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Auto-ID on the Line: The Value of Auto-ID Technology in Manufacturing

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Auto-ID Technologies Bring Sweet Success to Candy Maker

CHICAGO – What could have been candy manufacturer Choc-o-lot's worst nightmare recently turned out to be anything but, thanks to the company's recent implementation of Auto-ID technology. Choc-o-lot is the leading manufacturer of quality chocolate confectionery and a major seller of candies in 25 countries worldwide.

In preparing for the Halloween-to-Christmas season – when Choc-o-lot does 75 percent of its business – the candy maker needed to make sure all its operations went smoothly so that its products would be delivered on time to merchants and stores. All was going according to plan until the company was notified by a supplier that a previous shipment of ingredients was potentially contaminated and that the products using the ingredient needed to be recalled.

Instead of having to recall all Coco Cups that had been manufactured and distributed, the candy maker was able to trace the product genealogy and conduct a pinpoint recall in a matter of days of only the small quantity of product in question. How was Choc-o-lot in a position to do this? It all started when Choc-o-lot's No. 1 customer, a mass merchant retailer, began requiring the company to tag all cases of product shipped to the retailer. At the time, Choc-o-lot made the wise decision to use Auto-ID technology in its manufacturing facilities supplying the retailer, not just the distribution centers.

Little did Choc-o-lot realize what a beneficial move this was. In the case of the Coco Cups, the use of Auto-ID technology greatly minimized the cost of executing the recall and reduced the impact of negative publicity on the company's brand. Customers were so impressed with the company's focus on quality that sales actually increased after the recall.

"We've experienced more benefits from Auto-ID than we could have imagined," said Ed Cook, Choc-o-lot CEO. "We're so convinced of what Auto-ID can do for us that we are planning to implement Auto-ID as quickly as possible across all our manufacturing facilities around the globe."

Accenture Silent Commerce
www.accenture.com/SilentCommerce

Auto-ID technology has left the lab and is out in the real world so it's not a matter of if, but when. Will you be ready to take advantage of the future scenario described above? Accenture has a vision for Auto-ID and broader related technologies, called Silent Commerce. Silent Commerce creates unlimited new business opportunities by making objects intelligent and interactive. It is "silent" because communication and commerce can take place between objects such as cases of paper towels, dock doors and warehouse management systems. For several years, we have been exploring the business potential of these innovative technologies at Accenture Technology Labs' Silent Commerce Centers located in Chicago, Illinois; Palo Alto, California; Sophia Antipolis, France and the Accenture Institute for Strategic Change in Cambridge, Massachusetts.

We have built working business applications and industry prototypes. We host hands-on workshops where companies can explore near- and long-term business and industry implications. This year in conjunction with the Auto-ID Center, we've collaborated with retail, consumer goods and freight transportation industry leaders to bring you a series of white papers focused on this exciting new value-creation opportunity. Auto-ID technology is an innovation that will revolutionize your business as you know it today. We invite you to explore the possibilities. Read on!

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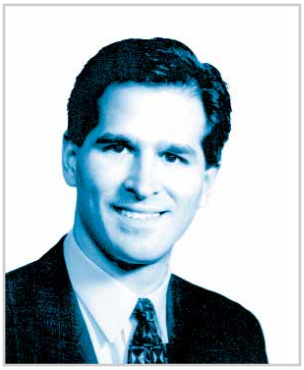
Biographies

Gavin Chappell
Partner

Gavin Chappell is a Partner in Accenture's Supply Chain Global Service Line. For more than 13 years, Gavin has specialized in developing and implementing solutions to drive improvements in Supply Chain operations, specializing in physical distribution and inventory management. He has worked extensively in the UK retail sector and across Europe for both retail and consumer goods companies. He is leading Accenture's Supply Chain practice in the adoption and implementation of Auto-ID solutions. Gavin has an Honors degree in Chemistry from the University of St. Andrews, Scotland.

Lyle Ginsburg
Partner

Lyle Ginsburg is the Managing Partner for Technology Innovation in Accenture's global Products Operating Group. With more than 20 years' experience identifying new technology trends and bringing them to market, Lyle is now focused on finding the value of Silent Commerce for Accenture clients in the retail, consumer goods, transportation, hospitality, pharmaceuticals, life sciences, automotive and industrial industries. He has a Computer Science degree from Northern Illinois University.



