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RFID- A Catalyst for supply Chain performance

Paper within Master Thesis within Logistics and Supply chain management

Author: Alagendran Lakshmanan

Tutor: Susanne Hertz & Benedikte Bergström

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Yours sincerely,

Alagendran Lakshmanan

1 Introduction

Radio Frequency Identification (RFID) is one of the most spoken emerging technologies in the business today. It has made a radical change along the links of the supply chain management around the world. The advantage of RFID presents a clear roadmap for implementation and adoption by manufacturers, distributors, retailers, and suppliers. This wireless technology is continuously growing and diversifying its application in this seamless digital world. Managing physical resources will be as efficient as moving bits in the digital world of information systems (Strassner and Fleisch, 2003). The "*networked physical world- is a world in which all objects carry digital information about themselves*" (Engels, Foley, Sarma & Brock, 2001).

RFID has its significance way back from World War II, the technology was used initially by military aircraft identification and later the application of the technology has taken a wide spread over the decades in various industries for its own economical cause (Spekman & Sweeney, 2006). In the last decade the technology as gained rapid significance due to miniature of the RFID tag, very low production cost, evolution of the information system, need for flexibility in the supply chain and many more factors adds to its significance. The technology of radio frequency identification (RFID) enjoy an enormous interest at the current time, not only from the standpoint of research but also from corporate practice.

The implementation of RFID has been a current trend in the 21st century in the retailers market, where the retail giants like Wal-Mart who wants to implement RFID with all its suppliers worldwide to automate its operation (Spekman & Sweeney, 2006). This technology also demanded by the US department of defence to implement it with all their suppliers and this trend started creeping into the necessity of this technology with their entire supplier's manufacturing segment. A study made in the University of Arkansas showed a 16 percent saving from out of stock items at RFID enabled stores (Spekman & Sweeney, 2006). The company like Wal-Mart could save up to 1 billion $ by their stock out in a year by sharing the point of sale information to its suppliers, which is done without any human intervention. This information is then retrieved in the upstream of the supply chain for their production scheduling, inventory and procurement purpose. So the necessity of this technology has become inevitable to stay competitive in the future business.

Enterprises from diverse industries are implementing the RFID technology in various applications to solve the wide range of management problems. This enables them to increase the process efficiency along the various stages of the supply chain. On comparison with the technology constraint of barcode for identifying the information about the object, the RFID is gaining competitive advantages in recent time due to its unique functional capabilities and instrument cost.

RFID became the next evolutionary step in Automatic Identification Data Capture (AIDC) technology. Its strong identification capabilities and tracing abilities make it possible to synchronise the physical flow of components/products and the related information flow without human intervention along the supply chain. This integration of the material flow and information flow in the business functions is considered as internal supply chain by Harland (1996). This technology provides various benefits for a variety of application across the life cycle of the product. This RFID provides a key tool in aiding the distribution of the product along the various process stages, right from the raw material to the end of the product life. The information flow pattern is networked in a structural fashion involv-

ing high degree of visibility, accuracy in information flow. Thereby eliminating human interventions and increasing the level of automation, enhancing the process efficiency, improving agility and responsiveness through end to end process integration through out the supply chain. In order to enhance the operation efficiency and data entry accuracy, enterprises have been continuously devoted in assessing various applications of the RFID technology in shop-floor control, logistics management & merchandise tracking, production flow control and supply chain management (Hou and Huang, 2006). RFID technology is increasingly "bridging *and even closing the gap between the physical flow of components/products and information flow in conventional manufacturing"* (Lu, Bateman & Cheng, 2006)

The latter RFID application has lead to the Real Time Location System (RTLS) of the object. The physical movement of the object carrying the tag makes use of the RFID signal strength measurements or other sensor information, in a complex manufacturing environment can locate arbitrary physical objects within their operation Zone (Borriello et al., 2005; Hazas et al., 2004; Sorenson, 2003). "*The RTLS provides a continuous stream of location data , which enables us to visualize the physical movement of the object in real time during the production process involving very low automation levels"* as discussed by (Piggin and Brandt, 2006) and also by (Thiesse and Fleisch, 2006). This technology is making a significance improvement in the performance of the internal production logistics in the supply chain. It prevents the human error involved in performing the process thereby enabling a high degree of process control flexibility along the chain.

As these actions and technology play out, the list of promises and problems continue to grow along with the innovation, as does the need to better understand what RFID is all about. RFID Strategic Implementation and ROI will help the reader comprehend the basics of RFID, the fundamental technology and components, the potential applications and business issues, and the marketplace forces at work in front of and behind the scenes. So implementing this technology effectively with all the necessary attributes, that suits the selected company based on their product, may improve the process efficiency and add value to their product along their supply chain.

1.1 Background

The practical relevance of the RFID implementation study will be examined in a Swedish firm, who are pioneer in manufacturing of mass customized motor furniture. The company is located in Jonkoping Sweden. In order to understand the nature of the company's product and their supply chain aspects, here is a short description of the selected company R about what they do?. The company R is a part of its Parent group company located in different premises inside the same locality, where the parent company is one of the leading international store fixture suppliers, whereas the selected company R specializes in the development & manufacturing of height adjustable table and also manufactures many ergonomically designed motorized furniture. It was established three decades back and now it is grown as a leading manufacturer in this field of motorized furniture. Their product variety has grown to almost 4000 products with majority of it involves high degree of customization so called 'costume made product'. The motorized table stand include columns, feet, actuators, control box and desk panel for various design of table tops, a free standing unit or as a part of an integrated system. This modular concept offers flexibility and fast assembly. The majority of the products are designed for the corporate needs. The major customer includes furniture retailer who have wide market in different geographical location and they have wide supplier's network from Asia and Europe.

The group annual turnover for the last financial year was USD 140 million. They are supplying to majority of the Scandinavian market and they manufacture more than 100,000 tables per annum involving customer driven supply chain, logistics and packaging to all clients. They have the core competence in their research and development of new product with all the best practices that industry has created. Above all their business idea is "powered by innovation" where the R team is ready to grasp innovation in all field and means which adds value to their product.

The company R as an efficient supply chain network well maintained by dynamic and a proactive supply chain manager Mr. Nicklas sahlquivst, who is going to guide me for the implementation study of RFID technology in their product. The in-house production of the motorized table is a semi automated production assembly involving high degree of integrated process flows for its products. The company's implies various work flow strategies based on its demand patterns for its specific product. The R's process offers complete transparency and keeps clients informed of the project status at all times is one of their main operational objectives. So by implementation of RFID information tag may prove the company's operation objective by adding more visibility to the information flow in their supply chain.

The company R being a manufacturing company for the furniture, in this industry most of the manufactures doesn't have the most essential feature of after sales service, where as the company R has always shown its competence than its competitor in the area of after sales service. The salient features of after-sales service of the company R include

-Technical help Desk. s

-Centralized spare part stocks for fast delivery.

-Tailor-made service contracts.

-Preventive maintenance contracts.

So the manufacturing company R is a company with lot of commitments to its customers and this commitments made through contract can also be digitalized, which adds another scope for the necessity for information Tag implementation. Further, details of the company's R process are discussed in detailed empirical findings for the implementation study.

1.2 Problem

The evolution of this technology in recent times has made significant application in various industrial fields. The necessity to know its functional advantage and its implementation procedure in the current system of practice is becoming a great challenge. The adaptation of this technology and the cultural changes, which the management has to work on, to leverage its benefit is one such vital problem, where many industries are facing today. As more and more the technological advancement is growing on a rapid pace and reduction in the RFID chip cost is drastically decreasing, the need for the exclusive technology based on their reliability is always been a more expensive factor.

The other major problem that the company would be facing will be in the selection of the right type of tag depending on the various industrial sectors. Some of the major issues addressed by Lu, Bateman & cheng (2006) are the quality of tag identification depending on the environmental condition, the material of the product, standardisation and integration. These issues raise a big question on the reliability and functionality of the RFID technol-

ogy. Many researches are carried out in this field, to make the technology more reliable. Considering the present study of implementing process, the choice to go for the latest invention may involve high cost of tag in terms of investment. Further there are many more technological barriers even in the commercialized technology, like tag information storage issue, tag fixing, tag reader related issues, antenna related issue, host system and its integration are detailed in the theoretical section.

The proximity of the sensor (RFID Transponder) is also a technological constraint in reading the object. Since the company R is first to implement this technology in their supply chain, none of their major customers currently are involved to ripe its benefits. When this technology is extended to the downstream of the R's supply chain, the standardisation of this technology is another issue which has to be synchronized (Lu, Bateman & Heng, 2006). According to Lu, Bateman & Heng (2006) many organisations like ISO/IEC (International Electro technical Commission), ETSI (European Telecommunications Standards Institute), EPC Global (Electronic Product code) and Ubiquitous ID Centre are working on unifying the product code of the tag so that the technology has standard interface between elements internationally. The specific function of each organisation is explained in detail in the theoretical section to have the better understanding in choosing the technology.

1.3 Purpose

The purpose of this thesis is how to adopt RFID technology for the selected firm in the internal supply chain process and discuss its implementation issue. The thesis explains the practical difficulties that one will encounter in the implementation and to bring a customised solution for the selected firm.

1.4 Delimitation

The implementation study of this RFID technology is going to be inside the company R. The traceability of the product using this technology starts during the assembly and moves to the downstream of the supply chain, this means that the product cannot be traced from the upstream in the procurement and inventory of the product. The integration difficulties in the area of software with the current ERP system will not be dealt.

2 Research questions

- To identify where this RFID fits into the current process to deliver the potential benefits?
- To select appropriate technology in relation to the specific application and the salient features required in context to cost involved and ROI?
- What is its potential risk that the company has to foresee in the implementation process in the area of technological barrier and other implementation issue?

Under specification selection :

- ❖ The feasible System requirements for the successful RFID deployment?

- ❖ To find the practical solution for the product in the existing process flow of how to carry digitalised information through RFID tag? (Concerning the environmental and form factor of the product).

3 Methodology

The Fundamental Approach to the Research Question:

The ideology behind this thesis is to produce a comprehensive report for the managers and the professionals in the area of RFID implementation. In order to construct the comprehensive report with the practical insight, a qualitative literature will be selected which deals with the real time industrial solution.

The RFID implementation is not a ready to install solution, it needs a customised solution for each industry based on their product line. In order to obtain the customised solution there is a need for in-depth analysis and understanding of the current process and the work flow pattern in the interested firm. Based on the framed research question, the initial approach will be formulated by the examining the right choice of data collection (i.e. for process understanding). Once the in-depth understanding of the process flow pattern is done, a serious of analysis will be made in order to identify the critical path in the process flow. This is done in conjunction with technological benefit that RFID could bring and act as a value addition to the current process flow.

On identifying the critical path in the current flow, the next approach is to choose the feasible tag. Choosing the right tag and its corresponding information flow pattern plays a vital role in delivering its right benefit over a long run. This will be done by gathering information from number of international journals which deals with technological implementation issues, from white papers of RFID consultants and eminent authors who have explored the RFID potential and its technological insight. The approach behind in choosing the right tag will be dealt with the technological capabilities of the tag and also to give the wide practical adaptability for the users, when the tag moves in their downstream of the supply chain. Though this thesis doesn't consider the factors of their downstream chain members, the tag is chosen in order to leverage the maximum benefit for the users in the downstream. This would eventually turn effective to improve the efficiency and availability of the product information, thereby improve the whole supply chain in the long run.

The selection of tag and implementation alone cannot not eventually solve the stakeholders motive to go behind this technology, their needs a measurement to scale the benefit of this operation. So in order to answer the Return on Investment (ROI), a careful study of current performance of the company is made through qualitative approach by interviews with the supply chain manager. This will drive serious of operation capabilities that needs to be improved in the current process flow. Though the operation capabilities may involve wide activity which may be out of scope of RFID benefits, identifying the key improvement tool which can be resolved by RFID benefits serves as a Key performance indicator. This indicator chosen will serve as a vital instrument in order to answer how the Return on Investment will be obtained for the share holders.

The following paragraph explains the in depth approach to the above logical explanation. As stated by McGrath (1982), Scandura & William (2000), the research question can be approached by triangulation, which can be employed for the purpose of research strategy, data collection or Measurements. It can be various forms of data collection in order to approach the research question. This can be through Literature review/Formal theory, Field

study (primary and secondary data), Laboratory experiment, Experimental simulation, Field experiment, Sample survey, computer simulation and judgement task as discussed by Scandura & William (2000). They also argue that the triangulation can occur in qualitative data (interview) and quantitative data (survey). In order to approach the research question and to obtain high validation, the author decides to triangulate various methods to obtain conclusion for the purpose. The methods involved in approaching this research questions involve literature review, field study and qualitative study.

The research process involves deeper literature review of the RFID implementation issue in various applications, understanding its technological barrier, followed by field study mainly by observation using mapping methods. The observation is carried out intensively to map the current process flow and to identify any bottle neck involved in the current information flow pattern. This observation is done on a prime motive to fit the RFID, which adds value and improves the efficiency of the whole system. This observation is then supplemented by the semi structured interview with the concern person who is responsible for the development of the supply chain process. As the implementation issue involves a wide number of factors to be considered, the collection of necessary data to answer the research question from the primary source collected was insufficient. This is due to the shorter term of the thesis time so the secondary source of data is also used in conjunction with the primary data collected. The secondary data are collected from the reliable source of RFID industrial practitioners. The detail research process of each methods are explained in the following paragraph.

The theory will be built upon the literature from international journals, white papers from the RFID solution providers and also from the website periodicals dedicated to the development of this technology implementation. This wide knowledge of study, from different background resources will give a comprehend approach to the problem practically. As to fulfil the purpose of this thesis, many industry case studies will be reviewed, So that the theoretical framework covers the wide factors for consideration for the successful deployment.

In the next approach the author will make serious of observation at the company site to track the process flow within the company. This involves many observation hours at site to understand the present process flow and its criticality involved. This is done by mapping process. The mapping is chosen as a vital tool in understanding the process flow of the product in the internal as well as external supply chain. On better understanding of the current process flow the mapping technique allows us to redesign the process in a better efficient way. The author finds that observation has no substitute and it also serve as a vital tool to provide a convincing solution for practice.

