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RFID: ROI Opportunities after the Sunk Cost

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ABSTRACT

Currently many alternative options exist to satisfy the RFID mandate by Wal-Mart – tag cases at the exit doors, tag all cases at the supplier's warehouse docks, tag a certain section of the warehouse, etc. The big question is how to prevent Wal-Mart suppliers from treating the cost of EPC standard - adoption from just becoming another one of those nagging costs of doing business with Wal-Mart and how the cost of RFID adoption can be leveraged to differentiate the company's products and service levels from that of the non-RFID-adopting/non-RFID-cost-incurring competition. In addition, it is worth exploring how can all of that translate into long-term comparative advantage for a consumer electronics manufacturer. By examining the different scenarios for a Consumer Electronics Manufacturer (CEM) supplier of Wal-Mart that will be RFID tagging small ticket items on a case level, this study proposes an ROI/ROA framework within which investments in RFID can be evaluated and validates through a simulated financial model that positive value exists for early adopters of RFID technology.

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1.1 The Wal-Mart mandate

Ever since CIO Linda Dilman officially announced in June 2003 Wal-Mart's RFID Mandate, which will require its top 100 suppliers to fully comply with its RFID/electronic product code initiative by January 2005, and the rest by January 2006, the topic of RFID implementation has been a hot topic across the industry. On the one hand, suppliers will incur significant costs in setting up the necessary RFID – enabled infrastructure, yet the benefits will stay mainly with the retailer. In fact, since there will be no cost-sharing, those suppliers will have to explore for themselves the return on investment (ROI) opportunities after the sunk cost of investing in the necessary technology and RFID infrastructure has been incurred. The idea is to generate some type of incremental financial benefits to recoup the cost of the capital investment in addition to keeping Wal-Mart happy. On the other hand, by sheer volume those 100 suppliers are some of the world's largest non-automotive consumer goods manufacturers[1] and for them this is a historical opportunity to reorganize their existing business processes around the efficiencies enabled by this revolutionary technology. From a macro-economic perspective, wider adoption will translate into lower barriers of entry which will allow smaller companies to benefit from the technology too, which will eventually transform the traditional notions of supply chain and logistics as we know them. This paper explores the different ways that return on investment (ROI) can be achieved by employing RFID technology to enhance existing business processes.

1.2 What is the mandate?

In a nutshell the Wal-Mart mandate requires that effective January 1, 2005 its top 100 consumer product goods (CPG) suppliers should place RFID tags on all pallets and cases shipped to three North East Texas (Fort Worth/Dallas) Wal-Mart Distribution Centers (DCs). Even though the technical requirements for those tags are still being updated, it is widely known that the tags on all pallets should be 100% readable by a standard RFID reader when passing through a docking door and that all cases should have tags which should be readable by a similar fixed reader when passing on a standard conveyor belt moving at a speed of 540-600 ft/minute. Per Wal-Mart's mandate guidelines, the suppliers have a choice between Class 0 and Class 1 tags, which represent both open standards that are unfortunately not interoperable. Basically, a Class 0 tag is a tag programmed by the tag-manufacturer and a Class 1 is a tag where the user (CPG manufacturer) can purchase a blank tag and wait until application time to write the EPC number on it. Usage of either tag class has certain pros and cons associated with it. Class 0 does not require the CPG manufacturer to do anything in addition to storing the tags on location and applying them to the pallets and cases in particular order. Storing a huge number of tags on the floor of a warehouse that carries thousands of SKUs, and keeping them in order, however, can be an overwhelming challenge for any organization. Class 1 on the other hand has a much greater level of efficiency associated with it since the CPG Manufacturer can wait till the pallets are put together (direct association between case tags and pallet tag can be created at the time of deployment), but that level of flexibility will come at the capital cost of having tag-writing equipment inside the warehouse, preferably at the outbound shipping point. The difference between Class 0

and Class 1 tags is expected to be mitigated by Wal-Mart's decision to employ Class 1, Version 2 standard readers which are interoperable between both standards, so in the end it will be entirely up to the CPG Manufacturers to decide what class of tags better suits their needs. At the time this thesis was being written, the technical specification for the Class 1, Version 2 standard were still being finalized, hence we can not comment on those. Either way, the enormity of the Wal-Mart RFID initiative can only be grasped when we take into consideration the fact that according to recent statistical data from Infoworld, Wal-Mart currently accounts for 17% of the total worldwide retail volume and it receives approximately 8 billion cases and or pallets per year, of which the top 100 suppliers account for approximately one-eighth or one billion cases[ii].

1.3 Why is Wal-Mart doing RFID?

Very little is known about the inherent motives of why Wal-Mart is so determined to implement RFID within its organization, yet its enthusiasm and perseverance in promoting RFID-adoption has been made clear by Wal-Mart's President and CEO H. Lee Scott, Jr, who claimed at the January 2004 National Retail Show that "Through RFID, we (Wal-Mart) will get more efficient as an industry, and savings will get passed to the consumer." Mr. Lee's statement is in alignment with a prevalent industry opinion which revolves around the idea that the benefit for Wal-Mart is hidden in the automation of the receiving process in the store and better management of the replenishment process from the back end to the front of the retail store, so whenever a stock out occurs on the sales floor it can be easily identified and the product can be quickly restocked. Industry experts such as Kevin Ashton, a Procter & Gamble executive and an executive director of

the now-defunct Auto-ID Center, the leading RFID research body program at the Massachusetts Institute of Technology, estimate that retailer and consumer products companies lose an average of 6% of their total sales each year due to out-of-stock situations[iii] in retail stores. That number could reasonably be estimated to be much lower in the case of Wal-Mart which has managed to leverage itself over the competition by paying particularly close attention to the performance of the sales floor, yet given its annual sales of approximately $244.5 billion[iv] even a conservative 4% stock-out situation translates into a whopping $10 billion missed sales opportunity per annum, which is a pain point that Wal-Mart believes can be relieved with the help of RFID technology.

Another way to estimate the potential impact of employing RFID to increase the in-stock availability of products on the shelves was suggested by a major retail chain executive that was interviewed as a part of this thesis research. According to him, in a mixed SKU environment every 2% increase in in-stock availability automatically translates into approximately 1% increase of sales, a number which can be multiples greater for fast-moving SKUs, assuming that the retailer is operating in the 96-97% current in-stock availability percentile, which is characteristic of the environment in which Wal-Mart operates. In the case of Wal-Mart a mere 1% increase in sales is the dollar equivalent of $2.4 billion, which is a serious enough number by anybody's standards.

A third approach towards estimating the magnitude of the Wal-Mart's potential benefits is proposed by AMR Research Analyst Pete Abell who looked at those from a strictly cost perspective. AMR's Abell estimates that Wal-Mart's costs associated with supply

chain--including storing, transporting and keeping track of goods--are about 10 percent of overall sales[v]. RFID, Abell said, could save 6 percent to 7 percent of those costs annually. Using the 2002 figures as a model, that would amount to about $1.3 billion to $1.5 billion saved.[vi]

Another potential benefit that Wal-Mart is hoping to reap is increased efficiencies in their cross-docking operations. Wal-Mart's rise as the world's #1 retailer is intimately tied to the cost savings enabled by cross-docking which accounts for a significant portion of the throughput of goods handled by its supply chain. In Wal-Mart's context cross-docking is the process of taking goods received in their Regional Distribution Center (RDC) and processing them through to the Distribution Centers (DCs) without the intermediate steps of storage and order picking, which are both very labor-intensive.

Most generally cross-docking can be broken into opportunistic and planned cross-docking. With planned cross-docking the process is intended and determined months or weeks in advance by the existing Enterprise Resource Planning (ERP) and Warehouse Management System (WMS) which match Advance Shipping Notices (ASN) and the barcode reads generated by the receiving personnel at the warehouse dock. The process of obtaining those reads involves manually scanning the Serial Shipping Container Code (SSCC), which is the master barcode that contains a listing of the barcodes and quantities for all cases that are allegedly contained on the pallet. There is no guarantee however that all cases are actually on the pallet unless the workers break down the pallet, and manually scan each individual case, which is a labor-inefficient process, and rarely done in a fast-paced cross-docking environment.

As a result the information of what is supposed to be on the pallet is transmitted electronically via Electronic Data Interchange (EDI) and manually via shipping manifest to a DC and from there to the final destination – the receiving Wal-Mart store. Depending on the type of product (staple stock vs. direct freight), a pallet can be broken down at either of those places, at which point potential inventory discrepancies are identified, yet inventory shortages are difficult to resolve given the relative lack of traceability of the items in question. Industry experts such as Sanjay Sarma, from OATSystems, Inc., estimate that approximately 20% of all Business-to-Business (B2B) transactions involve some type of discrepancy which can be mostly attributed to human errors, and the unavoidable shrinkage.

The second type of cross-docking, the so-called opportunistic cross-docking, deals with cargo that is received and scheduled for put away but is instead sent out to fill a DC order, without any advance planning, to avoid the cost of put away and order-picking.

One of the enhancements in the cross-docking process using RFID technology is that it would allow for incoming goods to be quickly read and processed immediately. This will eliminate much of the manual receiving processes, and will greatly improve operating efficiencies. As the pallet's tag is captured by the RFID reader, the information about the cases contained on the pallet will also be captured, and a Savant server will be able to create two types of "unit load" associations - one between the cases on the pallets and the pallet tag, and a second one between the pallet tag from the manufacturer and the ASN

and/or P.O., thus simultaneously updating the existing WMS and ERP systems and creating a written record that captures the flow of work operations. This will translate into an electronic shipping manifest to the DC, which will contain all information necessary to resolve inventory differences. This information, for example may include but not be limited to items such as: pallet tag, cases tags, time stamp, ID of the operator who built the pallet at the manufacturer, ID of the inbound and outbound trucks etc., and has the potential to generate tremendous savings in terms of building electronic verification that would follow the pallets and cases throughout the Wal-Mart supply chain until they are broken down.

A third potential benefit for Wal-Mart is that the proposed EPC-network which will be used to share RFID-generated product data is built around utilizing the capabilities of the Internet. Since the invention of the barcode and Electronic Data Interchange (EDI) in the 1970s, the transmission of electronic data has been handled through internal databases shared through value-added networks (VANs). Those VANs have traditionally been maintained by EDI VAN providers such as GE Global Exchange and others, which charged significant fees for that service. Recently, in a push to further drive down costs and to get its suppliers to share information in more cost-effective ways, Wal-Mart has mandated that its suppliers adopt the AS-2 standard to share electronic data, which is scalable and dependable enough to serve as a platform for volume-intensive B2B EDI and similarly to EPC utilizes the Web as its primary infrastructure. While the EPC network can utilize barcode data, the real savings for Wal-Mart in its RFID mandate will be realized through the fully automated data collection capabilities of RFID.