Paul Schmidt
Senior Manager

Paul Schmidt is a Senior Manager in Accenture's Retail & Consumer Goods industry group with more than 13 years' experience delivering Supply Chain, Customer Relationship Management (CRM) and Enterprise Resource Planning (ERP) solutions to global consumer goods manufacturers and retailers. He has worked with clients in program and project management roles during opportunity assessments, business process reengineering, technical architecture definition and application software evaluation, development and deployment. Recently, Paul served as the director of the Accenture Supply Chain Alliance Program with responsibility for identifying and managing Accenture's alliance partners across the entire spectrum of supply chain functions. Paul has a Bachelor of Business Administration from the University of Wisconsin-Whitewater.

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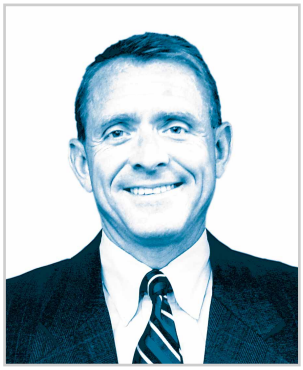
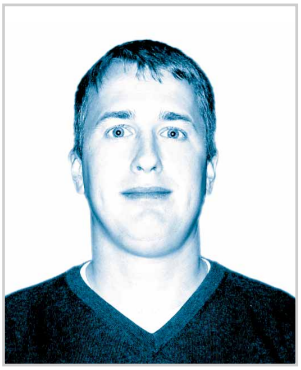


Jeff Smith
Partner

Jeff Smith serves as the Managing Partner for Innovation in Accenture's Retail & Consumer Goods industry group. He is an internationally known specialist in technology innovation and Enterprise Resource Planning (ERP) solutions, speaking regularly to retail, manufacturer and other industry trade groups in the Americas, Europe and Asia. Over his 23-year career, Jeff has specialized in strategic planning, data modeling, design and development of value-creating technology solutions for large retail and consumer goods companies, with a focus on customer/supplier collaboration processes and systems. Clients include Sara Lee, Meijer, Novartis Consumer Health, Nestle, Ahold USA and Wegmans. Jeff currently leads a research team assisting the Auto-ID Center in developing business cases for the commercial application of new Electronic Product Code™/radio frequency identification technologies (EPC™/RFID) in the consumer industries. Jeff holds a Master of Business Administration in Organizational Behavior/Informational Systems and an AB in Economics from the University of Michigan at Ann Arbor.



Joseph Tobolski
Senior Manager

Joseph Tobolski is a Senior Manager in Accenture Technology Labs. His main areas of expertise are Silent Commerce, Content Management, Collaboration and Knowledge Management and technical architectures. Joseph serves as the Director of Accenture's Silent Commerce Center, where he is investigating how emerging technologies such as RFID, sensors and actuators can enable inventory management, maintenance and logistics. Joseph received his Master of Science in Mechanical Engineering and his Bachelor of Science in Industrial Engineering from the University of Illinois at Urbana-Champaign.

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1. EXECUTIVE SUMMARY

Remember talk about "in" with the New Economy and "out" with the Old? It wasn't that long ago that the digerati declared manufacturing companies dinosaurs. How times have changed! Investors have again recognized manufacturing companies as the real thing. All the while, manufacturers have been steadily forging ahead, continuously seeking ways to improve performance even while the pace of change quickens and competition grows.

The key manufacturing challenge is to enable growth through product innovation and increase customer satisfaction while driving efficiency improvements. With the complex product and package portfolios that innovation drives, advanced optimization is required to be able to get best service to customers and the best yield from assets.

Auto-ID technologies – Electronic Product Codes™ (EPC™) and radio frequency identification (RFID) technologies – offer new enabling solutions that can dramatically improve production operations and yield results that impact customer satisfaction, the income statement and shareholder value. Auto-ID does this by increasing the certainty of the current and historical information about a product as it moves through the manufacturing process, as well as improve the control, quality and efficiency of the manufacturing process itself.

Auto-ID offers another level of improvement beyond today's Enterprise Resource Planning (ERP), barcode and automation technologies. Indeed, our analysis and experience indicate that significant benefits can be derived:

- 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.