Further, in order to get the practical insight and the company motive to drive behind this technology, a serious of interview will be conducted with the supply chain manager of the company. The SCM manager is chosen in order to get the effective response and also to know the practical difficulties of the real time situation. This could be obtained from the person who is managing in real time and practically involved in decision making in the company. In the selected company, the choice to interview and get the precise and relevant information for the research question becomes the criticality to yield a practical solution. So this second approach will be a convincing part of the empirical findings which will further assist the analysis part. Furthermore, Merriam (1994) and Patton (1990) states that "*when doing a qualitative study, the best useful method of gathering information is to conduct interview*". Interviews are segmented into three different kinds such as structured, semi-structured and unstructured interviews (Lewis, Saunders & Thornhill, 2003). The researcher has predeter-

mined questions which are structured strategically in a order are covered under structured interview. (Lewis et al, 2003). The semi-structured interviews are conducted by giving the respondents some information about the situation and then predetermined questions are asked to the respondents. Based on the respondent's discussion with the researcher, spontaneous questions are asked which are not determined in advance and not as per the order too. Finally the third kind of interview is the unstructured interview which is informal, no predetermined questions are prepared.

The author has decided to follow semi structured interview, as this has the high flexibility for the interviewer as well as for the respondents to put forth their views and to get the precise answers for the predetermined questions. By this way author finds that both the respondents and the researcher have the similar interpretation in their perspectives.

Mapping method

On the observation part, in order to understand the process flow and to obtain the relevant empirical findings for the purpose of this thesis, the author decides to go for mapping the process.The general idea is to map the information flow pattern in the company from the product order to product delivery. Identify how the information flows for the product in respect with the physical movement of goods inside the plant. Examining the each process whether the information needs to be tagged and it serves vital for physical movement of goods, then listing out the no of activities involved in the whole process. Further analysing for any human errors involved and identifying the possibilities to increase the process efficiency. This is followed by exploring the necessity of data/information from the product, while it is in flow which initiates the system to react dynamically and increase the productivity. This exploration will lead to stream line the activities in the internal process flow and reveal the benefits of the implementation of this technology.

Finding right case and data collection

As the selected company has many product ranges in their sales portfolio, selecting the right product for the RFID fit and proving the impact of implementing this technology that could really boost the efficiency of the whole system was a challenging issue. By the above methods of approach namely observation and interview will eventually solve this issue. The product line is chosen based on the complexity involved in tracking the goods within the premises as well as in the customer's warehouse. The right case is chosen from a mix of both the approaches, where the questions are framed based on the benefit that RFID could bring to the selected product line and the practicality would be resolved by the observation.

The data collections for the research question comprise of two types, primary and secondary data (Scandura & William, 2000). The primary type of data collected by the researcher (i.e. author) involves direct observation at site and through interview questions. The secondary data's are gathered from the real time technical consultants, who have a top technical support with a wide installation across many industries. This would eventually solve the many issues in regard to practical difficulty involved in implementation. This resource of data's are chosen as a most effective resources for choosing the right type of gadgets based on its technical constraints, the features loaded, its market standardisation, upgradation of the technology, its sustainability and environmental conditions. These data's collected from the pragmatic solution provider will make the trail study, truly a realisable project for the selected company. An experimental study also will be conducted in order to see the real time trouble with the selected tag. This will eventually give a broader perspective of the implementation issue, which will conclude the purpose of the thesis.

4 Theortitical Framework

This chapter will first introduce the reader to the supply chain integration, mapping of the supply chain flow, RFID technology featuring its technical capabilities, data management architecture, adoption standards, application, potential benefit sand implementation challenges.

4.1 RFID Technology - a supply chain performer

The RFID technology aids to bridge the gap between the product flow and information flow in the supply chain integration. Radio frequency identification (RFID) is one of the most promising and leveraging the performance of the supply chain in recent years. The rapid development in this technology and its potential application across various fields is fast becoming a industry standard. In recent times there where many articles, analyst papers, organisation around the globe are working closely to bring a standard use of the technology. The success of this technology and to leverage its benefits across the supply chain in various parts of the world is hammered by the lack of pervasive standards in the area of technology adoption (Jakovljevic, 2004). According to Jakovljevic (2004) "early *adopters of RFID will be wary of locking into the wrong standards, a potentially costly mistake both in terms of time and money*". The theory will explain in depth detail of what to be considered in choosing the technology standard that will remain as a basic platform for many years to follow.

The theory also explains briefly how this technology works; describe their current standards, the compliance environment and the consideration to make sure that you have a successful implementation and to get the most return out of the investment. As this thesis is based on the technology implementation in a manufacturing environment, the theory will comprehend what manufacturers can especially benefit from RFID and how the technology can make internal processes more efficient and improve supply chain responsiveness. And also how RFID can provide immediate and tangible benefits that would bring to the entire supply chain. Thus making its benefit really a supply chain performer.

4.1.1 SUPPLY CHAIN MANAGEMENT AND INTEGRATION

The Institute for Supply Management describes Supply Chain Management as
"*the design and management of seamless, value-added processes across organizational boundaries to meet real needs of the end customer. The development and integration of people and technological resources are critical for successful supply chain integration*" (Wisner, Leong & Tan, 2006).

According to The Global Logistics Research team at Michigan University (1995), "*information sharing is the willingness to make a strategic and tactical data available to other members of the supply chain*"(Cooper et al in, Mentzer et al, 2001).

In addition, it is argued that sharing information such as inventory levels, forecasts, sales promotion strategies, mass customization and marketing strategies shrinks the ambiguity among supply members and leads to a better performance. So in the above definition it is made clear that the efficient management and integration is the primary motive to stay success in the business. The collection of data, efficient management of these data, linking of these processed data over wide supply chain members needs very high technological resources to perform a reliable integration.

The evolution of the internet and the computer era has automated much of the business activities in the name of e-commerce. This facilitated the speed of information sharing and the efficient management of this information within the supply chain. The activities that are exchanged between the channel partners are the "*information flow, physical flow, finance flow and trading flow*" (Yan, Zhixue & Juan, 2006). In the above four flows according to Yan ,Zhixue & Juan (2006) the information flow, finance flow and trading flow are well integrated into the network of information system, whereas the physical flow lacks integration in this network world.

An RFID enabled supply chain in one sense will, for first time, allow information and product flows to inter-relate as the "product" moves through raw material, manufacturing, distribution, retailing ,consumption, waste, and even recycling.(Asif and Mandviwalla,2005). In the traditional supply chain flow the information and the physical goods flow has been an independent of each other. Although the barcode has made a revolutionary to carry the information, the technological constrains of barcode is very less significant in comparison to RFID technology. So the recent technological advancement that could efficiently handle this enormous data is the success factor of RFID technology. The ideology behind the introduction of this technology is to collect the errorless data without human intervention. Where this technology can deliver an immense advantage while the product is on move and can add seamless value added information when the product moves across various partners in the supply chain.

According to Asif and Mandviwalla (2005), it is interesting to analyse the data form a pilot projects in complex organisation and completely map the flow of information (i.e. the information embedded in tag). On obtaining such a flow of information it helps to restructure the information flow in the area where the lack of information can prove vital in making decision. It also helps to increase the automation level in the flow when this information tag is carried along with the product.

Rai, Patnayakuni (2004) suggested a research model that maps, IT integration capabilities into supply chain process integration capabilities. This leads to enhancement of specific firm performance. To integrate physical, information, financial flow, IT provides infrastructure platform to enable integration (Asif and Mandviwalla, 2005). There by the RFID act as a prime integrating tool and bridges the integration to develop an intelligent Supply chain network.

4.2 SCM Technology FIT

4.2.1 Ability to secure

The information that is carried and shared among the channel partners needs a very high collaborative relationship; such relation can exist only by developing a long standing trust between partners in the supply chain. Though the information shared along the supply chain leads to the increase in the performance and efficiency of the entire supply chain. On seeing the other side of the coin there is always an uncertainty exist due to the fear of the exploitation of the information shared. So "*trust is important from a relationship point of view, from a technological point of view a company can attempt to protect itself from exploitation while maintaining an open collaborative system by its ability to secure SCM systems" (*Rupple, 2004*)* and she also argues that certain level of trust can be replaced by secured information using technological capabilities. Thus the adoption to the information enriched physical flow across boundaries

of different channel members can be played safe and this leads to the wide scope of using the SCM tool selectively across organisation.

4.2.2 Return on Investment (ROI)

The rate of return on investments depends on the sensible RFID strategy that one has to follow to reap the break even in the short run and to bring high value to the stakeholders in long run (Poirier & McCollum, 2007). The investment return can be yield from the range of benefits it offers. The visibility it brings in the supply chain to make a tactical decision. How far the RFID can change the supply chain dynamics for efficient performance?. The benefits include high level of information accuracy, high degree of visibility, reduction in labor hours, improved through put and many more associated benefits. But these benefits vary among the different members in the supply chain. Based on the scale of varying benefits and the total cost of ownership for deploying this technology, it results in a varying rate of ROI for each channel partners involved in the same supply chain. Thereby the ROI depends on the extent of exploitation of this technology, the level of usage of this information for the efficient operational management within each partner of the chain.

In order to realize the Return on Investment, it relies on the extent of the technology user, it needs a deeper understanding what this technology can bring in for the stake holders. This involves a strategic implementation process, so that it delivers and aids in efficient performance over a long run.

4.2.3 Sensible strategy

Before any technological implementation one has to understand clearly what this technology can bring into their specific business need. Rupple (2004) suggested that technology should not be implemented merely for technology's sake, but rather to meet the specific business objective. So a sensible strategy has to be framed for the RFID adoption into the existing business practice.

How to fit it in the current business process, such that it changes to efficient supply chain and increase its performance is the questioned to be answered sensibly. The implementers have to understand the current supply chain dynamics and the changes that it should bring for better performance. And such that these changes are in align with their business needs. According to Hildebrand (1998) suggest that *"the greatest advantage can be obtained, when the implementation of the technology is closely aligned with the business need"*. The strategy to measure the post performance in the efficiency of the various benefits that this technology is delivering should also be incorporated. Introduction of Key Performance Indicator (KPI) before and after commissioning of this technology will define a clear road map for the improvement process. This in fact helps to control the process efficiently.

Since this technology needs a custom fit for organisation to organisation, a trial run of the project should be tested repeatedly for the consistency in the technical difficulties. The deployment of this technology needs collaborative approach for all the channel partners, so that the supply chain as a whole can be developed. As there are many industry standards in the deployment of this technological the channel captain has to make a cooperative solu-

tion in choosing the right technology from right vendor and to deliver the required synchronisation between the channel members.

According to Poirier & McCollum (2007) has suggested some important factors that need to be considered while developing the strategy for the deployment of this technology. "

- *Enumeration of the costs, delivery enhancements, potential savings, and effect on customer satisfaction that will be influenced by RFID applications — making at least an order-of-magnitude assessment of the costs and benefits involved with execution across an extended enterprise*

- *Definition of the steps necessary to execute a meaningful strategy for RFID and its relationship within the greater business strategy, operating plan, and supply chain model being pursued — explaining to key stakeholders what the firm plans to do and how it affects current business posture*

- *Exploration of piloting RFID-enabled processes with selected trading partners to identify shared benefits, instead of limiting RFID pilots to processes that take place within the "four walls" of the organization*

- *Listing the functions and services that acceptance and deployment of RFID can bring to the business and its supply chain strategy — identifying where value can be added beyond satisfying key customer mandates including tactical and strategic issues*

- *Beginning documentation of the expected financial impact that will derive from an RFID deployment, starting with controlled experiments and pilot tests to provide meaningful metrics — getting your hands on what the future state might really look like and how it will affect profits".*

4.3 Supply chain performance and KPI

As mentioned by Gunasekaran, Patel, Tirtiroglu, (2001) *"measures and metrics are needed to test and reveal the viability of strategies without which a clear direction for improvement and realization of goals would be highly difficult"*. The performance measurement is a vital tool for evaluating the performance that RFID is making in the supply chain scenario. These performance measurements are to be clearly aligned with the operational objective of the business.

For any newly implemented system to indicate its performance, the evaluation of the system is necessary. This is done in a real time industrial atmosphere to indicate the basic performance factor, which is called key performance indicator (KPI). Reh (2008) defines KPI as

"*Key Performance Indicators are quantifiable measurements agreed to beforehand, that reflect the critical success factors of an organization.*"

There can be a multiple KPI level can be set, which differ form organisation to organisation depending upon their objective. According to Reh (2008) some of the important KPI that has to be measured in relation with RFID deployment is

1. The process improvement,
2. Efficiency of track and tracing,

3. The level of inventory visibility,
4. Reduction of human errors,
5. Reduction in lead time,
6. Reduction in stock outs.

As Reh (2008) mentioned that the KPI should be clearly defined of how this indicator should be manipulated and also it should clearly define for any exception involved and the factors to be considered and excluded. Once the clear definition has been identified the measurement has to be recorded with in depth detail of the condition in which the performance is measured. Finally a well defined quantifiable target should be set for evaluation or to assess the progress of the implemented system. As a whole the KPI should reflect the organisational goals and align the improvement process strategically towards it. This will serve as a vital management tool for the organisational success over a long term.

According to Bendavid, Lefebvre & Fosso (2008) has segmented the KPI as horizontal and vertical KPI. Where the horizontal KPI will provide an overall assessment for the entire supply chain on four major dimensions: "*Reliability, Responsiveness, Flexibility and Asset management efficiency*". The vertical KPI will provide a specific assessment for the particular member of the supply chain concentrating on the inventory cost at supplier level or minimum down time at operator level. They argue that the supply chain will tend to move towards the horizontal KPI on the grounds that only if the Supply chain members are ready to share the information from where they considered previously as business confidentiality.

4.4 INFORMATION SHARING

The major objective of the RFID is to serve the accurate data and provide an information enriched product. The information collected should serve to improve the performance of the supply chain.The performance of the supply chain can be improved by the level of information shared among the members. According to Yu, Yan and Cheng (2001) states that "*willingness to share information among supply chain members will increase the whole system's performance from information sharing*". They also argue that uncertainties caused due to unforeseen factors can be reduced by efficient information sharing among the member. The level of information shared and the transparency should be given the highest priority. When this happens, the different members of the supply chain act as a single entity thereby maximising the profit for the entire supply chain. Thus RFID can serve the purpose of information sharing at any point in the supply chain accurately.