1.4 Who else?

Other major purchasers of manufactured goods that have recently mandated from their suppliers to comply with RFID programs similar to Wal-Mart's are the Department of Defense (DoD), which has 43,000 suppliers and the Target and Albertsons store chains. Maurice Stewart, Deputy, Automatic Identification Technologies (AIT) at the DoD discussed in a recent web cast[viii] the reasons behind DoD's decision. The military has long used active RFID tags (aka "data rich") to identify valuable assets in support of combatant commanders together with a plethora of other AIT Media/Devices such as: linear barcodes, 2D Symbols, Contact Memory Buttons (CMB), Satellite Tracking Systems (STS), Optical Memory Card (OMC), and Smart Card/CAC. Now, according to Mr. Stewart's presentation, the untapped capability of passive RFID tags would be used to improve DoD's business process by providing total visibility which will streamline the supply chain and allow for faster supplier response based on accurate DoD consumption data to reduce the Bullwhip effect associated with traditional forecast-based ordering, and ultimately provide improved combat support.

The DoD mandate involves passive tagging on all materiel, except bulk commodities such as sand, gravel or liquids, shipped to DoD, starting January 1, 2005 on a case/warehouse pallet and UID critical asset (value greater than $5,000) level based on a DFARS set of rules which would be published in May 2005. The passive tags should utilize either standard EPC identification codes or DoD's proprietary numbering system. In order to achieve the desired visibility all RFID applications will be integrated into the existing DoD ERP systems, which would ideally lead to a fully optimized supply chain

and reduced total ownership costs. At the time this paper was being written, DoD was completing a trial using Alien EPC Class 1 tags and readers at the Navy Fleet Industrial Supply Center (FISC) at the DoD Military Ocean Terminal in Norfolk, VA, which aimed to validate the technical capabilities of the technology and the extent to which it could be integrated in practice. The high hopes that DoD lays on RFID to sustain its competitive advantage were recently summarized by Alan Estevez, assistant deputy undersecretary of defense for supply chain integration: "The way we fight has changed... We have to transform our logistics capabilities in order to meet that new way of fighting wars. RFID is a key component of changing logistics capability, of enhancing our ability to supply our forces.[ix]"

In pursuing RFID-deployment, Target and Albertsons are seeking to achieve efficiencies similar to those of Wal-Mart, yet what makes their mandates interesting is that following Wal-Mart's example their own mandates will generate a "snowball effect" or "critical mass" adoption of RFID technology at zero or negligibly little incremental cost for their suppliers since they share most of their suppliers with Wal-Mart. In the end, broader exposure of this new technology to more manufacturers, suppliers, transportation providers and final consumers will promote both wide industry adoption and the development by 3rd independent parties of peripheral software and hardware that can collect real-time data and translate it into meaningful decision-facilitating input, which will ultimately serve to decrease RFID-adoption costs thus closing a benevolent circle for all parties in the retail world.

Chapter 2. ROI for a CEM who manufactures small ticket items?

In this context, one can easily understand the unease that Wal-Mart's suppliers are feeling with respect to RFID implementation since they will be fully responsible for introducing RFID tags in the supply chain. They will not only have to pay for the initial RFID infrastructure set-up, but also provide out of their own pockets for the cost of tagging each pallet and case. Hence, the vast majority of Wal-Mart suppliers are currently looking at their existing operations and trying to evaluate the impact that RFID will have on their organizations either through hands-on "pilot" projects or through analytical ROI models. No two suppliers, however, are identical and the internal benefits that RFID can introduce differ vastly based on the nature of the products and the relative percentage of products shipped to Wal-Mart compared to overall product volume.

The consulting firm of A.T. Kearney[x] uses a basic model to differentiate between the different types of manufacturers by dividing them into two groups – high impact and low-impact based on the type of products they manufacture[xi]. Low impact manufacturers (LIM), who sell high volumes of less expensive goods, will enjoy narrow benefits since they experience limited shrinkages and have built their business model around extremely efficient supply chains and distribution channels (i.e. ½ penny cost differential makes all the difference in the world for the pricing derivation of a can of Campbell's soup.). High impact manufacturers (HIM), on the other hand, are defined as those who sell lower volumes of expensive goods. Given the high opportunity cost of out-of-stocks and shrinkage for those items, RFID holds a significant value proposition for HIMs. In the

context of that framework, HIMs would definitely enjoy an advantage over LIMs, which makes them an interesting area for research.

One particular type of an HIM is the consumer electronics manufacturer (CEM) that produces a variety of products and supplies to both Wal-Mart and Target as well as to hundreds of other retailers who may or may not also be looking at adopting RFID technology in their own stores. As such, a CEM faces a dilemma whether to RFID-tag only items going out to retailers that mandate it or to tag all of its products and pass the benefits to all of its customers and hopefully recover the costs through less out-of-stocks situations on the retailers' floor which would correspond to overall product sales gains.

Most generally the products that a CEM produces can be divided into two categories – big ticket and small ticket items. Those are definitions subject to individual interpretation based on cost and a variety of other parameters, yet for purposes of this research paper we make the assumption that big ticket items would be items tagged somewhere in the supply chain that will retain their individual tag with the visibility associated with it until they are sold to the final consumer. Small-ticket items, on the other hand, will be defined as what is known as break-bulk products –cases of individual products that will get broken down sometime before they reach the retailer's store. If we visualize a relatively simple supply chain for a CEM doing business with Wal-Mart in the USA (Figure 1), it would involve its overseas outsourcing partners shipping completed products to an US CEM-run or 3PL-run DC, which would receive the products and store them until shipped out to the Wal-Mart DC which would then distribute them to the individual retail stores.

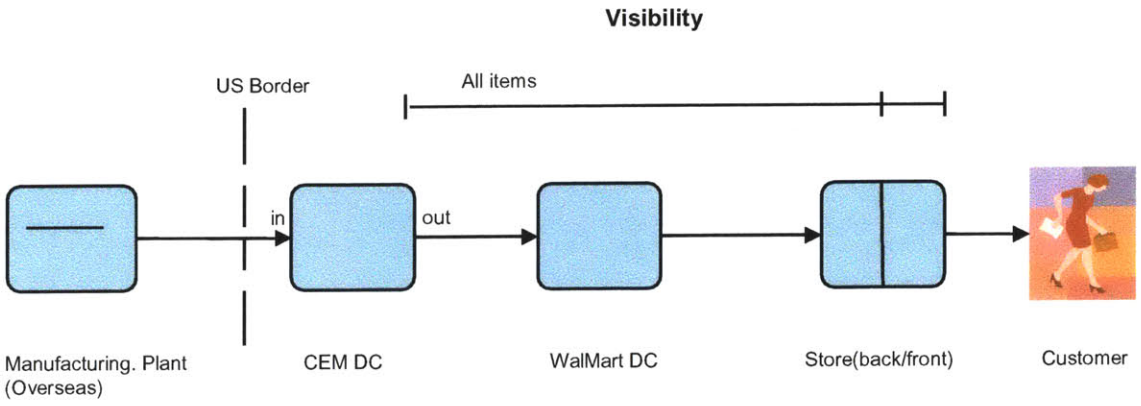


Figure 1. Visualization of a supply chain for a CEM doing business in the USA.

As a result, a small-ticket item can get broken down anywhere in the SC – possibly at the retailer's DC or at the retailer's store. The assumption under which this paper will operate will involve looking at a pallet which is made up of cases containing dozens of individual items packed together in master cartons. The cases may or may not travel with the same pallet throughout the supply chain but the one certainty is that the cases will get broken before the individual items are put on the retailer's shelves. While, it is highly unusual that individual items will ever be shipped to Wal-Mart, it is not uncommon for smaller customers to include individual items on their orders so that the cases have to be broken at the CEM DC. Another potential point to break down the cases could even be at the outsourcing manufacturing partners overseas that operate in a much lower labor cost environment provided that sufficient information is available to put together packages made up of non-homogeneous products geared towards the needs of an individual retail store. Hence, a CEM should reasonably evaluate all possible scenarios in terms of where in its supply chain to deploy the necessary RFID infrastructure and where to apply the tags in terms of the potential benefits and costs associated with each feasible scenario that

will generate maximal incremental return on investment (ROI) associated with complying with Wal-Mart's RFID mandate.

2.1 Definition of ROI

Since Incremental ROI in RFID for a CEM is the underlying topic of this thesis, it is important to provide some type of framework within which to be able to evaluate the bottom-line effect of RFID investment. A typical finance class would define the mission of senior management as conduct and policies that serve to maximize ROI and ultimately stockholder's value. According to Mr. Jeff Karrenbauer, President, Insight Inc.[xii] the three main components of ROI are Sales, Capital and Costs or to put in his words – Demand Creation, Resource Allocation and Finance Control[xiii].

Sales, for example should be interpreted as Customer Service, or even better we need to think of ways to use RFID within a logistics context as a competitive weapon. With the introduction of the global information superhighways, the traditional means of establishing and maintaining market control are not as relevant in terms of trying to establish a long-term competitive advantage. New **products**, no matter how sophisticated they are, can be reversed-engineered in a matter of weeks. As soon as Intel comes out with a new integrated circuit (IC) product, AMD instantly reverse-engineers it and then Intel leapfrogs into a new technology, without even bothering to pursue their rights in court. **Promotion** is also less of a factor because of the unprecedented availability of unsolicited information that literally overwhelms the consumers. And

finally, **price** has also declined in importance because the web has made the real value of products widely available for comparison both to the competition and the end consumers. Hence, in the end **place** – having the right product at the right place and at the right time is the last trump card that companies have to attract and more importantly to retain customers with a blend of competitive cost and customer service. Now however, with the help of RFID technology manufacturers and retailers have a historic chance to move beyond just pursuing cost savings towards using it as a competitive weapon to not only satisfy their customers with precise logistics but delight them with superior service levels.

Can such a strategy be copied? Absolutely, according to Mr. Jeff Karrenbauer, President of Insight Inc. -- if one can copy a CPU chip, one can copy anything but it is much more difficult to follow a logistics strategy because it involves hundreds of different details spread along a wide geography, which makes logistics more difficult to track than to figure out a blue print. Probably the best example of a business enterprise that has understood the importance of constantly improving their logistics operations in order to achieve and sustain competitive advantage is Wal-Mart, which is first and foremost a success story in logistics. Another example is the U.S. Military – whatever battleship achievements they have had over the last decade have been as much a victory in logistics as much as a victory in technology and military strategy. Those examples clearly show that logistics is a competitive weapon, and not surprisingly both of those major players have recently chosen RFID technology to spearhead that weapon.

So how can one measure ROI? Companies are constantly under pressure to show better ROI numbers doing so because of pressure from Wall-Street. The traditional financial theory defines ROI as follows:

ROI = Profit margin * Capital Turnover

But that formula by itself, according to Mr. Karrenbauer, is not much meaningful until we put the concept into a ROI matrix, and then look for ways to improve ROI.

ROI Matrix	Profit Margin: % Before Taxes						
Capital Turns	3%	6%	9%	12%	15%	18%	21%
3.00	9.00%	18.00%	27.00%	36.00%	45.00%	54.00%	63.00%
2.50	7.50%	15.00%	22.50%	30.00%	37.50%	45.00%	52.50%
2.00	6.00%	12.00%	18.00%	24.00%	30.00%	36.00%	42.00%
1.50	4.50%	9.00%	13.50%	18.00%	22.50%	27.00%	31.50%
1.00	3.00%	6.00%	9.00%	12.00%	15.00%	18.00%	21.00%
0.50	1.50%	3.00%	4.50%	6.00%	7.50%	9.00%	10.50%

Figure 2. ROI Matrix (Source: Jeff Karenbauer Presentation 2004 ©, IAP 2004, MIT)

If we look at the above matrix – the ROI numbers range from pretty modest to pretty aggressive returns – any company would love to be in the upper right corner of the ROI matrix. Suppose an organization's corporate objective is to generate ROI of 20 % - they can achieve that goal many different ways – there is a plethora of different combinations. The question is which strategy can work for a RFID-adopting organization, and if there is any one silver bullet strategy that would work for all organizations.