Based on our experience, we suggest the following steps to rapidly obtain the benefits of Auto-ID technology:

- Begin with an investment-grade business case to identify the highest potential value-creating opportunities.
- Determine deployment models.
- Conduct pilots to test and refine deployment models.
- Scale deployment to obtain maximum benefits.

The exact steps a company should take varies based on the company's product attributes and the extent of the organization's existing automation and interdependency with other trading partners in the value chain. With the progress now made on Auto-ID and its associated price points, it is our opinion that manufacturers can now deploy Auto-ID in most forms and yield significant benefits.

2. ACKNOWLEDGMENTS

Accenture would like to acknowledge and thank the many companies, organizations and individuals whose insights proved invaluable to this paper, including the Auto-ID Center, Alien Technology, Best Buy, Checkpoint Systems, ConnecTerra, Display Edge Systems, Escort Memory Systems, Gemplus, Gillette, Graviton, Identec, Intel, Lyngsoe, Manhattan Associates, Matrics, Microsoft, Omron, Philip Morris, Philips Semiconductors, Procter & Gamble, RF Code, Rafsec, Red Prairie, Retek, SCS, SAMsys, SAP, Sara Lee Corporation, Savi Technology, Sensormatic Electronics, Snyder Electronics, Symbol Technologies, Target Corporation, TEKsystems, Texas Instruments, The Home Depot, The Limited, Unilever, Wallace, Wal-Mart Stores and WhereNet.

3. INTRODUCTION

Working in collaboration with the Auto-ID Center, Accenture has developed this white paper to help companies in the manufacturing sector determine where the use of Auto-ID technology creates the greatest opportunities with the highest value in manufacturing operations. Our findings are based on extensive research, business and operations modeling, and financial analysis. This research includes in-depth interviews with Auto-ID board members, experts from Accenture's Supply Chain Service Line, Accenture practitioners in diverse vertical industry sectors and Accenture Technology Labs.

This paper focuses on the key challenges manufacturers face across a range of industries and how Auto-ID solutions can improve the effectiveness of their operations and the quality of their products, creating ways to remain responsive to and competitive in the marketplace. Manufacturing operations impact the four "Ws" of product: who, what, when and where to make and ship to satisfy customer requirements. A significant portion of a manufacturer's capital is committed to assets used to manufacture product as well as inventory stored at various points in the supply chain. This is done in order to buffer demand and supply variability, including raw materials and work-in-process (WIP) as well as finished goods.

Manufacturers vary in their level of sophistication in how they manage their operations. Some use alternate forms of automated identification, like barcode scanners, to track materials and products, while others still rely on various forms of manual tracking. Auto-ID technology provides a way to increase the level of detail of information captured throughout the manufacturing process, all with less effort. This information helps enable manufacturing companies to increase their efficiency and quality of product, potentially resulting in significant operational benefits.

[1] Auto-ID Center website: http://www.autoidcenter.org.

A basic understanding of Auto-ID technologies is helpful in order to analyze the potential benefits and implications outlined in this white paper. An overview of Auto-ID technologies is included in the Appendix, Section 9. Additional information can be obtained from the Auto-ID website.[1] A high-level application of Auto-ID across all functions and industries is discussed in the Accenture white paper, "Auto-ID Across the Value Chain: From Dramatic Potential to Greater Efficiency & Profit." For additional in-depth analysis of the application of Auto-ID technology for retail, freight transportation, manufacturing and consumer goods companies, please see the following Accenture industry white papers, which are also available on the Auto-ID website:

- "Auto-ID on Demand: The Value of Auto-ID Technology in Consumer Goods Demand Planning"
- "Auto-ID on the Move: The Value of Auto-ID Technology in Freight Transportation"
- "Auto-ID on Delivery: The Value of Auto-ID Technology in the Retail Supply Chain"
- "Auto-ID in the Box: The Value of Auto-ID Technology in Retail Stores"
- "If You Build It, They Will Come: EPC™ Forum Market Sizing Analysis"

4. TRENDS IN MANUFACTURING TODAY

Every day manufacturers face new challenges. These may come in the form of unforeseen competitors, impatient shareholders or more demanding customers. Challenges may also come in the form of changing health and safety, labor and environmental requirements. And just as manufacturers make progress in one area, they often turn around to face another set of issues, such as global security, new regulatory requirements and the proliferation of product variations along with smaller production runs, reduced lead times and lower inventory levels.

