsourcing
- Production volumes from each plant (broken into products)
- Production stoppages due to unavailability of raw materials
- Level of standardisation of production process
- Method for order procurement and management
- Typical order cycle times (split between information and material flow)
- Any continuous replenishment process?

Warehousing
- Number of warehouses; their location; any product focus; outsourcing
- Volume of product flow through warehouse
- Floor area available and volume capacity in each warehouse
- Inventory holding costs (for owned and rented warehouses)
- Stock turnover level

– Pound savings from, say, a 20% reduction in inventory
– Warehouse handling costs (labour)
    – Unloading/loading
    – Scanning and verification during goods-in and despatch
    – Stock checking
    – Picking
    – Average shelf life of products, and shelf life requirement from retailers
– Warehouse Management System (WMS) used

Transportation
– Level of inter-site movement of goods (say between two Gillette warehouses)
– Transportation costs (per shipment)
– Volume of returned goods from retailer
– Procedure for recapture of returned goods into WMS

Market Mediation
– Current levels of shrinkage (value) from each stage in supply chain
– Cost of invoice adjustments due to lack of proof of delivery at retailer
  both cost of goods and associated man hours involved)
– Frequency of promotions on products
– Accuracy of promotion sales forecasts
– Level of stockouts on supermarket shelves
– Cost of stockout (how loyal is the customer?)