One way to improve the bottom line is to increase Sales, which would be excellent because it would increase both capital turns and profit margins potentially at the same

time. That is a good but almost always impossible thing, since most businesses face tough competition. Next a company can try to reduce its inventory levels thus generating better return on its assets (ROA). Unfortunately reduction of inventory usually comes at the cost of decreased service levels where the opportunity cost of missed revenues due to out-of-stock situations is prohibitively high. Another way to improve profits would be the traditional cost accounting way -- to squeeze as much costs as possible from suppliers and business partners, which is what the Wal-Marts of the world have been doing over the last decade. Unfortunately there isn't much left to be done in this aspect to further improve the bottom line -- the carriers and the public warehouse people have given whatever they could give, and now most of them are running in the red. As a result the corporate strategists are simply running out of headroom there.

2.2 What is the premise of RFID?

A logical step would be for businesses to be willing and able to implement a trade-off i.e. to try enhancing service by reducing stock outs, and generating faster and more consistent delivery, that will be enabled by the easily-accessible more granular, accurate information on product availability and automation of processes currently performed manually, which is the premise of RFID. In a traditional supply chain rarely can one decrease costs and improve service at the same time, yet an RFID enabled supply chain is not a traditional supply chain. An RFID enabled supply chain is powered by information generated by Smart Auto ID objects embedded into products instead of the traditional bar-code system.

A recent study by Prof. Yossi Sheffi[xiv], Director of MIT School of Engineering's Center for Transportation and Logistics, presented at the 2004 Global Logistics Summit in Zaragoza, Spain pinpoints that an identity collection system based on RFID tags has two advantages over conventional barcode systems. Firstly, RFID will allow automatic scanning which will produce data that can be obtained continuously and thus be more up-to-date than data obtained only at specific intervals (like inventory counts) and specific points in the supply chain (like shipping and receiving). It will also eliminate the human factor, which will result in more accurate and less expensive readings since incremental readings after the system is set up will be virtually cost-free. Secondly, RFID readings do not require line-of-sight and such a touch-less method translates into improved information-collection speed as many tags can be read simultaneously, an ability to read the contents of various transportation conveyances automatically without having to open and sort them, and instantaneous location information particularly when the tagged goods are moving in relation to the reader. Another feature of RFID, also mentioned by Prof. Sheffi, is that RFID technology will provide information unique to each instance of an item as opposed to classes of items, which will allow for unprecedented opportunities for product customization in terms of manufacturing, distribution and even pricing. The German automaker DaimlerChrysler AG, for example, uses RFID tags to boost efficiency on its automobile production lines, by attaching RFID tags to the chassis of each vehicle in production, which automatically transmit data such vehicle options configuration and the color a vehicle needs to be painted. Knowing this information is critical, especially since an E-class Mercedes can be configured approximately 3.9 trillion different ways[xv].

Hence, the premise of RFID can be summarized as increasing service levels which will eventually translate into demand creation while decreasing costs through better resource allocation and financial control. Unfortunately, it is very difficult to measure what is technically called the Service Elasticity of Demand (aka response of demand to services changes.) and that's something that will be specific and unique to each enterprise that decides to deploy RFID whether voluntarily or as a result of having to comply with the Wal-Mart mandate.

Chapter 3. Literature search

3.1 Research done at the Auto-ID Lab (Accenture & IBM Consulting)

Most of the initial research on the business impact of this new emerging technology was done by the researchers at the now defunct Auto-ID Lab, headquartered at the Massachusetts Institute of Technology (MIT) in Cambridge, MA. The Auto-ID Lab started off as an academic research project that aimed to establish a set of common standards and rules for creating a seamless global network of physical objects. Funded mostly by industry business partners, the Auto-ID Lab attracted a plethora of experts who laid the fundamental groundwork through series of business cases. Those were not meant to be one-size-fits-all blueprints of RFID adoption, but rather served to help companies to better clarify their long-term strategy, given the eminent adoption path of RFID by showcasing the macroeconomic benefits and costs associated with this technology. A complete archive of those early business cases is available for download at http://archive.epcglobalinc.org/howtoadopt_business.asp. While all of those cases provided insights into the different ways companies could utilize the technology to

enhance processes within the four walls of their organization, several papers developed by consultants from Accenture and IBM Business Consulting Services actually provided the first snapshots of what the potential benefits of RFID could be through wider adoption across all processes in the supply chain.

According to the Accenture study *Auto-ID on the Line: The Value of Auto-ID Technology in Manufacturing*[xvi], significant benefits can be derived through deployment of RFID technology in the process including but not limited to the following:

- Increased revenues of up to 1 percent from improved quality and customer service.
- Decreased Cost Of Goods Sold (COGS) of 1 to 5 percent from improved overall equipment effectiveness.
- Reduced working capital of 2 to 8 percent from reducing raw materials, work-in-process and finished goods inventories with shorter cycle times and better visibility.
- Reduced fixed assets of 1 to 5 percent from better maintenance and utilization of plant equipment.

Another potential opportunity for value creation through adoption of RFID, Accenture found in demand planning for CPG manufacturers in a paper titled *Auto-ID on Demand: The Value of Auto-ID Technology in Consumer Packaged Goods Demand Planning*[xvii]. It states that bringing certainty via RFID into the demand planning process, could improve demand planning forecast accuracy by 10–20%, which would result in less product being

manufactured and distributed in closer alignment with true demand resulting in favorable trickledown effects for both manufacturers and retailers such as:

Manufacturer Benefits

a) 5–30% lower inventory levels

b) 2–13% lower warehouse and transportation costs

c) 1–5% higher sales

d) 10–50% reduction in lead times

Retailer Benefits

a) 5–8% improvement in store shelf stock rate

b) 5–10% lower inventory levels

c) 2–10% higher sales

d) 3–4% lower logistics costs

Further efficiencies, Accenture also found in the transportation process, where in a paper titled *Auto-ID on the Move: The Value of Auto-ID Technology in Freight Transportation*[xviii], the benefits of better **Asset Utilization, Operational Efficiency** and **Safety and Security** are clearly showcased.

IBM Business Consulting Services through its affiliation with the Auto-ID Lab studied the benefits of RFID further downstream by focusing on the applications of RFID within the Distribution Center and on the Retail Floor. In *Focus on the Supply Chain: Applying Auto-ID within the Distribution Center*[xix], the following benefits in terms of labor

expense, accuracy and throughput in each of the three main labor processes within the warehouse are quantified through the use of RFID:

Labor Expense:

- Receiving – check-in time can be reduced 60-93%
- Picking – through tagging on a case level savings of up to 36% can be generated in the order picking labor
- Shipping – Auto-ID can achieve up to 90% reduction in verification costs

Accuracy:

- Receiving – Auto-ID can achieve a near 100% accuracy while reducing labor from current levels
- Picking – Auto-ID will virtually eliminate errors in picking which will greatly increase shipping and customer service levels
- Shipping – Auto-ID will enable perfect orders, which is the goal of every DC.

Throughput:

- Receiving – Auto-ID will help achieve greater throughput from improved dock-to-stock time as well improved ability to identify and take advantage of X-docking
- Picking – efficiencies will be enabled through automation thus eliminating the need to scan each picked product, and record picked quantities.

- Shipping – Faster shipping times will be achieved through the exclusion of product verification on the shipping dock which will eliminate the need for staging.

And finally, IBM Consulting Business Services focused its attention on the impact that Auto ID would have on the retailers. In *Focus on Retail: Applying Auto-ID to Improve Product Availability at the Retail Shelf*[xx] the benefits were identified in the areas of: receiving accuracy, on-hand stock visibility, replenishment from the backroom, product lifecycle management, cycle counting, physical inventory counts, point of sale scan accuracy and inaccurate replenishment algorithms. While all of those are all valid pain points for any retailer, they all fall beyond the scope of this thesis paper, and we will hence not elaborate on them.

3.2 A.T.Kearney (Chicago)

Another company that did significant research into to exploring the different ways Wal-Mart's RFID mandate would impact the retail supply chain was A.T.Kearney (Chicago). In *Meeting the Retail RFID Mandate*[xxi] A.T. Kearney identified benefits for retailers in three main areas:

- Reduction of Inventory – a one-time cash impacting benefit of as much as 5% of system inventory
- Store and warehouse labor reduction – an annual recurring benefit estimated at a conservative 7.5% of warehouse labor

- Reduction in out of stock – an expected annual benefit of 7 sales dollar basis points (.7%)

A.T. Kearney validated those assumptions after conducting research at a grocer and an over-the-counter (OTC) drug manufacturer. Based on their work, A.T.Kearney estimated implementation costs to be in the range of $400,000 per DC and $100,000 per store.

3.3 AMR Research (Boston)

And finally, to conclude this literature review, we would like to mention AMR Research (Boston), who in addition to publishing a number of research highlights on the RFID subject were also the first firm to quantitatively estimate the system wide RFID Deployment cost for a typical CPG (consumer packaged goods) manufacturer. We consider this to be fundamental given the absence of any cost-sharing between retailers and manufacturers. AMR researcher Romanow estimates the compliance costs for a CPG manufacturer shipping 50 million cases per year.[xxii] to be in the range of $13M to $23M and those are broken down as follows:

$5M to $10M for tags and readers

$3M to $5M for system integration

$3M to $5M for changes to existing supply chain applications

$2M to $3M for storage and analytics of the large volumes of data

In conclusion AMR's Romanow states that actual costs could be much higher if physical infrastructure changes need to be made such as in the case, for example, for products or packaging that contains metal that blocks the RFID signal or others.

Chapter 4. RFID Benefits for a CEM supplier who tags on a case level

While all of the abovementioned benefits are intriguing, we would like to next evaluate the different ways in which a CEM supplier to Wal-Mart could benefit from tagging items on a case level, within an AMR Research's reference model proposed by AMR's John Fontanella[xxiii]

4.1 Individual Process Level

On an individual process level, RFID has the potential to replace existing technology that is used for certain processes, especially for complicated sequential processes where a high degree of information visibility is needed in order to perform the processes accurately or where the processes are extremely labor-intensive. The process of storing and distributing finished products can particularly benefit from the utilization of RFID technology which would initially work together with existing barcodes until those are phased out. A significant portion of the overall supply chain costs are associated with the warehousing process, which makes it an attractive investment center for RFID.

4.1.1 eliminate manual processes

For example, using RFID technology can result in improved efficiency of the inventory receiving process by elimination of the manual processes. As validated by Yantra

Software, accuracy is not an issue with the existing WMS software products that can easily provide accuracy of 99% if all procedures and steps are followed and there is no human error involved in the receiving and put away processes. Accuracy is defined in terms of knowing exactly what products you have and where exactly they are located within the warehouse. In this respect most WMS systems can provide complete visibility, which is continuously validated by cycle counts and periodic inventory counts of high-value items to catch operators' mistakes when certain SKUs are not put away at the correct location as specified by a WMS.