At the same time, two divergent strategic trends are occurring that have significant repercussions to the manufacturing supply chain: vertical integration and disaggregation.

Some companies are **vertically integrating** and consolidating their upstream and downstream operations for strategic reasons. By establishing the entire value stream under one roof, their goal is to capture all the value-added processes within their business model. In addition, they believe that proprietary technology, the recipes, the formulation, and a certain skill level in the labor base all combine to make the company more competitive. Under this model, a company needs to operate as the lowest-cost producer in order to be competitive and profitable. A critical success factor for organizations pursuing this strategy is to integrate and standardize acquired operations as quickly as possible.

Other companies are choosing the opposite strategic direction by **disaggregating**. These companies are outsourcing portions or all of their manufacturing operations and focusing on being a brand management company with heavy emphasis on marketing. A brand company can charge a premium for its product over and above the full cost of manufacturing and distribution, based on the strength of its brand. This approach allows others to own the assets, such as manufacturing and warehousing, by paying those providers some margin for the ownership and service they provide. A critical success factor for organizations pursuing this strategy is to collaborate and share information with their trading partners as if they were part of a single organization.

Regardless of the industry and how a manufacturing operation is structured, companies continue to invest in improvements to optimize capacity, operate efficiently within demanding regulations, maintain competitive advantage in a world of escalating commoditization and cultivate innovation while managing capital requirements and risk. The ability to obtain and use accurate, timely, granular information will have a direct impact on the success of these types of investments.

Few manual activities or current technologies can provide the information at the level of detail and with the required accuracy and volume that are needed for manufacturing operations without incurring significant costs. Auto-ID technologies, however, are proving to hold the potential to deliver significant value by addressing the key issues manufacturers face today, regardless of their chosen strategy.

5. AUTO-ID: TACKLING MANUFACTURING CHALLENGES WITH GREATER CERTAINTY

Many major initiatives of varying types are under way across all industries to address key manufacturing issues. Investments leveraging existing infrastructure and applications that obtain cost savings or increase operational control are commanding the highest priority.

Regardless of the strategy your company is pursuing or the state of automation in your manufacturing operations, a number of considerations and application opportunities exist to drive value into your

business using Auto-ID. Auto-ID can deliver benefits as a primary solution in a closed-loop application or enable another application with more accurate, detailed and timely information. Also, it can enable downstream solutions used in other segments of your, or your trading partners', value chain. The ways in which Auto-ID can provide benefits are described in the following sections.

5.1. Production Management

Product innovation is the single greatest driver of growth for companies. New products and packages, or changes to existing ones, give a company a reason to interact with existing and potential trading partners. Product innovation occurs at all stages of the value chain. Product proliferation and market customization add greater complexity to packaging and logistics. Thus, instead of running dedicated production lines, line capacity must be more flexible and more easily divided up among multiple products and packaging. In this environment, equipment bottlenecks are more difficult to prevent, essential preventive maintenance is more difficult to schedule, and equipment efficiencies are more critical to meeting yield targets and trading partner delivery dates.

At the same time, cost reduction is a critical priority given the slow-growth marketplace as well as constant trading partner demands to reduce prices and shareholder pressure to produce higher returns. These factors make manufacturing a key focus area for improvements. Consequently, companies are striving for optimal yields and efficiency by operating continuously and at capacity – a difficult feat when innovative new products are continuously being created in order to drive growth.

Production management addresses the details of creating product. This includes resource allocation, operations scheduling, production execution, document control, data collection, quality management, performance analysis, product tracking and genealogy (to facilitate recalls). All these processes require detailed, accurate and timely information to operate effectively and efficiently. What is emerging is that Auto-ID technology can enable these processes with information better, faster and cheaper than other currently available alternatives.

The degree to which Auto-ID technologies can enhance operations depends on the sophistication of process automation solutions a company already has in place. The range of systems and sophistication varies among manufacturers and can include a combination of the following:

- Paper-based forms
- Data entry on terminal within production environment
- Barcode scanning
- Manufacturing Resource Planning (MRP/MRPII) system
- Enterprise Resource Planning (ERP) system
- Manufacturing Execution System (MES)
- Factory automation

For companies that have **not** made a substantial investment in automation technologies, Auto-ID technologies can create value more cost effectively than investment in more traditional methods such as "heavy metal" factory automation systems or labor-intensive barcode-labeling systems.