4.5 Mapping

A good designed map communicates the knowledge and information and "*creates a basis for supply chain redesign or modification; construct a map to link corporate strategy to supply chain strategy; and assess current channel dynamics*" (Gardner & Cooper, 2003).

Why should a firm create an internal supply chain map?

According to Hines and Rich (1997), the compelling reason to create a map is to enhance the order planning process, ease the distribution of key information, it facilitates to redesign or modify the flow chain, it helps us to analyze and evaluate the current process, helps to bridge the communication gap between different levels in the organization and also pro-

vides knowledge and can act as a communication tool for the process developers to make the system to work lean.

Identifying the flow of process for each successive step inside the company's supply chain involves a string of operations or actions that are to be carried out in order to map the process. This sequence of operations should be well structured and legitimized, which in turn align with their corporate strategy of the company. The flow of these processes in the supply chain network is initiated by the information to act or proceed in performing the operations at each level. So every action in the supply chain flow is initiated by the information or data. In real time operation, the flow of product in the supply chain network to carry the information along with the physical flow became an essential factor. This ideology of coupling the product along with the information, initiates further chain of action and also triggers the system to react dynamically, when the product flows in the supply chain network. This enables a high degree of visibility and flexibility of the product when the product carries real time information coupled to it. So mapping plays an initial step to identify the current flow of activities that are in process.

" *when system analysts attempt to understand the information requirements of users, they must be able to conceptualize how data moves through the organization , the process or transformation that the data undergoes, and what the outputs are*"(Kendall and Kendall, 1995)

4.5.1 Process Activity Mapping

The process activity mapping has its origin form the industrial engineering. It is a group of techniques that can be used to "*eliminate waste, inconsistencies, and irrationalities from the workplace and provide high quality goods and services easily, quickly and inexpensively*" (Ishiwata, 1991).

4.5.1.1 Orientation

According to Gardner & Cooper (2003) "*the orientation of the mapping project can be defined as the focus of the mapping procedure*". They state that the process activity mapping directs its attention to a single operation or system within a company.

4.5.1.2 Level of details

The process activity mapping has a high level of details enriched with wide information involved in the process. Gardner & Cooper (2003) states that "*the process mapping tends to break down a process into a number of activities and steps*".

4.5.1.3 Purpose

The main purpose of the process activity mapping is to identify and recognize the problem area or a potential process, where an attempt can be made to improve operating efficiency (Gardner & Cooper, 2003). The objective of the mapping is to make effective changes in the current operation of the firm.

4.5.1.4 Significance of Process Mapping

According to Hines and Rich (1997) the process activity mapping has five stages, which are to be approached in developing the map. "

1. *The study of the flow of process*
2. *The identification of waste.*

3. *A consideration of the process, whether it can be rearranged into a more efficient sequence.*
4. *A consideration of better flow pattern involving different flow layout or transport routing.*
5. *A consideration of whether everything that is being done at each stage is really necessary and what would happen if superfluous task were removed".*

4.5.2 Physical Mapping in Manufacturing Environment

Once the efficient mapping is formulated, it helps us to identify the non value addition process and the value it adds in each sequential step during the process. According to Hines and Rich (1997) that the value stream mapping technique helps for several cross sectional analyses of the internal value chain, where the management can have a direct control over it. They also state that the vitality of the material to carry the information and the need for improvement and modification in the activity flow can be well understood. The elimination of the waste activities will helps us to understand the need for mapping the process and its significance.

Mapping the process activity will help us to determine the duration involved in performing each action. This determination of the duration will guide in analyzing for further process improvement in the supply chain flow. It also determines the level of human intervention involved in carrying out the action to perform and check for redundancy in the work carried out.

4.6 Functionality and Technical Insight

This chapter will first introduce the reader to the working principle of RFID, the components of RFID system, technical issues in choosing the RFID components. The major source for the technical information is from the white papers of Intermec technologies.

4.6.1 How RFID Works

RFID systems include tags, readers and software to process the data. Tags are the transponders which are usually applied to items, often as part of an adhesive bar-code label. This tag is of two types active and passive, where the passive receives power from the reader to transmit data and the active tag has its own power generation. Readers can be unattended standalone units which receives this transmitted radio signal from the tag/ transponders. The reader sends a radio signal that is received by all tags present in the RF field tuned to that frequency. Tags receive the signal via their antennas and respond by transmitting their stored data (Intermec, 2007). The tag can hold many types of data, including a serial number, configuration instructions, activity history (e.g., date of last maintenance, when the tag passed a specific location, etc.), or even temperature and other data provided by sensors. The read/write device receives the tag signal via its antenna, decodes it and transfers the data to the computer system through a cable or wireless connection. The model of a set of RFID system is shown in the figure 1.

The reader has to communicate with two systems simultaneously, one hand it has to interface with the RFID tag and the other hand it has to interface with the business network. The reader continuously receives data from the tag and sends the data for processing. The

reader can read multiple data from the number of tags at same time depending upon its operational capability.

The data received from tag are interfaced through its communication port to the host system. A middle ware is used to interface with the existing enterprise resource planning (ERP) or ware house management system or any business software application. This can be in either way interactive, that the information can also flow form the host system to the RFID tag when the information has to be encrypted into the tag. It is now apparent that this technology can communicate wireless, when the product is on move and change the status of the product while it is on move when it is within the receivable range.

The technical capability of the component can depend upon the manufacturer to manufacture based on the affordability and the additional features demanded. Today there are wide ranges of RFID components based on their operational ability. Here are some of the factors where the technical specifications vary for the different RFID components.

1. The range it can operate
2. The capacity to store data
3. The environment it can operate
4. The number of data it can receive simultaneously.

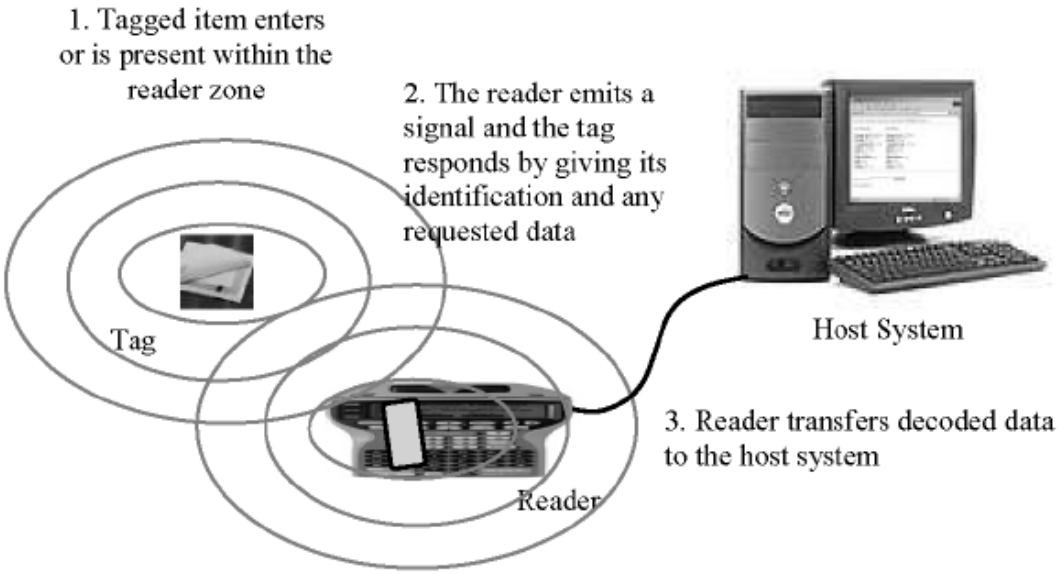


Figure 1 – Working principle of RFID Technology: (Lu, Bateman & Heng, 2006)

4.6.2 TAGS

RFID tags have two basic elements: a chip and an antenna. The chip and antenna are mounted to form an inlay shown in figure 2 .The inlay is then encapsulated in another material to form a finished tag or label shown in figure 3. The silicon chip can store large amount of data depending upon its capacity, but it quiet expensive. On the other hand less expensive chipless tag can offer several advantages when it comes to its application point of view. Due to the recent advancement in technologies the size and the range it can operate are increasing in its specification portfolio. These chipless tags are making their signifi-

cance very rapidly because of their enormous application in various field and very less manufacturing cost in compared to the other type of Tags

There are several technology used for chipless tags which includes inductive resonance and magnetic resonance. The inductive resonance type uses transistor less circuits made up of conductive polymers instead of silicon based micro chips. The magnetic resonance tag uses microscopic magnetic particles that are emitted from the reader (Asif and Mandviwalla, 2005). There are seamless innovations in the development of this technology for wide application around the world. The data stored can include product identification, expiration, warranty, handling and storage instructions, and service history.

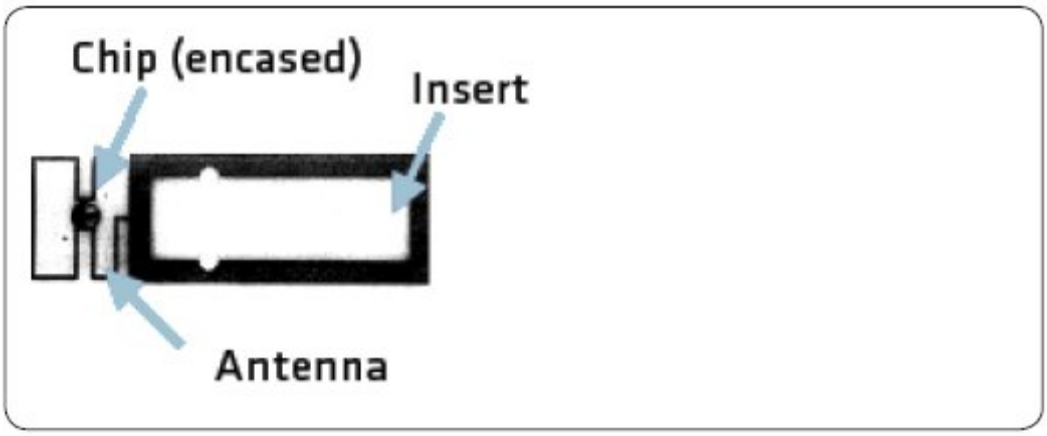


Figure 2 – Inlay RFID Tag components (Intermec, 2007)

The finally finished tag looks like as shown in the figure 3

Figure 3 – Finished Tag (Intermec, 2007)

4.6.3 Type of Tags

Various types of tags serve different environmental conditions. For example, tags suited to cardboard cases containing plastic items may not be ideal for wooden pallets, metal containers or glass. Tags can be as small as a grain of rice, as large as a brick, or thin and flexible enough to be embedded within an adhesive label. Tags also vary greatly in performance, including read/write ability, memory and power requirements (Intermec, 2007)

RFID tags also range in durability, depending upon the application and environment. Tags for permanent identification may be encased to withstand extreme temperatures, moisture, acids and solvents, paint, oil and other conditions that impair text, bar codes or other optical-based identification technologies. RFID tags can be made reusable and suitable for lifetime identification, thus yielding a total-cost-of-ownership (TCO) advantage over bar-code

labels and other disposable/impermanent identification methods. RFID tags can be either read-only or read-write (though the latter is now standard). Read-only tags are programmed at the factory with a serial number or other unalterable data. Data on read/write tags can be revised thousands of times. Read/write tags are often partitioned with a user-defined secure read-only area that may contain a unique ID number and a writeable portion of memory that users can freely reprogram.

Thus a user may permanently encode a pallet ID number in read-only memory and then use the read-write bank(s) to record items loaded onto the pallet. Then once the pallet is unloaded, the writeable section can be erased for reuse. For more information about read/write technology and applications, The Write Stuff: Understanding the Value of Read/Write RFID Functionality. Tags are also classified as passive, semi-passive or active.

4.6.4 Passive Tag

Passive tags, by far the most common, receive transmission power from the reader. All RFID smart labels are passive. They have chip and the antenna embedded in a tiny thin layer shown in figure 4. The Passive tags essentially reflect back the radio waves from the reader in order to communicate – a phenomenon sometimes known as backscatter (Asif & Mandviwalla, 2005). The power emitted from the reader is used for the tag's chip operation and also for the antenna to communicate.

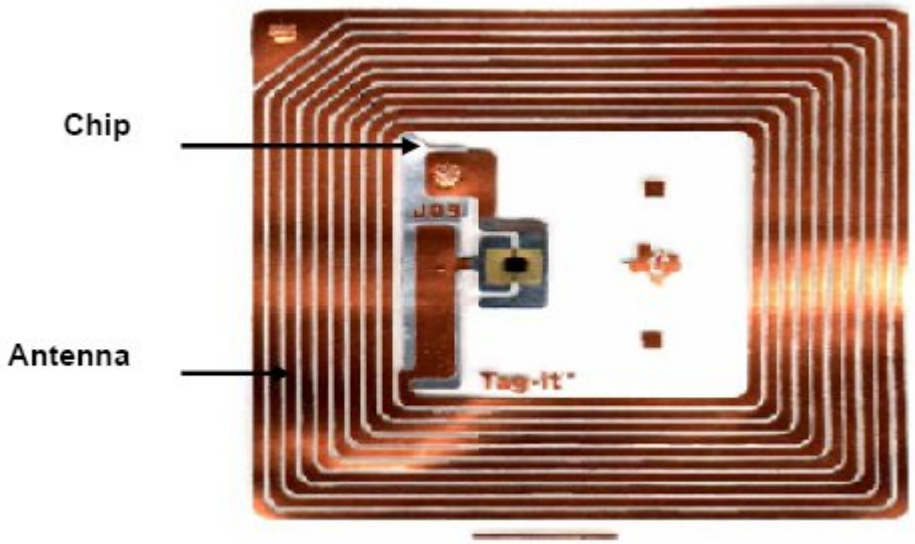


Figure 4 – Passive Tag (Asif & Mandviwalla, 2005)

4.6.5 Active Tag

Active tags include a battery for power transmissions in order to power the Antenna and the embedded chip. The main advantage of this chip is to provide a longer range. This makes active tags larger and more expensive than passive tags. The information can also be rewritten in to the tag and has the capacity to store large amount of data. The battery life in the active tag is generally around a year. (Asif &Mandviwalla, 2005).