The problem with achieving this high level of accuracy is that it involves high utilization of human labor and this is where RFID can potentially generate operating efficiencies by automating the data collection process within the warehouse/DC. Each DC has its own flow of work, but for purposes of obtaining a general understanding of the typical processes happening in a DC we can assume that a DC is in the business of storing and distributing large pallets or containers containing cases of finished goods moving into and out of trucks or through various parts of the facility. With the assumption that each of those pallets will have an RFID tag and that each case on the pallet will also be RFID tagged, the scanning will occur when the pallet or container passes through a mobile scan tunnel configuration located at the receiving/shipping dock gate, which will be equipped with RFID readers and antennas which may or may not be integrated with a conveyor belt depending on the warehouse set up.

New generation readers such as Alien's 9780 ($1,995) can read a single tag 350 to 400 times a second, and have a built-in ability to turn off tags that have already been read, which speeds up the throughput by eliminating data redundancy since each tag will only be read once in each pass through the tunnel. This information will be then collected by an End Savant (ES) server which deals with collecting and coordinating the information from the readers, motion detectors and perhaps a digital camera that can take a photo of each pallet as they go by. The ES is programmed to associate the unique EPC code from the tag to data stored in a database in the company's servers that contains data from an advance shipping notice (ASN) transmitted via EDI which identifies the pallet in terms of product description, quantities, size, and other relevant information. This data is associated and forwarded to the Internal Savant (IS) which keeps track of the data received from all ESs and is programmed with some type of business logic algorithm which allows it to periodically discard all redundant and old data (i.e. multiple reads of one tag). The IS will then record one instance of a complete transaction and will automatically add the contents of the pallet into the WMS. A simple visualization of the Savant server architecture is shown in Figure 3. The process would be reversed using a similar fashion process when cases of products located on a pallet are shipped out. An added benefit will be the ability of the ES to electronically match the tag information with shipping orders, thus preventing inaccuracies in the shipping process. Total inventory data will be stored in an informational depository at the national IS and will be available for sharing with trading partners over the Internet, which is the essence of the EPC network (see below).

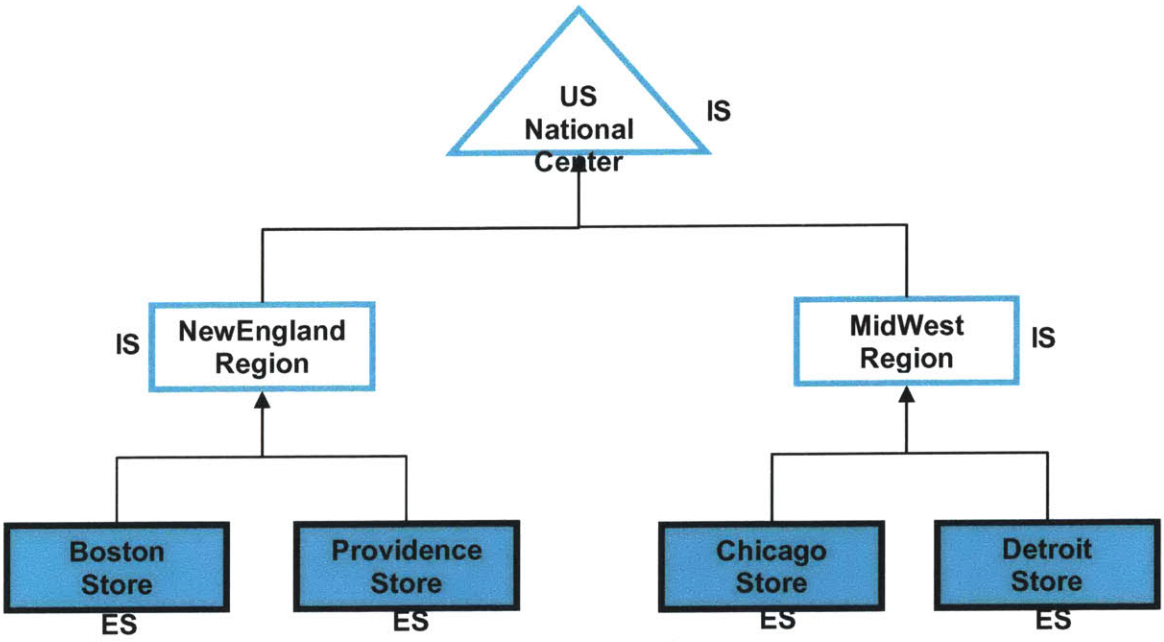


Figure 3. Architecture of a Savant Server Network: (Source: MIT Auto ID Center ©)

In terms of a matrix proposed by Dr. Larry Lapide, Research Director at MIT's Center for Transportation and Logistics, the benefits of implementation of RFID in a DC like that would be as follows:

	Benefits		
Function	Speed	Labor Costs	Accuracy
Receiving	Greatly Improved	Greatly Reduced	Unchanged
Putaway	Unchanged	Unchanged	Unchanged
Picking	Unchanged	Unchanged	Unchanged
Staging	Unchanged	Unchanged	Unchanged
Shipping	Greatly Improved	Greatly Reduced	Greatly Improved

Figure 4. Benefits of RFID

4.1.2 better space utilization

Existing space utilization is another pain point that RFID can address in the warehouse. Most warehouses use racks of different heights (3-high, 5 high, 7-high etc.) and those are usually "strict" locations where only one specific item can be stored in one specific bin. Unfortunately the volumes on a pallet of a single item often differ from one shipment to another and racks bigger than the actual pallet volume are allocated to make sure that the pallet will fit in the designated slot, which results in storage space waste. Assuming that the pallets are not broken up to cases and that each rack slot is RFID-tagged, an RFID-enabled WMS can use information collected from an RFID-enabled 3-D scanner located at the receiving docks of the warehouse to dynamically find and assign the closest available rack location to the dock based on the pallet's volume. That would allow for maximum capacity utilization eliminating situations where a single-level pallet suitable for storing in a 7-high rack is taking up space in a 3-high rack just because that was its designated slot.

4.1.3 reduce the size of the warehouse

Another possible use of RFID technology in a warehouse setting would be to reduce the size of the warehouse, which is an idea proposed by Prof. Sanjay Sarma and Prof. Brian Subirana at MIT. Presently existing WMS use what are called sticky bins, which are bins that are designated for specific items to be put in there. Hence with designated locations in the warehouse the WMS system knows the exact location of all items as their barcodes and the barcodes of the bins are scanned during the put away process and this information is utilized in an algorithm that the WMS uses to optimize routing of the picking process.

With RFID tags on a case level, an WMS can potentially automatically know where all items are at all times without the need for manually associating bins with items, which is traditionally done by scanning and matching the barcodes of the item and the bin. This provides an opportunity to fundamentally redesign the warehouse with several very important benefits stemming from it.

Firstly, instead of using strict locations we can use intentionally-fragmented locations where as soon as pallets of goods are received, the workers can look at what bins they have available and place the cases there without much planning. Random warehouses will have very good storage capacity because with relaxed inventory locations, any new case of merchandise that arrives can be put in the first location available, anywhere, which is a practice already implemented by U.K.-based, fashion-driven manufacturer and retailer of intimate apparel[xxiv], FigLeaf. Unfortunately for FigLeaf, their inbound shipments are not RFID-tagged so they could not fully automate the process, as it would be possible with a CEM warehouse where all inbound cases will be RFID-tagged.

As validated by interviews with CEM executives, what sets CEM warehouses apart from other types of warehouses is that CEMs do not use racks but rather store the merchandise on the warehouse floor. Assuming that all inbound cases are RFID-tagged they could be put anywhere on the floor as each location is also RFID-tagged by installing scores of RFID transponders into the floor to create a multi-dimensional grid. Information about the product locations would be continuously collected by RFID readers mounted on warehouse forklifts going around the warehouse as a part of their routine put away and

picking process. Since thousands of readings will be collected continuously, the Savant server would have to be programmed with logic to discard all redundant information which would also mean that at any point of time their would be a dynamic map of the exact location of every item in the warehouse.

As a result of this location-relaxed situation, you would have cases of the same products scattered all over the warehouse, which would create multiple opportunities to pick the product, depending on what locations are closest to the picker. Hence the WMS system would be able to calculate and come up with a shorter optimal picking route than with traditional sticky bins, at no incremental cost. This "orderly chaos" practice is currently implemented by companies such as Rockport and Amazon utilizing traditional barcode technology, where however accuracy comes at a very high price, since periodic and extensive checks are necessary to maintain the integrity of the system. The benefits of only having to go to whatever points are closest to the picker and not to all points where specific items would traditionally be grouped together are obvious as put away and picking time go dramatically down, and accuracy is managed by the WMS using cost-free data constantly updated by the readers mounted on the forklifts. In cases where merchandise is usually picked up in huge quantities, this system actually creates inefficiencies. Interviewing executives, however, we found out that CEMs doing business with Wal-Mart can benefit from a fragmented warehouse since they regularly ship out mixed pallets and do not face issues such as perishability of the products in which case you would like to adhere to a very strict First-In First-Out (FIFO) inventory system.

Another way that RFID can help reduce the size of warehouse facilities would be through eliminating the need to designate specific sections of the warehouse for otherwise identical merchandise that has been customized for the needs of a specific customer. One example from the CEM industry would be Qualcomm mobile phones which are currently used by a variety of wireless phone service providers that utilize CDMA technology such as: Sprint, Alltel etc. Since the phones are identical, the only difference between a case of Sprint-bound phones and a case of Alltel-bound phones is the company logo stamp on the face of the phone. Because of their non-interchangeability however, a CEM would designate different sections of the warehouse for Sprint and Alltel to avoid any mix-up. RFID technology can prevent such waste of precious storage space since there will be no need to ever separate the cases – they will be put away in the first available bin and the WMS system would use the RFID tag-generated data to find the correct product for each customer.

4.2 Intra-company process level – coordinate multiple tasks inside the four walls

On an intra-company level RFID technology can help achieve greater efficiencies in the execution of business processes across two or more departments within a company by providing important real-time data and translating it into business logic that can be used for seamlessly synchronized executive decision-making.

4.2.1 X-docking

The easiest example to visualize the potential benefits of having this real-time data at the fingertips of the decision makers would be to think in terms of the opportunistic cross

docking process within the four walls of a DC. In a traditional non-RFID enabled warehouse, as new merchandise arrives, the cases from the inbound pallets will be received and held in the interim storage until processed and put away. Often, however opportunities arise to cross-dock merchandise, which can be classified as "real-time" opportunities that were never planned as last-minute or unexpected orders come in and are being fulfilled in real-time. In order to be able to seize those opportunities, the existing business logic requires a level of synchronization between the decision-makers in receiving and shipping, which does not currently exist. Hence, it is often common that cases of one item are simultaneously being picked from the warehouse floor, while identical cases of items are being put away, which results in redundancy of the warehouse labor. Matching automatic RFID information about each case on the arriving pallets and pending shipping orders can quickly detect opportunities for cross docking in a dynamic environment without any manual input as those cases will be transferred from inbound to outbound, thus bypassing the steps of put away and order-picking.