For those companies that have already made significant investments in manufacturing automation technology, it is likely there are steps in the process that are not highly automated and can benefit from Auto-ID technology. In instances where a company needs to retrofit existing manufacturing facilities to obtain increased performance and maintain standardized approaches, Auto-ID may be found to be the most cost-effective solution as well. Also, as companies pursue high-growth, high-profit opportunities

in emerging regions of the world, they will have the opportunity to create new manufacturing facilities with the highest operating performance at the lowest costs, with Auto-ID contributing to an optimal cost-effective equation.

For applications used in the manufacturing area, Auto-ID can provide the enabling data at a much greater level of accuracy, timeliness and detail than other alternatives. For example, Auto-ID technology may close the link between a manufacturer's Enterprise Resource Planning (ERP) system and Manufacturing Execution Systems (MES). Today, the MES application does not have easy access to detailed information; and therefore, the ERP has no idea of what is really happening on the shop floor (e.g., subcomponents not being where they were expected, trained people not showing up when they should and machines going down). Auto-ID can provide the MES with the accurate, timely and detailed information it requires to operate effectively. When the information is available to the MES and ERP applications, they can adjust accordingly, both locally in the factory and centrally on the ERP, enabling the most efficient use of resources.

Regardless of the level of automation in a manufacturer's operations, the following are some of the key areas where Auto-ID technologies may have an impact.

5.1.1. Production Execution and Quality Control

Quality control has always been a top priority among manufacturers. Companies continually look for ways to improve quality control by preventing problems before they occur or alerting people to problems that have already occurred. In addition, manufacturers in all industries are facing increased regulatory tracking requirements.

By implementing Auto-ID technology, quality control has the potential to be improved without adding more factory automation. For example, Auto-ID tags on inbound and work-in-process (WIP) materials can provide detailed information that enables a high level of process control. Often, the materials specification/formulation or components determine certain aspects of the manufacturing process such as other ingredients/components or processing time.

One solution is to put tags on containers of raw materials with readers on the mechanisms that dump the containers into the mixing equipment. If the materials with an incorrect specification are about to be added, an alert could warn the operator to prevent the incorrect materials from being added. Depending on the sophistication of the factory automation, the process could be stopped altogether. This in turn avoids line or product contamination, thereby reducing scrap and increasing yield. Moreover, Auto-ID could provide alerts if sensitive raw materials/work-in-process are in danger of expiring or becoming out of specification.

Auto-ID can also be used to verify the correct components are put into the next step of the product manufacturing process and the appropriate manufacturing action is taken. Auto-ID supports the "pull model" of Kan-Ban production by providing detailed, accurate information on usage to remotely drive MRP through the value chain, including work-in-process, warehouse and third-party manufacturing. Many companies are pursuing lean manufacturing, Kaizen and Six Sigma manufacturing strategies. All of these quality-control methods require real-time data collection for statistical and root-cause analysis. Auto-ID enables all of these data collection needs to occur along with the ability to track the definitive, time-dependent path of erroneous product.

Unlike most other technologies that are stressed under extreme thermal conditions or wet environments, Auto-ID has the ability to withstand extreme environments. Industrial-strength RFID applications have proven that it is possible to collect information with a greater degree of precision than any previous generation of technology.