Recently a very tiny miniature active tag has been invented where it has readable range of 300 ft, where the manufacturer claims that it can run for a year and can store information about three pages is shown in Figure-5. From the Intermec (2007), the main advantages of Active tag over passive tag are

- Enhanced dependability because of high performance
- Enhanced security/access control including theft reduction
- The ability to automate identification and location by removing human intervention
- Improved data integrity because of accuracy and reliability
- Improved read accuracy and longer read ranges
- Increased data transfer rate

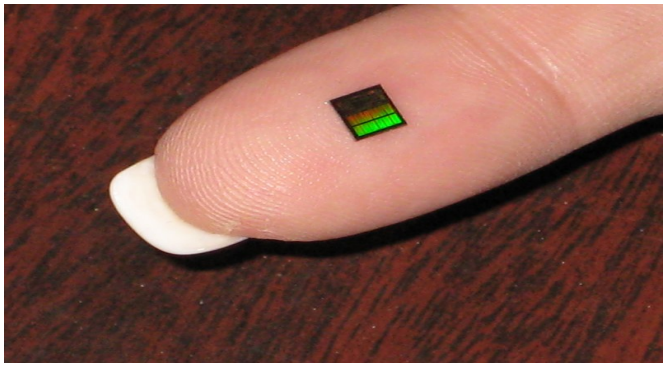


Figure -5 Smallest Active Tag , source- Axcessinc, (2008).

4.6.6 Semi –Passive Tags

Semi-passive tags communicate like passive tags but also have a battery. Their range falls between passive and active, and though their batteries have a long life, their size is comparable to passive tags.

4.6.7 Reader-Writer

RFID readers is designed for exclusively either for passive tags or active tags, this means that an RFID reader that is manufactured to communicate with active tags cannot communicate with the passive tags. But in fact the RFID readers can communicate at different frequencies for the same tag (Banks & Thompson, 2008). This act as an interface to send and receive information to the tag and it also interface between the host system (Object name servers).

The main technical features that RFID reader should be capable off is

1. Readable range (direct line of sight is not necessary)
2. Number of tags that it can sample in the tag population.

3. Frequency of sample taken per second.
4. The interoperability of the reader that it can communicate with wide business system.
5. It's operating atmosphere.

The readers can be mounted in various locations for example under floors or mounted on ceilings. There are several types of readers that can be incorporated into supply chain operations based on their need of application portable readers integrated with handhelds, readers mounted on vehicles/ forklifts, and fixed readers on dock doors and portals.

4.6.7.1 Fixed Reader

It is mounted on a close proximity to the tag depending on its range of the receiver. It is immovable as it is clamped to the wall or industrial rigid structures shown in figure-6.

Figure 6 Fixed wall mounted Reader (Intermec, 2007)

4.6.7.2 Portable Reader

It is a hand held device, portable one which carries a rechargeable battery, provides high flexibility and easy to track the right product in a rack of variety of product is shown in figure 7.

Figure 7 -portable hands held Reader (Intermec, 2007)

4.6.7.3 Fork-lift Mounted Reader

One of the most desirable implementations of RFID readers is mounting them on forklifts. This is widely used in the industrial atmosphere and ware houses. The advantage of forklift mounted readers is that they are typically fewer forklifts in a facility than dock doors, so less reader are needed to cover a facility. Forklift mounted systems are portable so that they

can go wherever they are needed as shown in figure 8. The data collected can also be used to track the movement of goods as well as the forklift movement.

Figure 8 - Fork lift Reader (Intermec, 2007)

4.6.8 Antennas

Antennas are used both in tag/transponder as well as in the reader. It can come in a diverse range of size depending upon its technical factors. The operating range of the Antenna also depends on its gain. This gain determines the ability to focus the radio waves. The reader antenna which is operating under ultra high frequency (UHF) can be classified as circular-polarised or linear polarised antenna is shown in figure 9 (Asif &Mandviwalla, 2005). The circular polarised antenna receives and transmits signals at 360◦ degree angle in a circular fashion but it has very less sensitive to transmitter (i.e less operating range in comparison to linear polarised antenna). The linear polarised antenna have higher gain thereby it has a high operating range covering a narrow area.

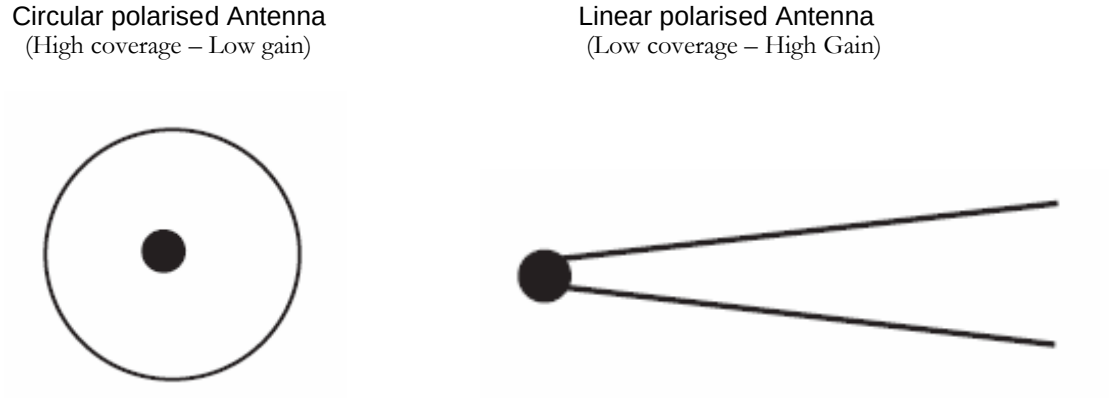


Figure 9 - Polarised Antenna (Asif &Mandviwalla, 2005)

4.6.9 RFID PRINTER

The RFID label embedded chip can be written using the RFID printer, where it can write the data into the chip shown in figure 10. This standalone printer can encode and print the RFID labels (UHF), enabling the tag to read at multiple frequencies (Intermec, 2007)

Figure 10 – RFID printer : (Intermec, 2007)

4.7 CHALLENGES IN IMPLEMENTATION OF RFID

Implementation of RFID to the current industrial practice is not a easy solution as you pick an office communication system and install it. Implementing RFID to cater its right benefit needs a custom fit for organisation to organisation. The technology implementation involves a significant technical issues such as the configuration of the antenna, its consistency in detecting signal, Environmental condition (interference of electromagnetic waves , absorption of the emitted radiation, its safety standards are the driving constraints),then interaction of the product material with tag material. The software related issues like choosing appropriate middleware to link to the current business system, provision for up gradation. The management issues like change management, choosing the right vendor, satisfying the stakeholders with the certainty of ROI, willingness to share information for effective supply chain performance are few of the major challenges for implementing RFID.

4.7.1 RFID COST

The cost of the RFID system is a major issue in the implementation of the RFID. Though the expenditure on the instrument costs is decreasing year to year, the complexity in deploying causes the major portion of the cost. The deployment of this technology is not the ready made application that it can reap the right benefits just by purchasing the RFID equipments. According to Li, Visich, Khumawala & Zhang (2006) argue that "Companies *need to explore opportunities in using RFID now so they can develop a business case for deploying RFID, correct mistakes in current processes educate and train workers, and phase in the technology"*

In order to explore the opportunities in using RFID it involves a price tag to view practically its benefits that this technology could bring in. The majority of the costs are driven towards exploring this technology in the form of merging this alien technology into the current business standards. The cost estimation for RFID deployment done by AMR research in Wal-Mart for its 50 million cases is estimated as per given in the table 1(Asif &Mandviwalla, 2005)

Tags and readers	$5M to $10M
System integration	$3M to $5M
Changes to existing supply chain applications	$3M to $5M
Storage and analytics of the large volumes of data.	$2M to $3M

Table 1 – Cost estimation for shipping 50 million cases. (Asif & Mandviwalla, 2005)

It is evident for the table 1 which shows that the majority of the cost adds apart from equipment charges This involves high managerial staff hours, evaluation of the deployed system for consistency, efficient middleware to communicate to the current business system (ERP or WMS), cost on system integration, data management, data security, software development to initiate intelligent chain reaction for the entire supply chain and software maintenance. These are the unpredictable cost in comparison to the cost of the hardware in long run. These behind process and the cost involved with it cannot be predetermined to any level of accuracy; this cost estimation can only be roughly figured for a pre hand calculation. This uncertainty of the predicted estimate causes the adoption uneasy and lack of confidence causes hesitation for implementation.

4.7.2 TAG Related Issue

The characteristic of RFID speaks about the technological capability of the system that the type of tag is capable off. The characteristics include frequency range, read range, tag size, ability to read data under condition of metal and wet environment, the amount of data it can transfer and data storage capacity. These characteristics differences decide which tag is suitable for the application and the amount of investment required depending on the enhanced characteristics of the tag. A consolidated characteristic difference between tags has been formulated by Tajima (2007), involving typical application of these tags in table 1.

The technical study states that the distribution of the electromagnetic waves is disturbed by the surrounding atmosphere thereby the readability of the tags is not perfect. So testing of the readability of the tag is much an essential part in deploying the RFID system. As Saran (2005) states that the supplier taking part in RFID trial would need to spend nearly £42,000 to test the readability of the tags. For any business application testing of the Tag readability in the different condition along the entire supply chain member is an additional cost taken into account.

(Lewis, Saunders & Thornhill, 2003 has also addressed some tag related issues which are to be considered for successful deployment of this technology. "

- *How to choose the right tags to fit different kinds of objects*
- *How to attach the tag onto an item needs to be researched from the viewpoint of application?"*

Along with the above issues, it is necessary to choose the tag on the basis of reusable or disposable type. In case of disposable tag the need for environmental friendly issues are also to be taken into consideration.

Operating frequencies and performance characteristics

	Low frequency (LF)	High frequency (HF)	Ultra high frequency (UHF)	Microwave frequency (MF)
Frequency range[a]	125–134 KHz	13.56 MHz	860–930 MHz	2.45 GHz
Tag type*[b]	Passive	Mainly passive	Active and passive	Active and passive
Read range (passive*)[a,b,c]	<0.5 m	1.0 m	3.0 m	10 m
Tag size (passive*)[c]	Larger	Larger	Smaller	Smaller
Data transfer rate[a,b,c]	Slow	Medium	Fast	Fastest
Ability to read near metal or wet surface[a,c]	Best	Better	Worse	Worst
Tag cost[c]	High	Lower than LF tags	Lowest	High
Typical application[a,c]	Livestock tracking, card-key access control, beer keg tracking, Exxon Mobil Speedpass	Airline baggage handling, library book tracking, electronic article surveillance	Supply chain tracking, warehouse management	Electronic toll collection, railroad monitoring

Table 2: Characteristics of Tags (Tajima, 2007)

4.7.3 Reader Related Issue

The reliability of the data collection depends on the receiving capacity of the RFID reader. The main issue addressed here is to find a common frequency where the entire supply chain members will coordinate to communicate with the tag or to find an alternate solution of having a reader which reads multiple frequency. To find the right answer, it involves better understanding and co ordination from all the supply chain members, this off course adds cost to the channel captain (i.e. first RFID adopter).

Lu, Bateman & Cheng (2006) has addressed some of the issues related to Reader selection which are to considered for successful deployment is "

- *Many manufacturers provide their own different readers to users, possibly leading to lack of coordination.*
- *External influences such as metal work , material dielectric properties and radio interference can constrain RFID remote reading*
- *A provision for multiple interface or standardised bus interface from the reader to the existing business system across different members has to be considered".*

Additionally there are further complexities that need to be looked insight in choosing the right reader. Banks & Thompson (2008) has addressed these insight issues in www.rfidnews.com

- When the reader goes offline or technical faults it must report to RFID support team with all the necessary last recorded information.
- The Reader should be able to report RFID tag events. For example when the tag enters or leaves the read range of the reader or the change of state should be reported to the application.
- The possibility for up gradation of the reader be located remotely using Ethernet or other means of wireless communication, which saves lot of time. Easy up grading strategy should be taken into count for the corporation before deployment in mass scale.

- The most key feature for the reader is to have the highest sampling rate in its tag population.
- The Reader should have multiple interfaces to communicate to the application system that can make use of this collected data. The most common communication interface that is used in today's technology are

    1. Serial – RS232 or RS422
    2. IP (Ethernet) – TCP or UDP
    3. USB

With above issues, one can get a clear understanding of how complicate the implementation process for deploying a single component of RFID system. This needs a high technical person who has better knowledge to integrate successfully into current business system. The integration of same proposition has to be applied across various members of the supply chain.

4.7.4 Frequency related issues

Frequency is the deciding factor at what range we want the tag to communicate. It determines the RFID range, Resistance to Interference and other performance attributes (Asif &Mandviwalla, 2005).The readable range of the different types of RFID tags and its technological constrains are given in the table 1. The main issue in deploying this technology when comes to frequency selection is that the interference of this radio waves with other communication system across the organisation. A common frequency has to be selected considering the environmental factor prevailing in different organisation across globe, who is involved in the same supply chain. The complexity to understand the fast emerging technologies, which may put the deployed technology out of date in future. These are the fearful question that the industry is facing towards deployment of this technology. According to Asif &Mandviwalla (2005), the Ultra high frequency (UHF) band is most common for supply-chain and Industrial-automation applications.

4.7.5 Range and Antenna placement issues

An RFID system's read range is the proximity that the tag is readable effectively under al circumstances that is prevailing locally to all the members involved in the supply chain. The placement of antenna subjected to 100 percent readable is the continuous trail process until an appropriate location is found. As detailed above in the frequency section the range depends on the operating frequency and environment condition. The practical installation procedure conducted at Amazon warehouse shows that though the antenna is provided within the readable range, the alignment or focus of the antenna pertaining to the particular case has to be determined at location (Shen, 2006). It shows that though the Antenna position is fixed according to the specification but in reality in order to have 100 percent readability, more antennas are fixed in the same spatial zone. The maximum range that frequency can operate is given under the table 1.