4.2.2 demand – pricing enabled by visibility of the pipeline on a case level

Demand-oriented pricing methods have been around and used by Sales and Marketing to charge different customers differently based on market conditions and customers willingness to pay. It has also been a cause for major tension and mistrust between the marketing and logistics departments in almost any organization as the latter often accuse the former of over-promising and the former blaming the latter for under-delivering. In a nutshell, the main source for this friction between the different departments has been the fact that promising was often based on fixed manufacturing lead times and current

inventory conditions at the manufacturer's warehouse and not on an overall yield management process that takes into account future inventory conditions that may need immediate attention. RFID technology can change that paradigm by providing full visibility of what merchandise is in the supply chain pipeline, which is invaluable information that can be embedded into business logic that will empower the customer service and sales representatives with information at their fingertips of what can potentially be on hand, and at what price based on how long the end customer is willing to wait for their delivery. What this will do is fundamentally change demand management by taking the supply chain and bringing it to the customer based on dynamic lead times, while increasing service level by helping customer service and sales reps execute 100% perfect orders all allowed by the seamless synchronization between demand and supply within the organization.

4.3 Inter-company – coordinate multiple tasks beyond a company's borders

On an inter-company process level, synchronization and coordination of businesses based on real-time data will allow for better business management both upstream and downstream of a supply chain.

4.3.1 upstream

Many CEM suppliers currently outsource some or all of their manufacturing processes to independent business partners located in lower-cost business environments. The relationships between those parties are governed by sophisticated contract agreements that specify acceptable levels of delivery performance, quality parameters etc., and the

related financial penalties associated with each case of finished goods that is not up to the agreed provisions. Breaches of those provisions make both parties worse off because they mean financial penalties for the outsourcing company and out-of-stock inventory positions for the manufacturer which translate into lost sales that greatly outweigh the penalties received in lieu. An RFID-enabled supply chain can mitigate that problem through automation of business processes and notifications amongst business partners beyond a company's borders. A CEM, for example, can automatically keep track of inventory-in-transit deep back in their supply chain pipeline and match it against demand forecasts and actual deliveries on a case level in its warehouse and send electronic reminders to its suppliers well in advance before the delivery schedule is breached, and any economic losses are incurred by both parties. Similarly, a CEM can use upstream data to coordinate merchandise drop-off times with its transportation carrier partners, which will allow it to schedule sufficient warehouse labor available at time of receipt for big shipments thus avoiding overtime pay.

4.3.2 downstream

Downstream visibility has several important benefits too. Firstly, automation of the verification building process can help resolve inventory discrepancies faster, which has been a pain point for many suppliers. Manufacturing executives interviewed for this thesis research, choose to provide somewhat vague answers to the question of how differences are presently resolved, but given Wal-Mart's history of hard-line policy with its suppliers, we suspect that unless the suppliers can clearly prove that the discrepancy is through no fault of theirs, those inventory adjustments are resolved in favor of Wal-Mart.

In this respect, our interviewees unanimously agree to the potential benefits of being able to electronically track the accuracy of all shipments. A proposed framework for real-time verification of shipments utilizing EPC-network is shown below, courtesy of the Auto-ID Center.

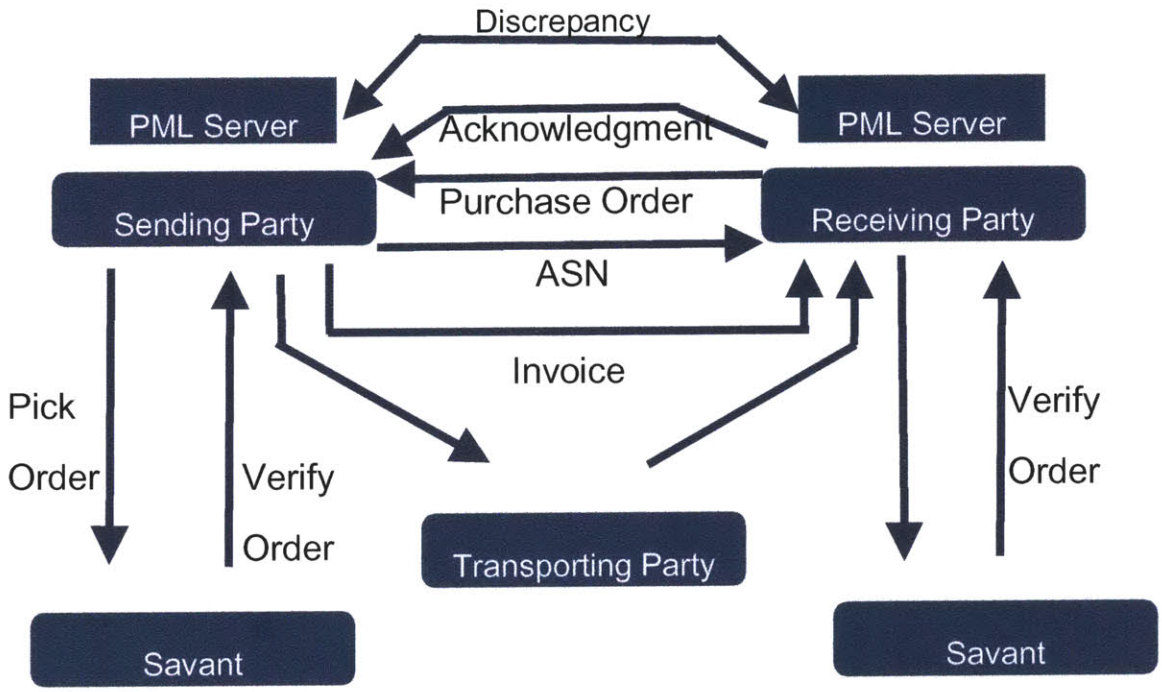


Figure 5. Real-time verification of shipments model. (Source: MIT Auto-ID Center ©)

Another benefit from downstream visibility would be improved opportunities for Collaborative Planning Forecasting and Replenishment (CPFR) & Vendor Managed Inventory (VMI). Wal-Mart currently manages its relationships with its suppliers through their proprietary B2B Retail Link system, which is a decision support system based on series of streams of data that has evolved from the old score cards that Wal-Mart's buyers used to keep on their suppliers. In addition, Wal-Mart gladly works with its suppliers on preparing demand forecasts which are extremely accurate in the aggregate

because they are usually based on forecasting algorithms receiving instantaneous signals from its perpetual inventory system. The ready-availability of more granular information such as consumption of individual instances of products on a case level for each Wal-Mart store, however, would allow for never-experienced before opportunities for customization of the pallets that the upstream sourcing suppliers send to the manufacturer. In a traditional supply chain, those pallets are usually made up of cases of homogenous products which are shipped to the Manufacturer's DC who then breaks them up and prepares customized pallets based on Wal-Mart RDC's aggregate P.O. that are then shipped to Wal-Mart's RDC where those are further customized according to the needs of each individual store. With RFID, the individual needs for each store can be automatically transmitted to the upstream suppliers who depending on their production mix may or may not be able to produce "store-ready pallets", which is a value-added service which can be compensated for by the manufacturer who will generate tremendous labor savings by being able to cross-dock the fully customized pallets straight to Wal-Mart's RDC or even designate them straight to individual stores, without any further action on behalf of the customer's (e.g. Wal-Mart) store management. As far as VMI is concerned, a manufacturer can use EPC information to monitor consumption of its products at the case level in the back of the partner's retail store and replace those on an as-needed basis, eliminating many meaningless trips by its replenishment people who routinely stop by each store on their route to manually record on-hand inventory levels. Alternatively, a manufacturer can equip its reps with hand-held RFID readers that will be capable of collecting in-stock information instantaneously saving the reps time that they would normally spend counting. Then that information could be shared on a regular

basis with the partner's e-portal to ensure integrity of the inventory system. In a nutshell, deploying RFID on an inter-company level would enable inventory signals for each store on a case level throughout the manufacturer's supply chain to be transmitted without much delay or bias, which is often the case when human interaction is required.

4.4 Synchronization – the notion of the totally efficient supply chain

Ultimately the idea would be to use RFID to synchronize the whole supply chain from sourcing of raw materials to the final consumer, which would result in a totally efficient supply chain based on a production-to-consumption manufacturing system where runs of the same product would be produced more frequently in smaller batches. That would eliminate the paradoxical situation where as a result of inflexible production scheduling issues, large inventory of slow-moving inventory would often build up while items that as a result of a retailer's promotion or any other external factors (i.e. sky-rocketing increase in sales of mosquito spray in the middle of a West-Nile virus scare) suddenly became fast-moving items will be nearly out-of-stock. Furthermore, demand-driven replenishment and new distribution models based on dynamic information sharing between partners would result in an uninterrupted flow of more predictable orders being fulfilled at a greater frequency which would serve to eliminate the need to carry excessive amounts of inventory in the supply chain pipeline to satisfy oscillating swings in demand resulting from the Bullwhip effect associated with uncertainty of the demand. The importance of the aforementioned two fundamental changes in established business practices can only be fully appreciated if one looks at a typical CEM inventory position. On an average day in 2003, for example, the existing supply chain pipeline of Royal

Philips Electronics N.V. held approximately $4 billion worth of products[xxv], which is a number that can be cut by 25% with real-time demand-driven replenishment and distribution while simultaneously shortening the average trip through the pipeline from current 63[xxvi] to as little as 45 days, as we estimate.

Finally, a fully-synchronized supply chain network based on RFID technology has the potential to not only reduce overall supply chain costs for all parties involved but to also improve customer satisfaction at the retail level through a cutback of incidences of stock-outs enabled through dynamic replenishment and more predictable demand. Stock-outs for a CEM today average anywhere from 5 to 8%, and the reduction of those numbers can further add to a CEM's revenue. For an average CEM, a 10% to 20% reduction in existing stock-out levels could increase revenue by 1% for low-value items shipped in cases or even as much as 2% for high value items fast-moving items that would be tagged on an item level, which for example in the case of Royal Philips Electronics N.V. would result in at least $360 million "hard" revenue boost not taking into consideration the corresponding "soft" benefits of repeat business and customer loyalty from being able to differentiate the company's products through increased customer satisfaction. Looking at the whole value stream, the outsourcing suppliers will incur a penalty, since they will not be able to move their goods into the CEM's pipeline as fast as before and some may have problems making the necessary technological changes, yet the ones willing to adapt will be rewarded with longer term contracts and higher volumes to guarantee a win-win relationship. Leading companies such as Procter & Gamble are thinking along the lines of that vision and are actively pursuing restructuring their supply chains around RFID[xxvii].

Chapter 5. Overview of the implementation Scenarios

Manufacturers have various alternatives regarding where to apply tags on both pallets and cases in the supply chain. Those alternatives are defined as the intersection of choice of tags to be applied and technical capabilities to physically apply the tags at different points of the supply chain. There is no ideal point in the supply chain to apply the tags since each CEM's supply chain differs. Some potential points would be as follows:

5.1 Slap and Ship model (S@S)

Slap and Ship model - tagging at the outbound dock of a DC – provides the greatest level of flexibility in terms of only having to tag items that are being shipped to Wal-Mart, DoD, Target and other retailers that are RFID-enabled, since tags currently represent a major cost in the RFID-compliance initiative. It is relatively easy to implement since it will require RFID-enabling in as little as one DC, provided that it can handle all outbound Wal-Mart volume. Alternatively, in the case of a DC shipping to multiple customers, outbound shipments going to Wal-Mart can be physically separated from the rest of the inventory through the use of designated shipping docks. Furthermore, this model will be the fastest and easiest to implement since it will involve virtually no change in the business processes currently in place except for the addition of a tag-writing machine at the shipping dock and a reader to record the shipment and create an ASN to be forwarded to the Retailer. No apparent "hard" benefits will arise out of a "slap-and-ship" scenario for the suppliers, yet RFID-implementation at the customer level will result in readily-available granular real-time demand data, which if shared, can be used to produce a more

accurate demand forecast and production planning. One downside of that approach is that it provides a short-term fix, yet doesn't provide a long-term solution as Wal-Mart would eventually roll out a national RFID mandate, in addition to the three Texas DC locations, which would make shipping out on a national scale from a single DC prohibitively expensive.