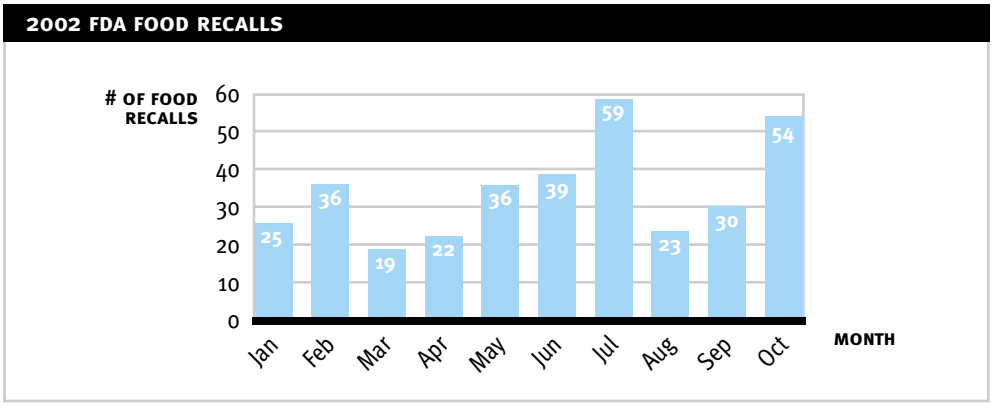
Another way in which Auto-ID technology can provide benefits in production execution is in the area of compliance with standards and governmental regulations, which is often a prerequisite for doing business with major companies. Losing certification or failing to comply with standards can put a company at risk. Likewise, the inability to prove correct execution of critical operations exposes a company to risks of legal action and costly recalls. Auto-ID technology is able to mitigate these risks by accurately tracking information at a very granular level. Auto-ID allows for complete tracking, verification and validation of processes, such as 21 CRF Part 11 compliance in the United States.

Overall, with Auto-ID technology, people are more productive, assets are used more efficiently and yields are increased. Perhaps most important, a company's brand and reputation are better protected by enabling the manufacturing of product that meets required quality specifications.

5.1.2. Product Tracking and Genealogy

Every manufacturer hopes to never have to do a recall; but if necessary, a company wants to be able to do it as swiftly and precisely as possible. The food industry, in particular, is prone to recalls due to the generally quick perishability of its products. Nearly 400 food-related recalls occurred in the first eight months of 2002 in the United States (Figure 1). However, food recalls are not the only issue – more than 1,400 U.S. recalls occurred nationwide across all other product categories in the same time frame.

Figure 1: 2002 U.S. Food and Drug Administration (FDA) Food Recalls



Well-publicized food recalls and increasingly stringent U.S. Food and Drug Administration (FDA) quality control regulations are driving food, beverage and other consumer goods companies to better manage inventory control, lot tracking, quality assurance and product recalls across their networks.

With the prospects of increasing regulatory reporting and compliance in many countries, Auto-ID could play a pivotal role. For example, in the United States, Congress has recently expanded the U.S.'s counterterrorism agenda by passing the Public Health Security and Bioterrorism Preparedness and Response Act of 2002, which makes safeguards for the security of domestic and food imports more stringent. One aspect of the Act mandates that by the end of 2003, food companies will need to comply with requirements to improve product tracking throughout their supply chains. These requirements will necessitate greater supply chain visibility and product control for consumer goods companies as well as increased visibility to tracking of ingredients from raw material supplier trading partners.

A company needs to know the source of its materials and the destination of its products given that the manufacturer is responsible for them even after they leave the manufacturing facility. Tracking, however, can be difficult if a plant is producing high volumes of product. Significant effort can be required to track product genealogy or conduct a recall.

Auto-ID technology can be used to enable genealogy tracking by recording relevant information such as product ID, time stamp, physical characteristics, lot number and disposition at each step in the manufacturing process. The technology enables the tracking of specific raw material components and action taken during every step of the manufacturing process. Sensor functionality could be added to track characteristics through distribution to the point of purchase. Encoded certificate of analysis and sensor technology can be used to verify that individual products were made within specification, and then automatically alert company personnel if they go out of tolerance.

Batch/lot control can also facilitate root-cause analysis, that is, the ability to track back to exactly when and where (and potentially under what conditions) a specific unit of production was made to identify a manufacturing success or failure (linked with the ability to do recalls) in manufacturing the product.

After an item has been manufactured, Auto-ID can track the history of product or material at a very detailed level in the following areas: where the product or material came from, who did what to it, where it is and where it has been. Batch/lot control track and trace is much easier to perform, as are pinpoint product recalls.

Auto-ID technology enables a manufacturer to manage any recall with surgical precision. Where a recall is required, Auto-ID provides the ability to trace back to specific units and all of its genealogy (supplier of raw materials, specific piece of equipment, operator, etc.).

5.2. Asset Utilization

The utilization of assets is a key driver to the overall effectiveness of a manufacturing operation. There are two areas where Auto-ID can have an impact on asset utilization: reusable asset utilization and maintenance, repair and overhaul (MRO).