4.7.6 Standard

The lack of standard was a major concern in the industry during the evolution of RFID in a broad scale. Following a strong industry standard makes the adoption easy and the cost to come down for implementation. This was the major concern in order to follow industry wide standard across globe. This issue has been resolved to a certain extent recently by few standard organisations due to wide acceptance of many adopters to their standards. There are RFID standards existing for item management, logistic containers, fare cards, animal identification, tire and wheel identification and for many other applications (Asif &Mandviwalla, 2005). The list of RFID standard software organisation that is followed widely is

1. EPCglobal Inc.
2. ISO SC31 / WG4 / SG1
3. IATA Baggage Handling Group
4. Other Standards Organizations (ANSI,IETF, UPnp Forum,OASIS,DMTF,NFC)
5. Intermec Proprietary RFID Interface.

Each organisation is specializing in various applications. The most relevant for supply chain is the ISO and EPC global Inc. There vision is to provide a open standard so that the information will act neutral and the data can be exchanged across organisation boundaries. These standard data organisation also act as a neutral data carrier.

The information that can be shared via EPC standards are the information about when, what, where and why of the events occurring in any supply chain can be shared safely and securely(Epcglobal, 2008)

The need for EPC standard and many uncleared doubts about the benefit that this standard could bring are well answered in their FAQ's (Epcglobal, 2008). Some of the questions that answer the implementation issue are given below and the corresponding answers could be found in the Appendix 5.

1. Why use EPC standards over earlier RFID specifications?
2. What are the data elements in the EPC standard?
3. EPC data secured?
4. How might a sample implementation work for a small company?
5. How do I integrate the EPC interfaces with my existing systems?

There is always the cost associated with this standard, for each tag that EPC generating a unique code is sold at a cost. So thereby a detailed study is needed in order to adapt to this technology.

4.7.7 Middleware

It act as link between two components in the system (i.e. between the RFID devices and system software). Choosing the Right middle ware based on the application is quiet sophisticated. The responsibility of the middleware is to effectively filter the required tags information from the pool of information tag and to send this related data for processing. The

complexity in choosing further is further mobilized by the number of readers deployed, which needs a complex algorithm required to integrate into the existing Enterprise resource planning (ERP). Banks and Hanny (2007) has also argued that choosing the middle ware depends on the degree of integration and data management requirement.

4.7.8 Security

Though the information sharing is vital for the effective functioning of the RFID and to leverage its benefits across the supply chain members, the information has to be secured for any mishandling of information. The technology has been built with the sophisticated coding, which makes extremely difficult to counterfeit. The item level tagging ensures that each product is genuine and protected. The level of information shared among the different supply chain members can be authenticated depending upon the level of interest that each member is relied on with one another for information. Asif &Mandviwalla (2005) has also stated that "*different levels of security can be applied to data on the tag, making information readable at some points in the supply chain but not others*".

On adapters perspective one has to clear with the level of security that the product should carry when it moves in the supply chain. The complexity in software management in relation to secure the data for trust worthy members and for the new members remains a challenging issue.

4.7.9 Organisational Culture

The success of implementation of this innovative technology cannot be harvested over night. The need for cultural change within the organisation is one of the crucial factor in successful deployment. The acceptance of this technology, understanding its benefits need a structural and a strategic implementation under all level within and across organisation. The lack in innovation culture, fear of change in work environment, animosity and internal distrust in IT department are few cultural problem reported in the survey (Abbort, 2004).

4.7.10 Others Factors costing Implementation

The change in the organisational culture needs continuous training as the technology grows. The human resources have to be constantly upgraded with the up gradation in the technology. All this process of training involves cost. There is also an additional cost incurred for RFID consultants, relocation of staff, additional hiring and maintenance contracts (Smart, 2004). The licensing fee for subscribing with standard organisation for product code and for their data management. The organisation has to find right staffs that have the combined knowledge of software and business skills.

4.7.11 Vendor Selection

Choosing the right vendor determines the reliability of the support for the implementing firm in the future. The vendor should have the strong ability to deliver continuous improvement process and to have a global support. The industry may be segmented into

hardware, software, system integration, printing and service sector. Some operate in more than one sector (Asif &Mandviwalla, 2005). For more details about the vendors can be obtained from website www.rfidjournal.com or www.rfidnew.com.

4.7.12 Data Management Architecture

The deployment of RFID technology is quiet complicated when comes to maintaining the enormous data. The efficient management of these data to deliver the objective of the business process needs structured IT infrastructure. Many organisations in the field of IT have developed different architecture for the system deployment. Each architecture has its own advantage and disadvantage. The widely accepted architecture that may be the interest in the future for successful deployment is shown in the figure 11. This framework of system architecture belongs to EPC global Inc. This architecture is based on the Data on network. The data is stored and protected in the network and it is independent of the object (Diekmann, Melski and Schumann, 2007). A unique Electronic Product Code (EPC) pertaining to the particular manufacturer is generated and this code is embedded into the Tag. When this access code is retrieved by the members of supply chain the information is accessed over the network from the central database management. The successful implementation of this technology needs high coordination from the IT support of the implementing organisation.

The level of integration and the partnering of this architecture into the current business architecture need keen study by the expertise. The architecture must allow seamless flow of information across supply chain. It should also have provision for up gradation of new module and thus ensure endless connectivity with various application software.

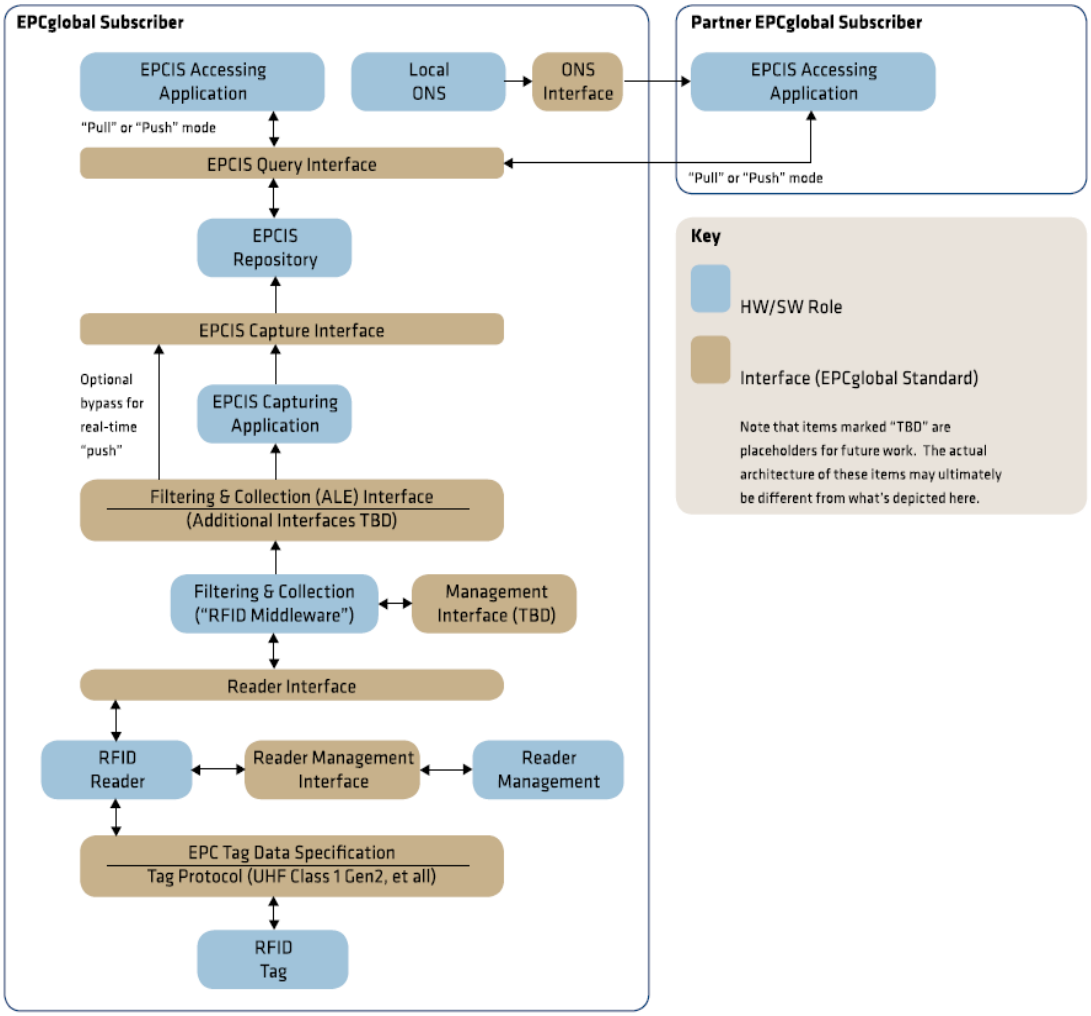


Figure 11 – System Architecture (Epcglobal, 2008)

The data on tag is another approach to store data, here the data is stored with the object and the information about the object can be accessed without the network infrastructure. An interesting comparison about the characteristics of both the system of data on net and data on tag has been summarised by Diekmann, Melski and Schumann (2007) in the table 3.

	Data-on-network	Data-on-tag
Concept	separation of object and data	integration of data with the object
Requirement for data access	network infrastructure	presence of object
Storage of object data	centralized (database)	decentralized (object)
Content of data on the tag	ID (EPC)	object related data
Nature of data on the tag	(mostly) static	(mostly) dynamic
Necessary storage capacity on the tag	low	high
Transponder cost	low	high
Tag standards	EPC class 0 and 1	EPC class 2, 3, 4
Data security	access mechanism in databases	coding on the tag

Table 3 – Characteristic Difference between Data on tag and network : (Diekmann, Melski and Schumann, 2007)

4.8 Benefits of RFID

The benefits of RFID are enormous which is driving the wide step implementation in various applications. The staggering cost savings of billions of dollars by deploying this technology by retailer giant like Walmart and US Department of Defence has been repeatedly spoken in many articles (Asif &Mandviwalla, 2005). This trumpet, its benefits across many industries. The RFID acts as supply chain performance tool, which helps to manage the supply chain efficiently by saving cost. This helps to lessen the burden on administration and spares them time to provide more products to their customer.

According to Intermec (2007), in manufacturing and distribution environments, the adoption of RFID technology can deliver:

- High product visibility
- Increased throughput and productivity
- Reduced costs, leading to more competitive pricing
- Shorter order cycles
- Faster shipping
- Better inventory management

• Reduced labour costs by reducing the workforce needed for tracking and inventory management.

• Increased revenues/higher profits

• Better customer service

• Carries dramatically more information than bar code labels

• Eliminates human error

• Improves speed and efficiency

• Increases information availability and location

• Allows enhanced security

• Delivers data with or without network connection

RFID provides real time visibility when the product changes it state from one location or position to another. This high visibility of monitoring and the intelligent information chaining delivers enormous benefits in its usage. Its benefits go on budding in this seamless horizon of innovation.

4.9 RFID Experimental Design for Pilot study

The RFID implementation is different for each application and it needs a repetitive test to check the reliability of the technology during the pilot study. This test can prove a worth for the implementer that the technology is reliable for data collection or not. This test is conducted at Amazon warehouse by Shen (2006). The trial test has to be done repeatedly using different mode of packing and considering all the practical possibilities into consideration for testing. The trial test will determine location of the antenna for better readability, number of RFID Reader units can be decided for broad scale deployment. The observation of data using different tag from different vendors will provide the performance of each tag. This will help in selecting the right tag and the number of equipments to purchase and the associated middleware. This practical performance measurement metrics will guide in implementing the RFID in broad scale. Shen (2006) has proposed an Evaluation Metrics to test the RFID trials. He recommends that each test (i.e. experiment) should be run multiple times for redundancy.

Definition of the basic variable for the experiments.

Total Reads –*The Total number of reads recorded of each product or tag during an experiment,*

Total Seen – *the total Number of unique tags seen during all runs of the experiment, for this measurement, regardless of how many times a tag is seen during each run it is only counted once.*

Total Possible – *Total number of possible reads taking into account that some tags may have been damaged or died prior to the start of the Experiment*.

Alive/Visible Rate- *Total seen/total reads (known as the Visible or Alive rate*)

Actual Seen – *The actual number of unique tag seen during an experiment, it is not certain that all tags will be seen during each run of the experiment, For Eg Let us assume four runs* per experiment. If a tag is seen across three runs and not the fourth, it counts as 3 in this count.

Read Rate- *Actual seen/ Total Possible (this rate discards invisible/ non-Readable tags during an experiment)*

Success Rate- *Read Rate x Alive rate = success Rate invisibility and Readability*.

The table can be created to do a comparison study on the type of tag from different vendors (AAA, BBB and CCC) and it can be repeated for different package and real time condition at the site.

	AAA TAG	BBB TAG	CCC TAG
Total reads			
Total seen			
Alive/Visible rate			
Total Possible			
Actual Seen			
Read Rate			
Success Rate			
Missing Tag If any			

Table 4 - RFID Reader performance measurement table (Shen, 2006)

This above table is formulated originally by Shen (2006) for Amazon warehouse. For general approach, this table is modified for wide applications which will guide the manager in choosing the right tag based on their reading performance at site condition.

5 Empirical findings

For the implementation of the RFID into the existing business system, as per the literature and expertise review gathered from the journals and RFID professionals. A pilot project has to be tested on a trial basis for wide scale deployment. Based on the research question the empirical data is collected. The information regarding their business operation is collected by semi structured interviews, observation, primary and secondary data.

5.1 Company's customer and their business strategy

The company R have both Business to Business (B2B) as well as Business to Consumer (B2C) deliveries. The majority of their customer belongs to Business to Business category. The company R follows both push and pull strategy for their B2B customer. Some of their major B2B customers are global retailers who have their functional business across many countries. These customers have their distribution centre from where the goods are distributed to their retail networks. The responsibility of company R for the order fulfilment process ends up once the goods are shipped from the dock door of the company premises.