5.2 Tag at the Receiving dock of DC (T@R)

Tagging at the receiving dock of the DC will be a viable model only if the CEM's DC itself is RFID-enabled to be able to capture and utilize all the information that will be available at management's fingertips. The downside of that model is that it will considerably slow down the receiving process and create bottlenecks at a critical point for every DC point and should be avoided at any cost. In the worst case scenario pallets will be pushed to the side and stored for extended period of time until RFID tags are applied to them which will add a completely unnecessary process between the Receiving and Put away steps.

5.3 Tag packaged item at the end of manufacturing process before shipping to DC (T@M)

Tagging packaged item at the end of manufacturing just before shipping to DC is a viable alternative for CEM Manufacturers with sophisticated ERP and WMS systems in place as meaningful information can be generated and transferred using the EPC network between different nodes in the Manufacturer's supply chain. For example, an RFID-enabled three-dimensional reader/scale system can be installed at the outbound dock that will at the point of shipping record the three dimensions of the package (height, width and

length) and weight and then write those as properties to be associated with this particular case. Knowing this information can be very useful and meaningful for the DC managers for several reasons. Firstly, it would allow them to check for shrinkage at the receiving point if any of the dimensions of the package have changed during the transportation process. Secondly it would allow them to plan in advance for X-docking opportunities since they would know the physical dimensions of the inbound goods and can match them against available space in outbound carriers well ahead of time. Thirdly, it would allow them to generate efficiencies in all five steps of the warehouse inventory physical management process by allowing them to eliminate the time-consuming manual processes associated with traditional barcode-managed inventory. In the **receiving** process, RFID-tagging on a case level will eliminate the need for barcodes on each case to be individually scanned. **Put away** will be done using the first available bins randomly placing products throughout the warehouse. **Picking** will also be done more efficiently as random placement of products will result in shorter picking routes for individual cases of a product. **Staging** will be shortened through eliminating the need for manual audits of each pallet. And finally, **shipping** will be done with a greater level of accuracy as readers located at the shipping dock will automatically match the contents of an outbound pallet with the P.O. from which it was put together. Fourth, with global outsourcing, in which most manufacturers produce some or all of their products overseas in less labor-costly environments, additional savings can be generated by using cheap labor to apply the tags. Hewlett-Packard, example, has started requiring its Taiwanese suppliers to embed RFID tags on the pallets or cartons of shipments with the cost being shared, at least initially[xxviii]. Fifth, in the case of products that would be imported to the

US, additional savings can potentially be achieved in the customs-import process by being able to convey to the Customs and Border Protection Bureau the fact that each package comes with electronically traceable supply chain history in return for expedited customs processing times. Speaking on an RFID panel in Washington, DC[xxix], Mr. Stewart Verdery, assistant secretary for border and transportation security policy and planning, validated the assumption that RFID could help the Homeland Security Department do its job better through gaining greater confidence in those [RFID] supply chains "thereby lessening the need for us to come in with some kind of one-size-fits-all regulatory structure".

Chapter 6. Benefits and Costs of Implementation Scenarios

Each of those scenarios has a certain set of benefits that an organization needs to take into account when deciding on a level of deployment for RFID, based on its short-term and long-term corporate strategy and objectives. While those benefits are based on existing processes, management should not lose sight of the possibility that RFID technology can help their company invent totally new business models accompanied by new processes and benefits beyond our imagination. At the same time, depending on the type of products processed, barcode technology can still be more cost-efficient for a long time to come. For the time being, however, we have intentionally decided to break present-day achievable benefits down by Income Statement and Balance Sheet account benefits so that the ultimate decision makers will be able to determine at a glance the different ways in which RFID could affect their organization in terms of operating effectiveness versus better asset utilization. The first critical group of benefits could possibly generate ROI by

raising sales volume without eroding price levels, not so much through traditional demand creation as much as by being able to increase service level on a par with the service level increase at the RFID-enabled retailers. The second set of benefits arises in the area of financial control where RFID technology can be used as leverage lower costs in the areas of administrative costs, warehousing and transportation, as more predictable order patterns will allow opportunities for advance planning and scheduled shipping. And finally RFID can help with the better allocation of resources such as money invested in inventories, equipment and facilities, which can all be summarized as more efficient use of capital.

		Implementation Scenarios		
Benefits		S@S	T@R	T@Mfg
Income Statement		-	-	-
	Revenue Enhancement (Sales)			
	Reduce OOS situations	Yes	Yes	Yes
	Preferred Supplier for RFID-enabled retailers	Yes	Yes	Yes
	Rapid Response to Demand			
	Cost Reduction (COGS)			
	Decrease Warehouse Receiving Time	No	No	Yes
	Decrease Warehouse Put Away Time	No	Yes	Yes
	Decrease Warehouse Picking Time	No	Yes	Yes
	Decrease Warehouse Staging Time	No	Yes	Yes
	Decrease Warehouse Shipping Time	No	Yes	Yes
	Decrease Warehouse Shrinkage	No	Yes	Yes
	Reduce Overtime Due to Better Scheduling	No	No	Yes
	Reduce Backorder Costs	No	No	Yes
	Increase Accepted Shipments Accuracy	No	Yes	Yes
	Improve Picking Accuracy	No	Yes	Yes
	Improve Outbound Shipping Accuracy	Yes	Yes	Yes
	Improve Invoice and Billing Accuracy	Yes	Yes	Yes
	Allow for Opportunistic X-docking	No	Yes	Yes
	Allow for Dynamic Routing	No	Yes	Yes
	Lower Inbound Freight and Delivery Costs	No	No	Yes
	Reduced Customs Processing Expenses	No	No	Yes
	Variable Overhead Expenses			
	Less Accounting/Admin Staff Needed	Yes	Yes	Yes
	Fixed Expenses			
	Better Leased Asset Utilization	No	Yes	Yes

Balance Sheet				
	Inventory			
	Decrease Safety Stock	No	Yes	Yes
	Increase Inventory Turns	No	Yes	Yes
	Accounts Receivable			
	Speed-up Payment Settlement Process	Yes	Yes	Yes
	Other Current Assets			
	Deferred Tax Assets	Yes	Yes	Yes
	Fixed Assets Utilization			
	Increase Warehouse Capacity Utilization	No	Yes	Yes

Figure 6. Reference Table of Benefits

The costs of RFID deployment will vary from organization-to-organization based on the desired level of deployment and the infrastructure. To provide a basic framework within which RFID investment can be considered, we have divided the costs by Fixed (one-time) and Variable (per annum) costs. The task of actually quantifying the cost of deployment of RFID technology in an organization or in a particular process is however, beyond the scope of this thesis paper. RFID consultants that we interviewed have revealed certain algorithms that can be used to estimate the cost of deployment such as ratios between the number of antennas that each multiplexer can serve and the amount of date transmitted but given the rapid rate with each RFID technology is developing, those become quickly obsolete. New generation multiplexers, for example, can operate numerous antennas with only one reader. Hence, we would not provide advice in that matter but rather list some of the typical costs that need to be taken into consideration before any RFID deployment decisions are made.

Typical Costs	
	Fixed (One-time)
$ 25 - 500	Antennas
$ 200 - 1,000	Readers
$ 500 - $2,000	Multiplexers
$ 4,400 - 7,000	RFID Printers
$ 10/sq.ft	Gold-plated Cabling
$ 3,000 - 10,000	Controller Software
$ 250,000 - 500,000	Custom ERP/WMS Middleware
$10/100 Sq.ft.	WiFi Coverage
	Variable (Per Annum)
$ 80,000 - 100,000	IT staff to maintain RFID system
$ 10,000 - 20,000	Hardware and software maintenance
$ 10,000 - 20,000	Ongoing Service costs
$ 8,000 - 10,000	Staff Training
$ .25 - .40/tag	Passive RFID Tags

Figure 7. Reference Table of Costs

Chapter 7. ROI Model for The Warehouse

Proposed Methodology (Copyrighted to MIT / MIT Sloan Working Paper No. 4450-03)

A recent MIT research paper[xxxi] by Prof. Brian Subirana and Prof. Sanjay Sarma actually attempts to provide a blueprint that companies can use to quantify the value proposition of RFID adoption in business process performance metrics, which can help companies prioritize their investments. In the case of a Consumer Packaged Goods (CPG) warehouse, the methodology of quantifying the value and productivity of RFID investments would consist of the following steps.

1) Determine objective of estimating process performance metrics.
2) Analyze the existing business processes by utilizing a process mapping tool – MIT Process Handbook[xxxii] is a good example of a tool that can be used.

3) Pick a specific process and dig down into the ways in which RFID could improve efficiency and accuracy (i.e. receiving pallets into the warehouse, involving a fork truck, a computer terminal and a barcode scanner).
4) Define performance metrics for RFID-enabled new processes that would replace the existing manual processes (e.g.Case level tags read with 100 %accuracy, pallet identification barcodes replaced with RFID, RFID replaces the manual entry of data into the WMS eliminating need for manual data-entry and barcode scanning)
5) Analyze how would RFID-implementation change the existing processes and document the changes.
6) Make a comparison between metrics that describe the current process ("as-is" metrics) and future RFID-enabled process ("to-be" metrics): those may include metrics such as: Average hourly cost of forklift worker, Average hourly cost of fork truck maintenance, Average cost per barcode label including data input time into WMS to create association with product, Average amount of time it takes for one iteration of the particular process to be performed, Average number of pallets handled per week by the process etc, (process-specific metrics that will be different for each process)
7) Spread the metrics through existing steps in the process – come up with a effort/time allocation for the different steps that constitute one iteration of the existing "as-is" process. Do the same for "to-be" process making sure to account for steps that will be eliminated by RFID technology.

8) Apply dollar value by combining time to perform the process times the average cost of the metrics without RFID "as-is" and with RFID "to-be" to determine the cost-savings of RFID.
9) Explore opportunities for similar savings in other processes and quantify the overall value proposition by incorporating implementation costs and savings into a discounted cash flow (DCF) model for an estimated useful asset life of 7 years.

Chapter 8. How do I estimate parameters that drive the warehouse ROI model?

The method described above relies heavily on business process analysis, which looks at the individual steps involved in completing each process and looking for ways that RFID technology can create efficiencies, augment or completely eliminate some of those steps. Each company has its own unique process of performing the individual processes and as a result there is no generic blueprint of each process that one can copy and analyze. Process analysis is best done through a combination of personal observation, interviews with the warehouse personnel and video-taping of the operations. Below is an example of steps involved in a receiving process that occurs on a daily basis in every warehouse, as recorded by Mr. Dennis Duckworth, an MIT Master's student in the Engineering Systems Division, who allowed us to use it to illustrate the business analysis process.