5.2.1. Reusable Asset Utilization

Reusable assets are the totes, containers, trays and racks that manufacturers use to carry the raw materials, work-in-process and finished goods through the value chain. The availability of these assets is critical to production efficiency. To the bane of manufacturers, reusable containers are continually subject to shrinkage, leakage, disrepair and a general lack of visibility.

Auto-ID identification tags can enable a company to track and trace reusable assets through the supply chain. This application of the tags will track where an asset is at any time, who last had possession of the asset, what its contents are, whether it needs to have maintenance performed on it and numerous other pieces of information. With better visibility to each asset, fewer assets will be needed, less time will be spent tracking the assets and costs for the assets will be allocated appropriately. When assets are disposed at the end of their usable life, they will be accurately tracked and eliminated from the company's ledger. This can increase inventory accuracy, increase labor productivity, reduce losses of containers and reduce fixed asset costs.

Because tagging of reusable assets can be used in many different applications, it should be the first area where companies look to apply Auto-ID technology. Reusable assets may not be the area that provides the biggest return over the long term, but **it provides a way for companies to obtain benefits in a controlled, closed-loop system in the short term, while gaining experience with the technology**. This will better prepare companies for further deployments of the technology across the broader value chain as technology (chip and reader) prices continue to fall.

5.2.2. Maintenance, Repair and Overhaul

For companies that are highly automated, maintenance, repair and overhaul (MRO) activities and materials support the efficient operation of any facility, equipment or asset.

[2] Fifth Annual Census of Manufacturers, IndustryWeek, November 1, 2001.

MRO processes are supported by a Computerized Maintenance Management Systems (CMMS) application, one of the top three priority IT application areas for manufacturers.[2] A requirement for CMMS applications, however, is the availability of detailed, accurate and timely data. Auto-ID can provide that data more cost-effectively than other automatic data-collection technologies.

With Auto-ID technology, the significant events in the life of a piece of equipment (installation, usage, events, damage, repair, overhaul, decommissioning) can be captured. Auto-ID can alert an operator when an asset requires action such as preventive maintenance or cleaning.

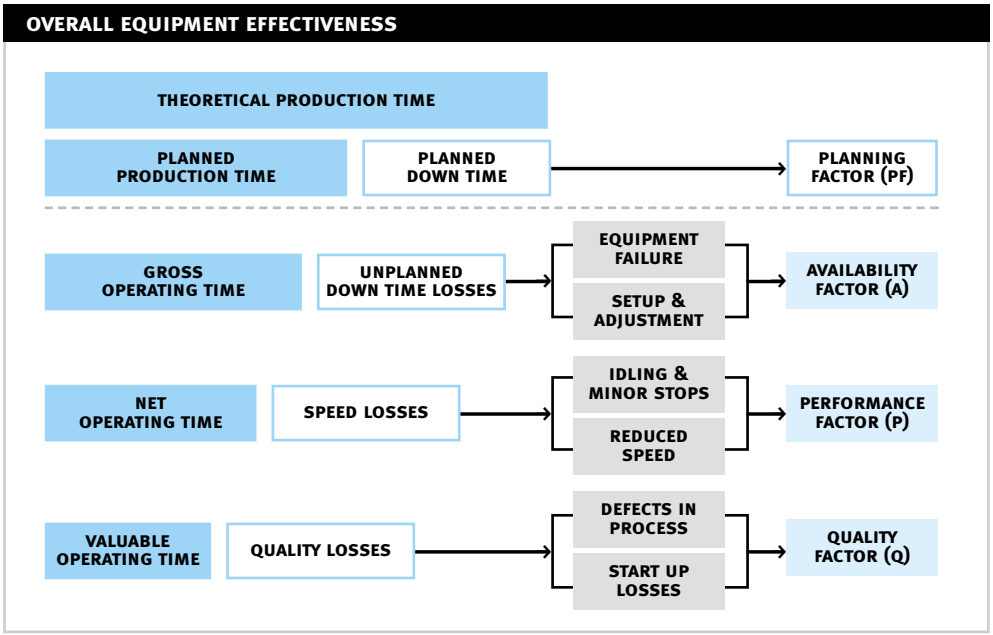
Other situations exist where Auto-ID technology can assist as well. Highly engineered factory equipment often has detailed specifications for each part. If replacement parts are needed for a machine, the specific parts and that machine's engineering revisions need to be accurately known in order to obtain the correct replacement. Auto-ID could easily track revisions to machinery and quickly identify unique parts. This would enable greater machine availability.