The company R purchases its contracted semi finished goods both domestically and from Europe and Asian market. The company R's plant does the conversion of semi finished product to finished dismantled product. This finished dismantled product consists of complete set of components required to assemble at the consumers place. The company follows modular design in order to postpone the product differentiation as long as possible as their product strategy. This kind of product model is becoming much common in furniture industry to save logistical cost and difficulties during transportation.

The upstream of the Company R is quiet complex with many articles (parts) sourced from different locations. The upstream supply chain of the company R involves many suppliers from different geographical locations. The downstream of the company R is quiet simplified with few article and with few major customers. The company is also making its footprint in many new geographical locations to expand its market. The Company follows both make to stock (MTS) and make to order (MTO) strategy with their customer. The immediate demand for this technology comes from the downstream of their supply chain for their efficient functioning and need to improve the process efficiency as the first priority. Further company wants to capture the information about the physical flow of the goods to understand the complete product life cycle and the supply chain dynamics in the downstream. These above source of information are collected from the semi structured interview with the supply chain manager of the company R.

5.2 Current Customer Order Process Mapping

This empirical data's are collected form the observation and semi structured interview. In appendix 1, the flowchart details how the order comes into the focal company and how it is processed within the company. This flowchart shows the sequence of operation that is to be completed for the order fulfilment process. In order to understand how these operations are carried out in real time, the operation flowchart detailing the nature of activity involved in fulfilling this process is mapped down. This mapping is done after a serious of observation at the site of operation. The movement of the product in the order fulfilment process flow and the current prevailing information flow pattern is mapped down in the appendix 2. This detailed synthesize study of the each process involved from the product knock down assembly to the shipment will help for further analysis.

The flowchart also details the manual and the automated process involved in fulfilling the order from the assembly to the shipment comprising of both physical movement and the information flow of the product. This mapped process is done for the Make to Stock (MTS) customer. For understanding purpose the complete mapping process is divided into two sections, in section 1 is from the product assembly to warehouse placement of pallet and in section 2 from the warehouse to delivery.

5.2.1 Packing process

The manufactured components are packed in the carton package with the barcode label in one of the component. This carries the product code of the set of component packed. The staff packs the necessary component in the package according to the packing list and then he verifies it. In this stage the product carries the inspection code and the packer code in the form of a unique label with serial number. The individual packed carton is placed on the pallet until twelve packed carton is finished. The twelve packages are arranged in a two columns such that each column consists of six packages. Then the pallet is moved to the wrapping station for wrapping this twelve set of similar packages along with the pallet. The Article code label is fixed to the pallet for identification. This identification serves for article tracing during picking process.

5.2.2 Storage/warehouse process

It is also visible from the current process flow chart in appendix 2 that after the wrapping section of the pallet, the placement of this wrapped pallet in the ware house rack is not guided by many source of target place. The company R's staff has to find the vacant position in the ware house rack to store the wrapped pallet. This is a time consuming process to find the vacant slot in the rack and to place the pallet over it. The manual entry is made into the system about the address of the rack, in which the pallet is placed.

5.2.3 Order picking

During the order picking process, the company R's staff has to hunt for the article code to find the right pallet to be moved to the dispatch area. This is a time consuming process to track the article code. Once the Article code is tracked, the pallet is placed in the buffer storage area for loading into the truck. The Address label is printed out and fixed to the pallet.

5.2.4 Loading and Reporting

When the truck arrives for delivery, again the article number is traced from the buffer storage zone for loading into the truck. At present tracking of these goods for loading into truck is quiet easy from the lot of few stored goods in the buffer area. Once the goods are loaded, delivery note is signed by the truck driver and it is reported into the system for confirmation.

5.3 RFID Equipment selection

5.3.1 Application data to assist selection of TAG

The selection of the tag is based on the several factors that are listed below which has to suit the application, this selection criteria is based on the implementation issue detailed in the theoretical framework.

1. Frequency as per regulation of the country,
2. Range of operation
3. Memory Size (Data on tag or Data on net)
4. Form Factor (size of the tag)
5. Environmental Condition
6. Industry Standards compliance

The National Post and Telecom Agency (PTS) is the regulatory board for spectrum allocation in Sweden. For ultra high frequency range it has allotted frequency range between 865.6-867.6 MHz. It was approved as of 13 Dec 2005 and in the law since 1 Jan 2006 (source – www.EPCglobalinc.org).

The company R's environment is mostly consisting of metal parts (steel) and electrical equipments. The tag is to be applied on the cartoon package for each individual item. The form of the tag is to be in the size of the thin label which will be adhesive to the carton package. The tagging is to be done on item level for tracking of individual goods. The company has wireless connection network inside the factory premises.

The tag pertaining to the above standards and environmental factors is produced by many vendors. The form of tag that mostly likely suit this application is shown in the figure 13. Their technical details and operating conditions are as follows (Alientech, 2007).

Product specification

Operating Frequency	- 860-960 MHz
Operation Area	- Americas, Asia, Europe and Africa

Environmental Specification

Operational Temperature Range	- 25° C to +65° C
Shelf Life	- 2 years
Recommended Storage Conditions	- -25° C to +50° C, 20% to 90% RH, Non Condensing

RF Protocols

ISO/IEC 18000-6C
EPC Class 1 Gen 2

EPC Memory Size	- 96 Bits
Access Control	- 32 Bits
Kill Code	- 32 Bits
Programming Cycles	- 10,000 Write Cycles

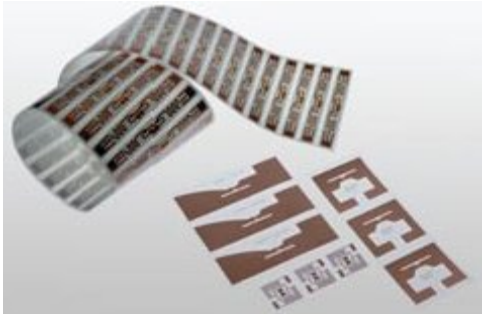


Figure 13 - RFID label Tag (Alientech, 2007)

Many such forms of tags are available from many vendors and their technical capabilities can be taken for comparison study.

The Article code of the product in the company R is identified by eight digit number. The information that the product carries referring to the particular Article number are shop order number, description of the product, location number, date of manufacturing, employee code of inspection and packing personnel, customer's product code and customer's purchase order number.

5.3.2 Exploring the Location for Reader

The packing of the individual product set in carton is done at the end of the assembly line. It is stacked in pallet of 12 pieces. Then the pallet is moved to the wrapping station and the article code label is fixed and placed on to the warehouse. During order picking the pallet is picked from the rack and put on the buffer area for loading into truck for delivery.

The location of the reader is feasible to be placed in many locations for the movement of material to be tracked within the plant until its delivery. The Possible locations are

1. At the end of the assembly line, where the individual packing is done.

2. At the palletizing section, where the 12 sets of individual package is stacked.

3. At the wrapping station where the group of package is wrapped to the pallet.

4. At the warehouse location, where the pallet is placed.

5. At the dock door, where the pallet pass through for loading into truck for delivery.

6. At the forklift

These locations serve best for tracking the product within the plant and can be communicated through the communication port either through wireless or Ethernet.]

5.4 Vendor selection

The company R is a expanding its global presence both in the down stream and upstream market of supply chain. The kind of partner that the company R is looking for a reliable partner, who can deliver the right product and good service over a long stand. The selection of vendor to deliver right technology to meet the R's industry standard is the primary concern of the company. The company R has dedicated IT support team.

5.5 Cost of RFID System

The cost of the RFID hardware depends on the number of quantity and the feature. The cost of the hardware decreases with increase in the quantity ordered. The cost scale of the hardware over a wide range of feature is give below. (Poirier & McCollum, 2007)

1. *Passive RFID tags, passive UHF 915-MHz Electronic Product Code (EPC) Gen 1 and 2 — $0.20 to $0.45 each*
2. *RFID label printers (EPC Gen 1 or 2) — $5,000 to $8,000 each*
3. *RFID high-speed label applicators — $15,000 to $25,000 each*
4. *EPC-compliant antennas — $250 to $600 each*
5. *EPC-compliant readers — $500 to $2,500 each*

The middleware cost ranges from $15000 to $100000, the cost varies drastically depending upon the degree of integration and functionality.

5.6 Data collection for ROI analysis

The pilot study for the implementation in first phase is to find the right product line which will give the maximum benefit. From serious of observation at site and from the interviews with the supply chain manager of the company the right product pertained to one of their major customer Z is chosen for pilot study. The number of Tags required to tag this product as per the forecasted order for this current year is obtained. The potential benefits in the companies internal supply chain is obtained by the lower efficiency in labour productivity from assembly to despatch.

The number of Tags required per year - 25000 units
The potential savings in labour hour - 3400 hrs
The savings per hour - 25 $

This above source of information is obtained form the Supply chain Manager of the company R through structured interview.

6 Analysis

6.1 Choosing the right case for Pilot Implementation study

As the company R follows different strategy for different products in relation with their customer. Choosing the right product for pilot study will remove the road block for investment in this new technology. The strategy involved in deploying the technology is wholly based on the strategy of Poirier & McCollum (2007). The company R's potential product is chosen for pilot study on the grounds of high revenue customer (i.e. in turn high volume product), the strategy followed in relation with the product, length of the product's downstream and different geographical locations. These factors are considered based on the complete RFID system compliance as discussed in the theoretical framework, which would preferably profit the stakeholders of the company R. As per Hildebrand (1998) and Rupple (2004) argument that the technology implementation is chosen, closely in alignment with the business objective of the company R

6.2 Identification of RFID Fit

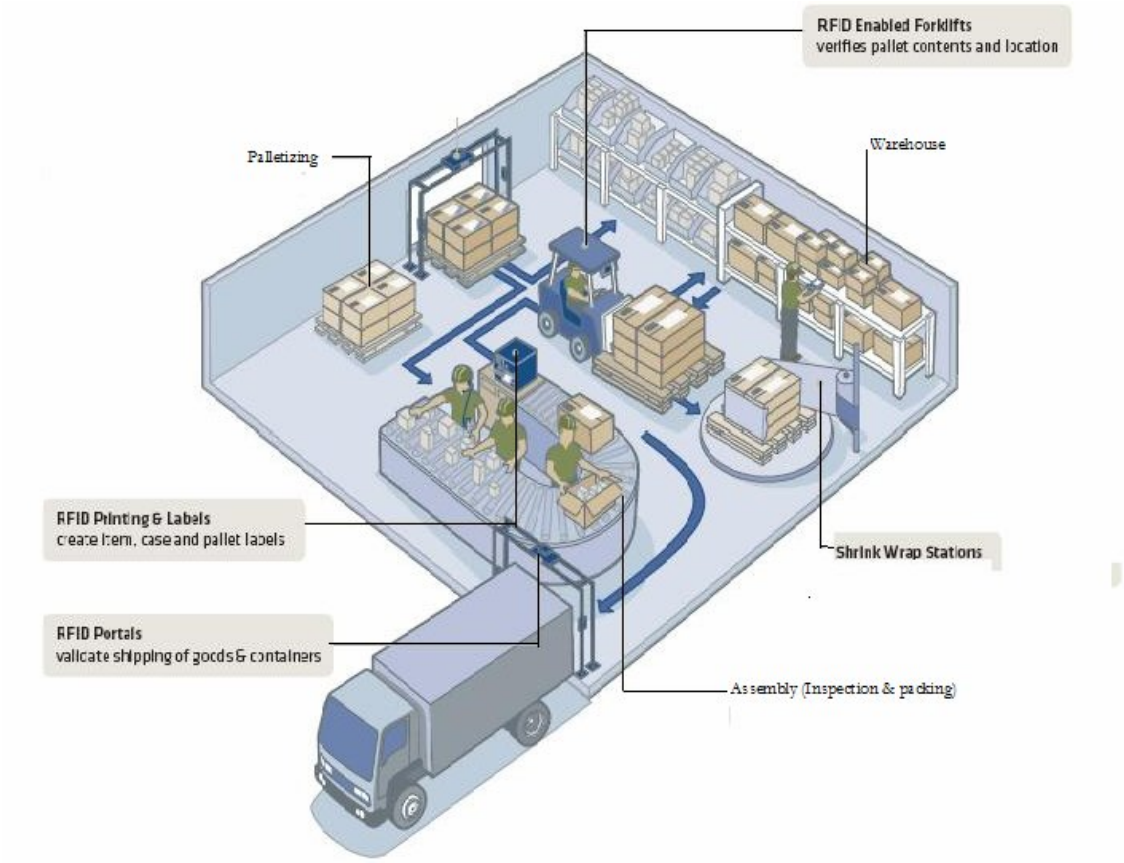
From mapping the current order fulfilment process within the company, it is identified that moving the package from assembly section to warehouse (Section 1) involves three action of manual entry of information about the product. Apart from these codes the barcode label carries the general product information related to production date.

The identified actions of human involvement between these processes are

1. Inspection code (The staff identity, who inspects the product)
2. Packer code (The staff identity, who packs the furniture parts in carton package)
3. Location code (The staff enter the location of pallet in warehouse).

In all the three cases, it is identified that there is a possibility to have an automatic data entry of these codes into the product. This can be done by having an RFID tag on the carton package coding the necessary information about the product, instead of having the individual labels for inspection, packer and production code. This saves the excessive labour hours involved in these processes. The identification of the right fit into the existing process is examined after a serious of observation made on sight as discussed in the methodology and also Merriam (1994), Patton (1990), Lewis, Saunders & Thornhill, (2003) statement by gathering information through interviews with the Supply chain Manager.

Figure 14 – Typical Assembly and Warehouse operation



In the section 2, during the order picking from warehouse to delivery, RFID tag enabled the consignment verification process automatic. This in turn saves labour hours and avoids wrong deliveries. The real time operation scenario of these processes is shown in figure 14.

The proposed order fulfilment process with RFID for the company R is shown in the appendix 3. This order fulfilment process coupling product flow and information is restructured to get the maximum benefit of RFID in the internal supply chain.

6.2.1 Optimal Location

On analysing the six different options on location, the effective location of the reader under section 1 can be constrained to two locations. In option 1, is to have the reader at wrapping station where all the 12 cases comes into visibility. Once the entire product is identified, the system has to find the location in warehouse for storing these products, so the staffs have to be intimated with the warehouse location. A display system needs to be incorporated at wrapping section to guide the staff. In option 2, the forklift reader will solve eventually both the problem of displaying the target location and the identification of the palletized 12 cases.