Example of a Receiving Process:

1. Merchandise gets dropped off on the receiving dock.
2. Receiving staff physically verify information from the factory-generated Packing Slip to actual by scanning individual barcodes as well as SSNN master barcode

   2.1 Scan each case

2.2 Add up quantity of product and reconcile to Packing Slip

3. Receiving Supervisor manually logs into WMS

   3.1 Manually identify event 1 (i.e. location – Northeast USA)

   3.2 Manually identify event 2 (i.e. movement – receipt)

   3.2 Manually identify event 3 (i.e. warehouse – Cambridge, MA)

   3.3 Manually enter event 4 (i.e. P.O. number or Packing Slip)

   3.5 Manually enter event 5 (i.e. Employee ID Number).

4. WMS retrieves relevant shipment data.
5. Supervisor visually verifies that WMS data matches with receiving log information
6. Supervisor visually confirms the following information.

   6.1 Units per box

   6.2 Storage unit type

7. Supervisor confirms for WMS to store information
8. The product is now officially received by the warehouse.
9. Receiving Supervisor places a "Storage" sign on the transport cart and receiving staff physically move pallet with cases on it for storage in the warehouse.
10. Warehouse personnel places goods in storage. This process has not been detailed.

Once the users have identified all the steps involved in the analyzed process "as-is" the same steps are analyzed in terms of whether those will exist, be eliminated or perhaps new steps will need to be added through the deployment of RFID. Once that is done, the users need to think of the financial and performance metrics that are involved in each of

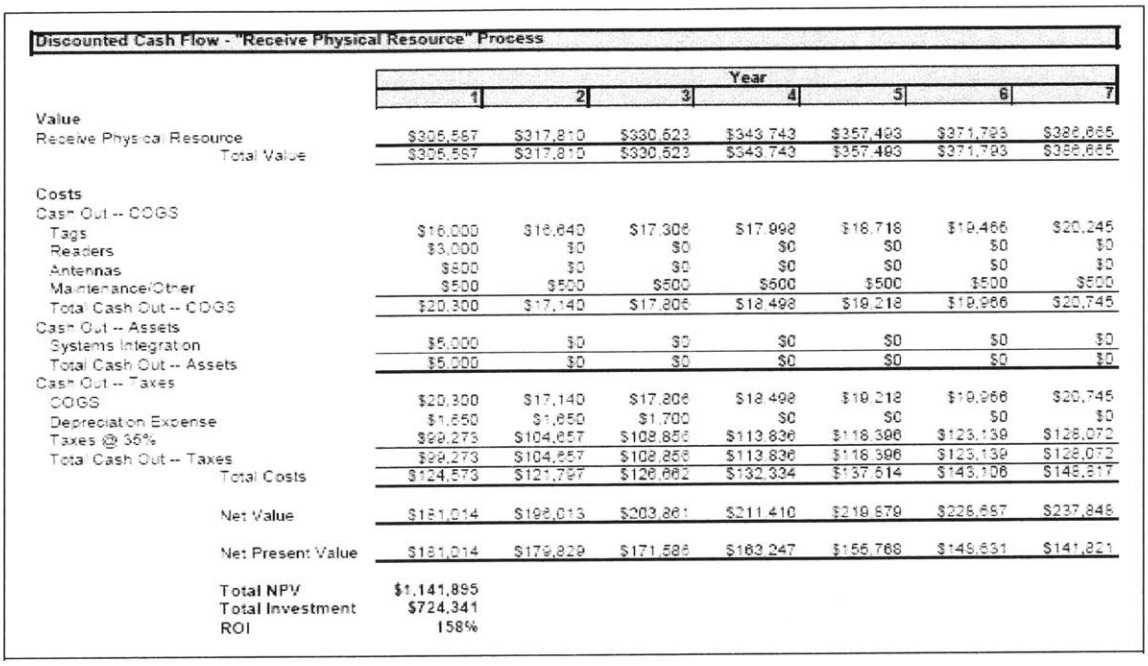
the steps of the existing processes through analysis of cost reports to see what is included when calculating the costs of each process. *Subirana et al*, for example, looked at metrics such as the average hourly cost of fork truck operator, average cost per barcode label, average time it takes to perform on iteration of the process, average number of pallets and cases handled per week by the process, etc. Those metrics will be different for each process, yet they all have to be quantitative to allow them to be combined with actual cost data that will show the cost of performing the process "as-is" compared as "to-be" as enabled by RFID, which would provide a bottom line number of savings per year generated by the process, excluding all costs involved of achieving the benefit. This process of calculating bottom-line process savings resulting from RFID technology deployment is illustrated in Figure 8 below:

Value Generated by RFID - "Receive Physical Resource" Process

	As-Is	To-Be
Process duration (in seconds)	240.00	40.00
Process duration (in minutes)	4.000	0.667
Saved		3.33
% improvement		83.3%
Pallets per hour	15.00	90.00
Pallets per week (constant)	6000.00	
Barcode labels per pallet	2	
Hours per week to perform process	400.00	66.67
Variable Costs		
Cost per hour of fork truck operator	$15.00	
Cost per hour of fork truck	$2.00	
Cost per barcode label	$0.0175	
Cost of process - fork truck and operator		
Per week	$6,800.00	$1,133.33
Per year	$353,600.00	$58,933.33
Cost of process - barcode labels		
Per year	$10,920.00	$0.00
Total cost of process per year	$364,520.00	$58,933.33
Savings per year		$305,586.67

Figure 8. Illustration of Savings per Year (Source: *Subirana et al*)

This yearly benefit can next be included in a standard Discount Cash Flow (DCF) that incorporates a list of all input parameters which can be broken up by variable year-over-year and fixed parameters. Variable input parameters will include the cost of tags, number of tags, cost of RFID readers, number of RFID readers, and cost of antennas, number of antennas, cost of system integration, maintenance expense and all other expenses affected by the level of deployment and the nature of the process. The variables are then assigned a burden rate based on what percentage of all warehouse activity does each process represent, so that an appropriate portion of the variable costs are assigned to the process. For example a 5% process will bear 5% of all the warehouse integration costs and a 100% of all costs of variables specific to the process such as readers and antennas at the receiving dock. Fixed input parameters will be those components of costs that are company wide and will not be affected by RFID, such as cost of capital, sales growth rate, tax rate etc. The fixed parameters are essential in calculating the true cost of RFID deployment since the expected benefit of RFID will increase year-after-year proportionately to Sales growth and also depreciation expense and tax expense will need to taken into consideration. All those parameters will be then included in a DCF over the expected useful life of the RFID infrastructure which *Subirana et al* estimated to be 7 years, which would produce a Net Present Value (NPV) of the project that can be used to calculate Return On Investment (ROI). *Subirana et al,* quantified the value proposition of using RFID in the warehouse receiving process of a CPG manufacturer and concluded that significant positive ROI existed for that process. An illustration of an ROI calculation adhering to this framework is found below in Figure 9.



Discounted Cash Flow - "Receive Physical Resource" Process

	Year 1	2	3	4	5	6	7
Value							
Receive Physical Resource	$305,567	$317,810	$330,523	$343,743	$357,493	$371,793	$386,665
Total Value	$305,567	$317,810	$330,523	$343,743	$357,493	$371,793	$386,665
Costs							
Cash Out -- COGS							
Tags	$16,000	$16,640	$17,306	$17,998	$18,718	$19,466	$20,245
Readers	$3,000	$0	$0	$0	$0	$0	$0
Antennas	$800	$0	$0	$0	$0	$0	$0
Maintenance/Other	$500	$500	$500	$500	$500	$500	$500
Total Cash Out -- COGS	$20,300	$17,140	$17,806	$18,498	$19,218	$19,966	$20,745
Cash Out -- Assets							
Systems Integration	$5,000	$0	$0	$0	$0	$0	$0
Total Cash Out -- Assets	$5,000	$0	$0	$0	$0	$0	$0
Cash Out -- Taxes							
COGS	$20,300	$17,140	$17,806	$18,498	$19,218	$19,966	$20,745
Depreciation Expense	$1,650	$1,650	$1,700	$0	$0	$0	$0
Taxes @ 35%	$99,273	$104,657	$108,856	$113,836	$118,396	$123,139	$128,072
Total Cash Out -- Taxes	$99,273	$104,657	$108,856	$113,836	$118,396	$123,139	$128,072
Total Costs	$124,573	$121,797	$126,662	$132,334	$137,614	$143,106	$148,817
Net Value	$181,014	$196,013	$203,861	$211,410	$219,879	$228,687	$237,848
Net Present Value	$181,014	$179,829	$171,586	$163,247	$155,768	$148,631	$141,821
Total NPV	$1,141,895						
Total Investment	$724,341						
ROI	158%						

Figure 9. Illustration of ROI calculation for RFID (Source: *Subirana et al*)

We deem the above-mentioned ROI model as an excellent attempt to determine the value proposition of RFID in a specific process, and we recommend it as a blue-print for any organization that attempts to quantify the annual savings that RFID can bring to a specific warehouse process. The model however was not designed and should not be used to appropriately quantify the value of RFID deployment across the entire organization of a Wal-Mart supplier. Unlike a specific process, a company can not allocate an appropriate burden rate for each cost involved in the warehousing process since a company under the Wal-Mart RFID mandate has no choice but to fully comply with the mandate. Indeed, only a few select labor-intensive high-yield processes will generate positive ROI standing alone, yet significant benefits can be expected if all processes were RFID-enabled and could be executed in a coordinated manner, without much need for manual synchronization. In addition we believe that calculating ROI as way to measure the

performance of any one particular process is only meaningful in the context of measuring its impact on the performance of the entire organization (i.e. the entire warehouse.) For example, if an organization attempts to satisfy the Wal-Mart mandate by RFID enabling only a few selected processes, negative ROI may be generated since the benefits created by those few processes can be more than offset by the full cost of RFID deployment. This is why it is important to take a wider view of the entire business organization in a ROI model, as discussed below.