The option 2 is more reliable than the other, because the location is anytime accessible for the staff when they are on move in the warehouse. This eliminates the human error of misreading or forgetting the location code while on move. The real time scenario is shown in the figure 14.

Under section 2, there are two processes before shipment, one is two pick the pallet from warehouse shelf and to place them in buffer area before shipping for truck and the second

operation is to move the pallet form buffer area into the truck. In both of the cases reader plays a potential role in saving labour hours and increase productivity.

In the first case the reader is placed on the Forklift which guides the staff in easy tracking of goods and first verification is done before placing at the buffer area. For the second operation, the ideal reader location can be at the Dock door as shown in the figure 14. This location is perfectly suited because it confirms the shipment and automatically updates the company R's IT system.

This eliminates the excessive labour hour involved in picking the right pallet and the inaccuracy. This in turn increases the productivity of the firm.

6.3 Choosing the Right Tag and RFID system

As there is wide complication in choosing the Right Tag, as discussed in the theoretical framework under implementation issues from the studies made by Lewis, Saunders & Thornhill, (2003), Lu, Bateman & Cheng (2006), Asif & Mandviwalla (2005),Tajima (2007), Banks & Thompson (2008), the selection is done on all the analysis and factor to be considered for successful deployment From the empirical data gathered from the company to select a tag which suits the companies parameter, the technological constraints, cost factor, the environmental condition, RFID compliances, capability benefits and Industry standards. The ideal tag that can suit the application will be the passive tag, working under ultra high frequency (UHF). The form of the tag should be in the form of labels, which is adhesive to the carton package as shown in the figure 13 under empirical findings. This tag is well suited for this application on the grounds of the technical qualification, wide acceptance across many countries, the ability to decentralize and centralize the data, cost competitiveness and simple method of labelling.

6.3.1 Middleware and Communication network

In relation to the reader's communication port required to connect to existing business system, set of technical questions is framed in the Appendix 4 which will guide the IT support team in selecting the software system. The selection of the communication port, the middleware and other integrating difficulties to suit the operation is beyond the scope of this thesis.

6.3.2 Standard

In theoretical framework, two type of architecture is discussed that is data on tag and data on network by Diekmann, Melski and Schumann (2007). As the company R is expanding its product portfolio and their customer base in various countries. In order to meet the requirement of R's expansion plan and need for a standard system architecture and hardware support system becomes a most essential factor. Considering the credential of having the data on net, it is benefitable to have the data over the net in comparison to data on tag. For ROI analysis, the author decides to follow the data on net as a preferred architecture. This ensures reliability of the system standard across continent and to have a uniform system which allows easy integration of new member into the supply chain (Epcglobal, 2008).

6.4 Return on investment

This is a rough estimation, which gives a broad view of the investment scale that is needed for the deployment of RFID in this pilot study. This estimation is subjected to the selections that are made by the author on the basis of the criteria considered as per the present condition of the company.

The number of hardware system selected is based on the assumption made by the author in conjunction to the observation made at company site and technical feasibility of RFID component. The quantity of RFID units which are selected for this study is not under optimum level. The cost of the hardware and software are based on the empirical findings under cost of RFID system mentioned by Poirier & McCollum (2007). The cost of the each item is manipulated on the author's assumption by choosing the average cost in their respective cost range. This cost estimation will guide the company to have a broader analysis of the expected cost for complete deployment. The operation cost is assumed by the author based on the proportion of the installed hardware and the related system.

The labour hours saving is identified as a key performance indicator which will serve as a prime instrument in order to answer the stake holders investment to implement this technology. Though there are many advantages coupled to this technology, only the labour hour saving alone is considered as a prime return factor as it saves time in tracking the goods in the warehouse.

Calculation of payback period for pilot study (unit cost are derived form Poirier and McCollum (2007) , no of units and labour hours savings are calculated from the data received from Manager and the rest are as per authors own assumption)

Variables / components	*Units*	*Unit Cost ($)*	*Amount ($)*
Hardware			
Tags (UHF)	25000	0.35	8750
Readers at Forklift and Dock door	4	2000	8000
Antenna	10	400	4000
Servers	1	600	600
Printers	1	7000	7000
System Integration			
Installation labour hours (hardware &software) and middleware software		100000	100000
Total Fixed Cost			128350
Operational Cost			
Maintenance spare and damages of Reader	1	2000	2000
Printer	1	7000	7000
Antenna	2	400	800

Software licence and development		10000	10000
Tags damage (pampered)	100	0.35	350
Total operational cost			20150
Total Investment (Fixed + operational cost)			148500
Savings			
Labour hours	3400	25	85000
Total payback period (Total Investment/Savings)			21 months

It is evident from the payback calculation that the ROI for the company's internal operation is around 21 months. The total saving on labour hours alone is considered in this calculation as the major factor. Apart from this, there is an additional profit due to increase in productivity and saving from wrong deliveries. These cost benefits are not included due to insufficient data, so it is excluded from the ROI analysis. This return scale considering one factor alone (i.e. labour hours) is making a promising reason for the deployment and to convince the stakeholders. This is inline with the statement made by Poirier & McCollum, (2007).

6.5 Implementation Procedures

On understanding the implementation issues detailed in theoretical framework, it involves a serious of action that has to drawn for successful implementation. Initially it starts with

- Strategy formation inline with the business objective.
- Assessment of the current process flow.
- Identification of RFID fit into the existing process flow.
- Choosing the right RFID system based on internal& external supply chain integration.
- Exploration and evaluation of the pilot study.
- Assessment of the complete cost of RFID system and its returns.
- Assuring the positive impact to stake holders.
- Wide step deployment.
- Evaluating the performance improvement using KPI.
- Coordinating with other supply chain partners in extending the application of this technology in further downstream and upstream of the supply chain.

This check list of procedures will serve as a guide for successful deployment.and is inline with the strategy of Poirier & McCollum (2007).

Evaluation test Procedure

The trial test for the RFID deployment has to be conducted. This involves the selection of vendor based on the specification prepared from the R.'s IT support Team and from the plant manager. The selection of which vendor is subjected to company's internal matters and it is beyond the analysis of this thesis. A minimum of three vendors are to be selected for the experimental study as discussed by Shen (2006).

A real time practical experiment is to be conducted repeatedly to check for consistency and accuracy of the RFID instruments. This will help to determine the right Tag, right vendors, right location of antenna, right quantity of antenna and reader units and other unforeseen practical difficulties. Although the authors analysis gives the quantity of units required it is safe to undergo this test to avoid those assumptions. On conducting this test repeatedly with various packing conditions, will ensure the manager about the reliability of this technology. This will guide manager for the successful deployment in full scale for their entire product line.

7 Conclusion and Recommendations

The main objective of this thesis is to make the RFID technology adoption feasible for the focal company and to bring the right benefits for the shareholders. The technological barrier and the implementation issues, involved are dealt explicitly in this thesis for the successful implementation. The reason for adoption of this technology to their current process and how this change will restructure their business process to improve their efficiency and their advantages is also put forth in the analysis.

It is also evident that implementing this technology is not a readymade solution to cater its potential benefits. The adoption needs a wide understanding of the technology by itself, its fundamental fit from which point of the process will serve the focal company effectively and act as a vital tool to increase the performance in the internal supply chain. The author tries to put forth that only by clear understanding of the implementation issue for their own business case can deliver the right benefits. If the RFID doesn't finds the right fit in the business process which may involve inefficient use of data received from tag, may not deliver the chain benefits associated with this technology. For example considering the internal supply chain, the chain benefits can be the data received from the production assembly will help to track the inventory of the product in the upstream, this in turn controls the lead time of the product, which in turn will guide in efficient forecasting for the purchasers and this benefit can propagate further upstream into the supplier side of the company. In addition to these benefits, the immediate realizable benefits like reduced labor cost in inventory management and need for tracking the goods in warehouse, increase productivity by shorter order pick cycles, reduce mishandlings (wrong deliveries) are some of the internal operational benefits and they also act as Key performance indicator. Thus this performance indicator serves the purpose, to measure the ROI for the stakeholders.

This thesis also gives the manager the implementation procedure by performing an evaluation test as shown under theoretical framework. On evaluation based on the parameters will help to determine the practical difficulties that will arise due to readability of the tag. Thereby the authors suggest the focal company to carry out this experimental evaluation test before implementation.

7.1 Holistic perspective

1. The selection of the right tag is now mainly focused on the company's perspective, on its environmental factors and on its internal difficulties. As the product tag moves across the supply chain member it is wise considering the factors involving the chain member's real time difficulties on implementation. This is required in order to reap the maximum benefit of the whole supply chain. A uniform and a compromising solution have to be obtained by cooperative and collaborative approach. The extent of information sharing and the security level has to be explicitly discussed so that it delivers maximum benefit and improve the performance of the entire supply chain over a long run.

2. The focal company has to act as a channel captain to make ensure that this technology is trustable and it delivers high potential benefits, so that the entire supply chain is a head of their competitors.

3. The supply chain managers has to understand that in today's fast rising raw material price and stiff competition in the sales price, the only controllable factor is to reduce the operating cost. So that the profit margin stays for the survival of the business. This can be realized only by the continuous improvement process. The managers has to make a convincing move to all the stake holders of the entire supply chain that, implementing this technology can drive the performance rate of the supply chain, thereby the business as a whole can stay in the race.

4. At present the company is following a push strategy for this product line, when this technology benefits are extended to the down stream of the supply chain to the consumer, the point of sales data shared by the downstream members will help the manager to redefine the strategy that is following for this product line. This piece of accurate information shared in real time, will help to better forecast its supply in the upstream. The strategy from push will tend to move towards pull, which has enormous benefits of reduced inventory cost, lead time and thereby the risk.

5. The accuracy of the data collected will ensure all the members in the supply chain to act precise and make highly reliable decisions. The forecasting inaccuracy that is prevailing today can be resolved effectively. The gap can be narrowed down by effectively using this technology.

6. The company as now possibility to foresee the entire product life cycle; the information embedded into the tag can help better the customer's satisfaction level, in the area of after sales service and maintenance. This can be done by having a double layer adhesive on the tag which is initially tagged to the carton is removed at customers place. Then this RFID tag is fixed to a furniture part while assembling at customer site. There by the information about the product can be gathered at anytime during their life span.

7. On clearly understanding the functionality of this technology, it can assist the manager in trying an innovative approach to extend this technology for tracking other asset in the company.

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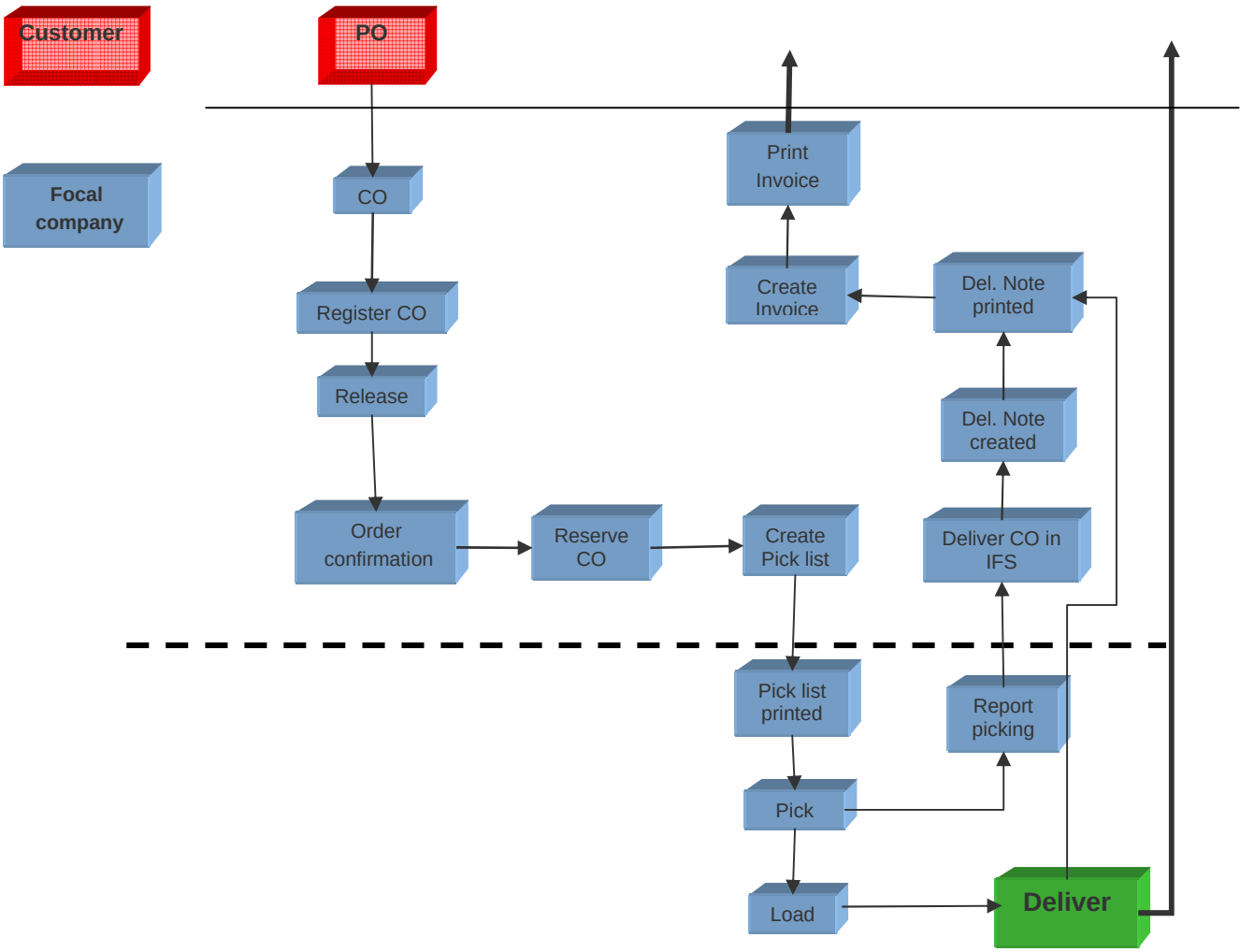
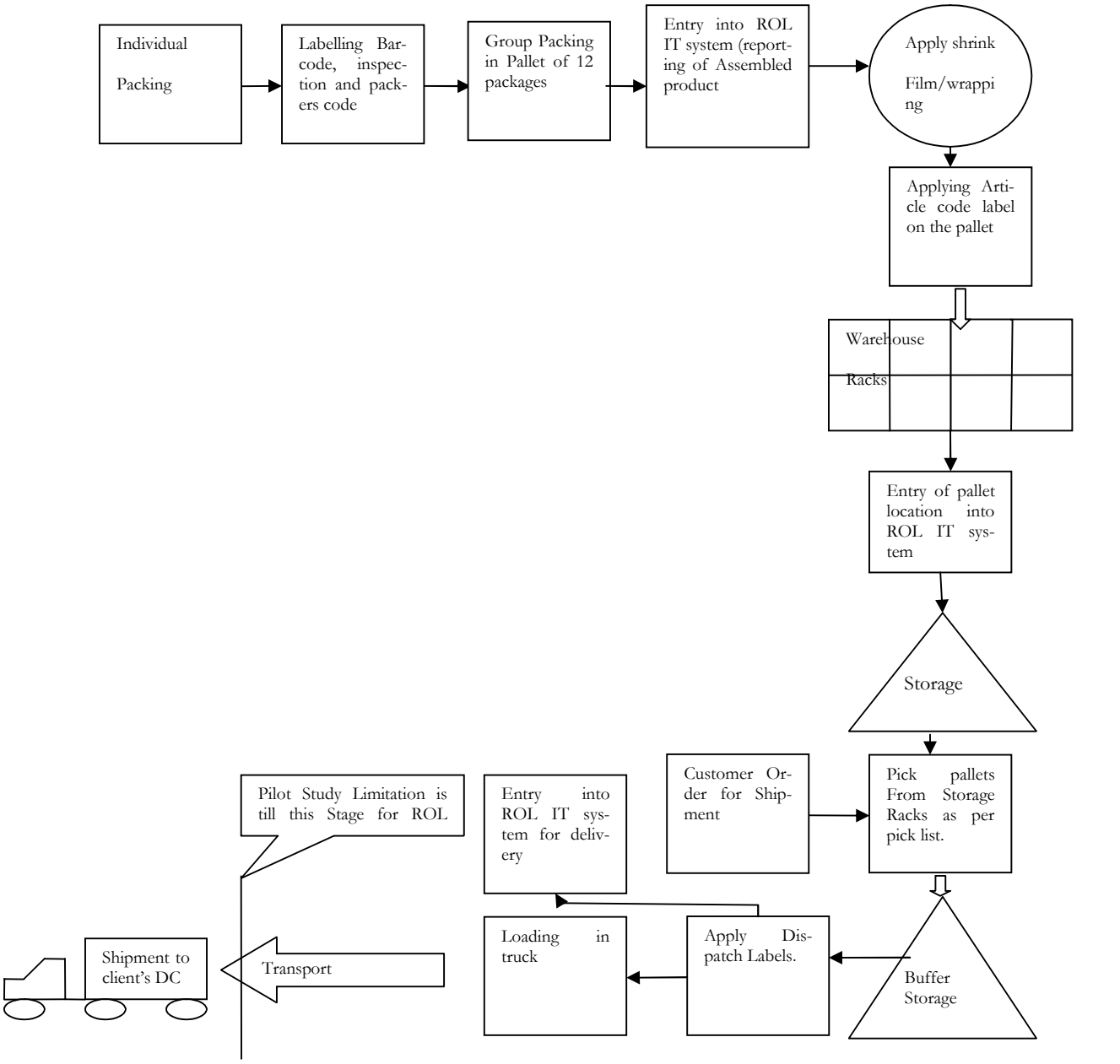
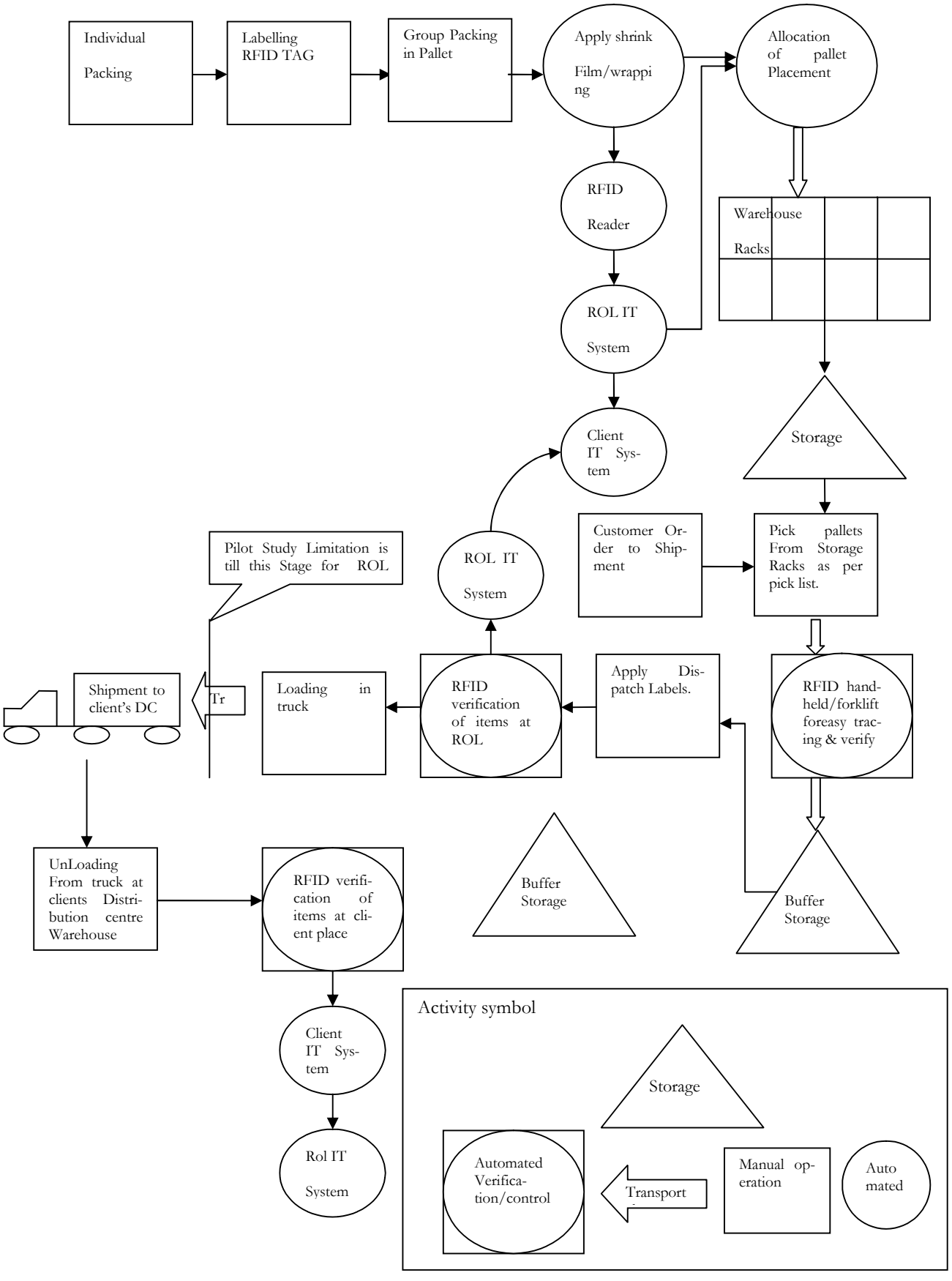
Appendix 1 – The company R's –> Order fulfilment-current Process flow chart



Appendix 2 – Current- Order flow process



Appendix 3 PROPOSED PROCESS FLOW WITH RFID TAG



Appendix 4

RFID system Configuration and Requirements for implementation.

Questions related to the Company R's IT support system.

1. What interface or middleware supports R's existing IT system .Example like WIFI (802.11) or Ethernet or RS232 (API) / (configuration) or USB etc..

2. In what format R's IT system required in order to process the received data's from RFID reader .Example (C#, .Net and VB.Net , if any please specify) .

3. What level of information security (i.e. who can be allowed to access the information?

4. Whether the data should be carried in Tag or in network?

5. What are the pros and cons in following the software architecture of the Standard organisation?

6. What is the software capabilities of the supply chain members and their infrastructure capabilities.

7. What will be the estimated cost of the software development and maintenance cost in adapting to this technology?

8. To ensure whether the technology and the hardware chosen will provide an option for upgradation?

9. To ensure whether the current system configuration can handle the enormous data generated for further processing?

APPENDIX 5 - Source (Epcglobal,2008)

1. Why use EPC standards over earlier RFID specifications?

RFID tags have been used for decades for mostly special purpose, proprietary tracking purposes. However, in modern commerce almost everything needs to move fluidly across enterprise boundaries. By providing open standards for tags, readers, and middleware EPCglobal has enabled the creation of a standards based industry where tags applied in one country can pass through many different organizations to their final destination and the identity of the object understood and authenticated. EPCIS is an additional EPCglobal standard that supports a detailed representation of the location and state of material as it moves between organizational boundaries and provides for sharing this in a technology supplier independent way between entities or partners. It should be noted that the EPCIS standard is data carrier neutral and can be used to exchange data found from RFID tags, barcodes and other data carriers.

2. What are the data elements in the EPCIS standard?

The data elements in the EPCIS standard data model define WHAT (product), WHERE (location), WHEN (time), and WHY (business step and status) for granular product movements in the supply chain.

WHAT

• EPC – can be a list (Object or Transaction Events) or parent/child (Aggregation or Transaction Events). It is possible to include any unique identity in the EPC field.
• Business Transaction – includes a type (e.g.: Purchase Order, Invoice, Bill of Lading) and a number. By including the Business Transaction number in a business event, it is possible to relate EPCs to a Business Transaction – e.g.: state that EPCs 1-5 are in Purchase Order CompanyA-123.

WHERE

• Read Point – indicates the location where an event took place- e.g.: DC X conveyor belt 2
• Business Location – describes where the object is immediately after the event occurs e.g.: DC X Shipping Area

WHEN
• Event Time – states when an event took place
• Record Time – indicates when the event was received through the EPCIS Capture Interface

WHY
• Business Step – indicates what business operation was taking place at the time of the event – e.g.: Receiving, Picking, Loading, Shipping
• Disposition – describes the status of the product immediately after the event occurs – e.g.: Sellable, In Progress, Non Sellable, Destroyed

3. How is EPCIS data secured?

There are two forms of data security described in the EPCIS specification authentication and authorization.
1. Authentication – the EPCIS standard enables the use of multiple message transport bindings that include authentication – including SOAP over HTTP with TLS (web services) and XML over AS2. The implementation of the bindings is defined outside the EPCIS standard.
2. Authorization – an implementation of the EPCIS Query Interface may use the authenticated identity of the requester, together with arbitrary business rules, to decide which events to deliver to the requestor and which information to include within those events. The EPCIS specification itself does not specify what those business rules are – it is up to each implementation to use authorization rules that are appropriate given its own business situation. The specification defines what types of data may be withheld, and includes a standard error message to be provided when the EPCIS wishes to deny access to data entirely – i.e.: Security Exception

4. How might a sample implementation work for a small company?

There is no standard definition of an EPCIS implementation. But based on our experience from the EPCIS pilots, we can provide some thoughts.
A small company could first determine how it would like to capture and share EPCIS business events. For data capture, the company could set up EPC readers and middleware. For data sharing, the company could make arrangements with its trading partners to monitor shipments and receipts of EPC-tagged products.
The company would need to compile master data for the products and locations in its supply chain. Then the small company could set up an EPCIS repository application with help from a solution provider. The company would load the master data into its repository. The company could route its captured EPCIS events from its middleware to its EPCIS repository via the capture interface. Then the company could set up subscription queries with its trading partners to track all shipments and receipts.
There are many known use cases for EPCIS based on our current pilots. These use cases include electronic proof of delivery (e.g.: tracking receiving & shipping between trading partners), electronic pedigree (e.g.: tracking which trading partners had custody of an EPC in the supply chain), product authentication (e.g.: verifying the manufacturer of an EPC), promotional compliance (e.g.: ensuring that displays of sale product are setup on time in stores), and inventory management (e.g.: detecting when a product goes out of stock). A company will typically enable these use cases by building applications on their base EPCIS infrastructure.

5. How do I integrate the EPCIS interfaces with my existing systems?

A: The EPCIS standard does not mandate any implementation or repository. So it is possible for an end-user to build the EPCIS interfaces and data model themselves on top of an existing enterprise system. But it may be simpler for many organizations to buy an EPCIS repository application from a solution provider, or obtain EPCIS-compliant application enhancements from their existing application providers. A company could leverage their EPCIS repository for capturing business events from middleware, integrating the EPCIS repository into the enterprise architecture via web services, and allowing trading partners to access data in the EPCIS repository in a secure manner via the query interface.

Appendix 6

These are some of the major vendor dealing in hardware and software of the RFID system.

source -(Asif &Mandviwalla, 2005).

Organization	Major Expertise
Accenture	Services
Alien Technologies	Hardware
Canon Fintech	Label and Printers
Capgemini	Services
Checkpoint Software Technologies	Software
Datamax	Label and Printers
Deloitte	Services
DynaSys	Software
EDS	Services
HK Systems	Services
IBM	Services
IDTech	System Integrators
IDTechEX	Services
Impinj Inc.	Hardware
Intermec Technologies Corporation.	Software
Matrics	Software
Northern Apex	System Integrators
ODIN Technologies	System Integrators
Omron Auto ID Systems	Hardware
Philips Semiconductors	Hardware
Printronix	Label & Printers
RedPrairie	Software
SAP	Software
Savi Technologies	Hardware
SEEBURGER Business Integration	System Integrators
SUN Microsystems	Hardware
Symbol Technologies	Software
TAGSYS	Hardware
Texas Instruments	Hardware
ThingMagic	Hardware
Xident Technology	Label & Printers
Zebra Technologies	Software