Chapter 9. Proposed company-wide ROI/ROA Model

Providing a meaningful return on investment (ROI) analysis for a company –wide deployment of RFID technology is very difficult to accomplish. Costs are somewhat easier to quantify than benefits, yet it is the cost-saving effect of the benefits that will eventually translate into ROI. After considering a number of different models such as Economic Value Added (EVA), Residual Income (RI), and a number of non-financial performance measures (NFPM), we eventually concluded that the DuPont financial model would probably be the best way to visualize the impact of RFID deployment as ROI is best illustrated in monetary terms. Usually ROI is achieved either through increase in revenue or reduction in hard costs, accompanied by some soft cost benefits which can differ from one industry to another. In the case of a CEM supplier of Wal-Mart the value will result from a combination of all of those. As illustrated in Figure 5 Sales Enhancement will be a result of three factors. Firstly, RFID tagging on a case level will reduce out-of-stock situations on the retailer's store, which would translate into an increased number of much more predictable retailer's orders from the CEM (increase in

revenue from operations). Furthermore, RFID would enable the CEM to establish itself as a preferred supplier for retail chains and customers that are also RFID-enabled, and are looking for other partners who are RFID-enabled in order to reap the benefits of a fully RFID-enabled supply chain (acquisition of new customers). And finally, through real-time automated information sharing CEMs will be able to rapidly respond to market fluctuations through shifts in production schedule based on demand signals. On the Cost of Goods Sold (COGS) side significant savings will be realized as a result of the new efficiencies made possible by RFID. Beyond that, the biggest cost savings will be achieved through the automation of tasks previously done exclusively manually in the warehouse which will eliminate the potential for human errors and potentially reduce the human resource needs of the organization. Similar savings will also be achieved in variable expenses in the area of Sales, General and Administrative expenses as fewer administrative and accounting people will be needed to monitor operations and resolve invoice disputes, incomplete shipments and other labor-intensive administrative tasks. It is worth mentioning here that those savings will not be expressed in absolute dollars figures but rather in lower cost per unit processed (higher profit margin per unit) since the expected increase in throughput would require sufficient human resources to process the extra workload. Fixed Expenses will also decrease mostly in the aspect of leased equipment assets which will be better utilized through RFID-tagging. From a Balance Sheet – standpoint the biggest savings will be generated as a result of decreased inventory levels in the CEM pipeline enabled by the inventory visibility provided by RFID in terms of shorter lead times which will translate into decreased safety stock and increased inventory turnover. Furthermore, the EPC network will use RFID-automatically

generated data to streamline the payment settlement process which would result in lower Accounts Receivable outstanding. Other Current Assets would be mildly affected with a potential Deferred Tax Liability resulting from accelerated tax depreciation of the core RFID fixed assets infrastructure offsetting existing Deferred Tax Assets (DTA) on the books provided that they originate from similar type transaction. It is important to not that a gross DTA related to unrealized capital losses could not be offset against an ordinary income DTL, but those can be offset if they are both related to depreciation expenses differences for tax and financial reporting. And finally, RFID can generate ROI by decreasing dollars invested in fixed assets (i.e. warehouse space), provided that those assets are no longer fully utilized. As the DuPont model illustrates below RFID affects all ROI components and we will try to illustrate that for a CEM supplier of Wal-Mart.

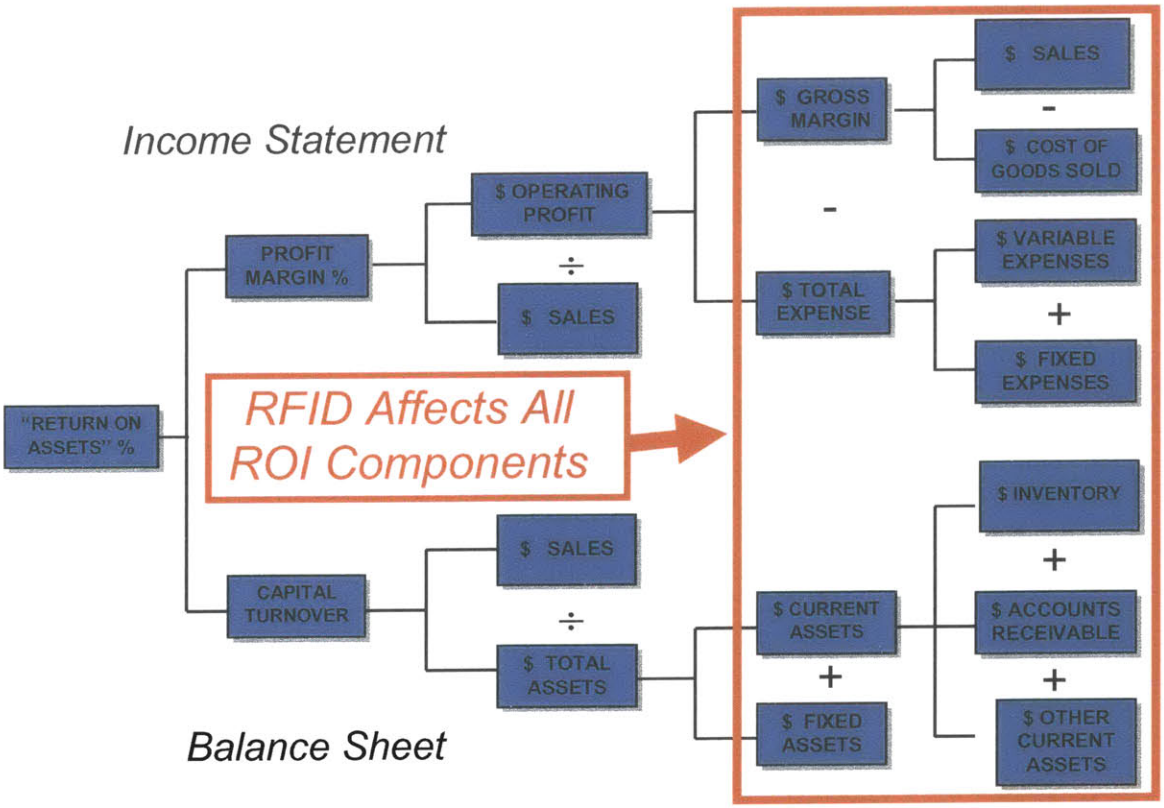


Figure 10. DuPont Model

Chaper 10. Illustrative Use of the ROA Model

Assuming AMR's cost calculations that state the cost of RFID compliance for a CPG manufacturer shipping 50 million cases to be between $13MM and $23MM per year are correct. We obtained from Hoovers[xxxiii] on-line database the 2002 Financial Statements for an actual CEM supplier of Wal-Mart to quantify our model. All of our assumptions were based on a downstream RFID-enabled supply chain (simple Wal-Mart RFID compliance) and approximately 20% of all outbound shipments going to RFID-enabled customers such as Wal-Mart and Target, which is the actual case for this particular CEM. We made the following assumptions to illustrate the model's use:

- **Sales:** Given annual sales of $12,006 (mil) using a conservative 1% increase in sales for the 20% market share going to RFID-enabled customers, we estimated an increase of sales due to elimination of out-of-stock situations of $24MM, which is a number that by itself pays off for the cost of RFID compliance in one year.
- **COGS:** A 5% decrease in COGS for the same 20% market share generated another $89MM in savings as COGS went down from $8,719 to $8,632.
- **Variable & Fixed Expenses:** Conservatively assuming no immediate savings in terms of variable and fixed expenses because of the increased throughput, we added the full cost of $10MM for tags and readers to the Variable Expenses and $13MM for integration and changes to existing supply chain application to Fixed Expenses. Please note that for purposes of being conservative in calculating ROA in this particular instance we will assume that the full cost of the Fixed Expenses

will be written-off in the first year, whereas one would normally depreciate those costs over the estimated useful life of the assets.

- **Inventory:** The next big savings for this CEM came from a conservative 15% reduction of inventory levels for the same 20% market share that currently goes to RFID-enabled customers, which reduced inventory from $1,134 to $1,099.
- **Accounts Receivable:** Similarly, accounts receivable (A/R) also went down assuming that RFID would speed up the settlement process with its RFID-enabled customers by 10% from $3,480 to $3,410, which is a reduction of A/R of $70MM at year-end.
- **Fixed Assets:** And finally since all fixed asset are located within the four walls of the organization, a reduction of 2% of all fixed assets was assumed, which is reasonable given the fact that management constantly seeks ways to decrease dollars invested in assets that are not productive. As a result Fixed Assets went down from $1,912 to $1,874.

We followed the DuPont model with those assumptions and that produced a post-RFID ROA of 12.47% compared to pre-RFID ROA level of 10.94% and improved capital turnover ratio of 1.78 compared to 1.74 before. While this example is strictly hypothetical and based on a number of assumptions, it illustrates how to apply the model and highlights potential benefits of RFID deployment within a CEM, even at the simplest compliance level. Summary of the results is found below:

Annual Financials			
Income Statement (All dollar amounts in millions.)			
	Pre-RFID	**RFID Change**	**Post-RFID**
Revenue	$ 12,006.00	$ 24.01	$ 12,030.01
Costs of Goods Sold	(8,719.00)	87.19	(8,631.81)
Gross Profit	3,287.00	111.20	3,398.20
Gross Profit Margin	27.38%	0.87%	28.25%
SG&A Expense	(2,013.00)	(23.00)	(2,036.00)
Depreciation & Amortization	(520.00)	-	(520.00)
Operating Income	754.00	-	842.20
Operating Margin	6.28%	0.72%	7.00%
Non-Operating Income	(102.00)	-	(102.00)
Non-Operating Expenses	(161.00)	-	(161.00)
Income Before Taxes	491.00	88.20	579.20
Income Taxes	(66.00)	(11.86)	(77.86)
Net Income After Taxes	425.00	76.35	501.35
J/E Adjustment	15.00	-	15.00
Continuing Operations	440.00	76.35	516.35
Discontinued Operations	0	-	-
Total Operations	440.00	76.35	516.35
Total Net Income	$ 440.00	$ 76.35	$ 516.35
Net Profit Margin	3.66%	0.63%	4.29%

Figure 11. Potential Income Statement Impact of RFID deployment on compliance level

Partial Balance Sheet (All dollar amounts in millions.)			
Cash	$ 1,725.00	-	$ 1,725.00
Net Receivables	3,480.00	(69.60)	3,410.40
Inventories	1,134.00	(34.02)	1,099.98
Other Current Assets	369	-	369.00
Total Current Assets	**6,708.00**		**6,604.38**
Net Fixed Assets	1,912.00	(38.24)	1,873.76
Other Noncurrent Assets	2,830.00	-	2,830.00
Total Assets	**$ 11,450.00**		**$ 11,308.14**

Figure 12. Potential Balance Sheet Impact of RFID deployment on compliance level

Chapter 11. Recommendations for Maximization of ROI in RFID

Several factors are critical when successfully implementing an RFID deployment in any organization. Firstly, a clear understanding is needed within management that "You are not going to get ROI immediately" as stated by Mark Engle, director of IT at Campbell Soup to ComputerWeekly[xxxiv]. Next, meticulous analysis of the existing legacy

WMS/ERP systems needs to be done to carefully evaluate if their technical specifications would allow tracking unique instances of individual items as opposed to the traditional product classes for which they were designed, and recording and storing all the pertinent data for each unique instance of an item traveling throughout the supply chain. Ideally, it would help keep costs down if the existing legacy systems could be retro-fitted or used with some minor modifications, yet if that is not the case, perhaps the RFID deployment can be timed to coincide with the next scheduled system upgrade. And finally, the importance of picking appropriate hardware that will support multiple RFID standards (Passive, Active, GPS, microwave) simply can not be overemphasized. Nobody can predict what direction will RF standards evolve in the future and businesses need to be prepared for the possible scenario of different partners in their supply chain adopting different RF standards based on their specific operating needs and the technical capabilities of each technology. Hardware investment including RFID data servers represents a significant percentage of the overall RFID infrastructure cost and it would be very difficult for a company to switch later if it realizes that its chosen hardware does not fit its specific needs in terms of cross-functionality and long-term scalability.

Chapter 12. Summary

In summary, we believe that even though certain proprietary benefits of RFID can be achieved on an individual process level, education and collaboration should be extended to all partners in the supply chain because only through full "cradle-to-the-grave" RFID deployment throughout the entire supply chain can RFID technology realize its full potential. Without full collaboration the floods of RFID-generated data will remain useless bits of zeros and ones with no significant tangible benefit associated with them.

ENDNOTES

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