In yet another common situation, Auto-ID can enable capture of tools or equipment information and provide an audit trail of a particular critical operation that was performed using that equipment. The benefits related to inventory tracking and visibility are the same whether the item being tracked is product being manufactured or the tools and equipment used to keep the manufacturing operations running smoothly. The next section, Section 5.3, discusses how Auto-ID addresses inventory tracking and visibility.

Auto-ID can make planned downtime more productive and reduce unplanned downtime by supporting predictive maintenance triggers through intelligent remote monitoring and supporting real-time production information for networked and non-networked equipment. Also, Auto-ID can provide real-time detection of changes in production speed, performance degradation and quality measurements. As shown in Figure 2, availability, performance and quality are all factors that impact the key measures of Overall Equipment Effectiveness (OOE):

Figure 2: Overall Equipment Effectiveness (OEE) Diagram

Overall Equipment Effectiveness
OEE = A * P * Q
Total Productivity = OEE * PF



5.3. Inventory Tracking and Visibility

Manufacturers have pursued practices such as lean manufacturing and Just In Time (JIT) to obtain the benefits of reduced inventory in manufacturing operations. However, the best laid plans can be impacted when major disruptions to the supply chain occur, such as the U.S. West Coast dockworker strike in 2002 or the 2002 typhoon that impacted a major portion of Taiwan's manufacturing infrastructure. Preparation for such events causes companies to build up a buffer of inventory so they can better deal with unexpected circumstances and because they lack visibility to in-transit materials and product. In these situations, Auto-ID could provide detailed visibility and help alleviate those concerns.

Auto-ID could enable manufacturers to tighten down stock and buffers through real-time tracking and automatic synchronization, tightening up response time and inventory management. This can be especially critical with third-party contract manufacturing arrangements.

Some of the specific areas where Auto-ID could improve inventory visibility and tracking within manufacturing operations include:

- Visibility to inbound raw materials and/or urgent components
- Control and visibility to inbound/outbound transportation through a yard management system
- Control and visibility to the location of work-in-process inventory within the manufacturing operation
- Alerts of sensitive raw materials/work-in-process in danger of expiring or becoming out of spec
- Improvement in the sequencing of materials
- Tracking and confirmation of the disposition of scrap/rework
- Prevention of shrinkage

5.4. Labor Productivity

Many operations and activities still exist that use some form of manual data capture. This could be the writing of a lot number on a form that is later keyed in by data entry or the keying of a weight into a data terminal right at the manufacturing operation. In these instances, Auto-ID could provide significant improvements in speed and data accuracy.

While barcode technology is prevalent throughout manufacturing operations today – suppliers provide raw materials with barcodes, work-in-process contains barcodes – issues with accuracy remain that Auto-ID could improve. In most cases today, an operator needs to scan the correct label. Any labels that are not in line of sight must be found. Conversely, with Auto-ID, the technology can save the time it takes to scan each individual barcode. For high-volume operations, this can have a significant impact.

It is commonly accepted that the biggest cost for a manufacturer is typically labor. If employee uniforms or ID badges are tagged, productivity benefits could be obtained in areas such as:

- Ability to link user, machine and task together, to verify that only qualified and properly equipped people are maintaining/operating the equipment.
- Ability to know what employees have done which task in case of quality or safety issues.
- Ability to know where all employees are on site and measure productivity and maintain safety.

Tagging individuals, equipment and materials can also improve safety and workforce ergonomics. Real-time tracking could ensure improper materials are not mixed, causing an improper reaction. Adding sensor functions would alert to improper heat, gases and the like. Tracking and monitoring of environmentally sensitive materials or in harsh environments could provide a level of detail not available today without high costs.

The concept of tagging an individual, however, often raises privacy and labor law issues. As the technology proliferates and awareness and comfort level is raised, tagging of individual badges or uniforms may occur on a broad scale. In the near term, applications related to safety that provide major benefits will make pursuit and resolution of these activities worthwhile.

6. THE IMPACT OF AUTO-ID ON MANUFACTURING

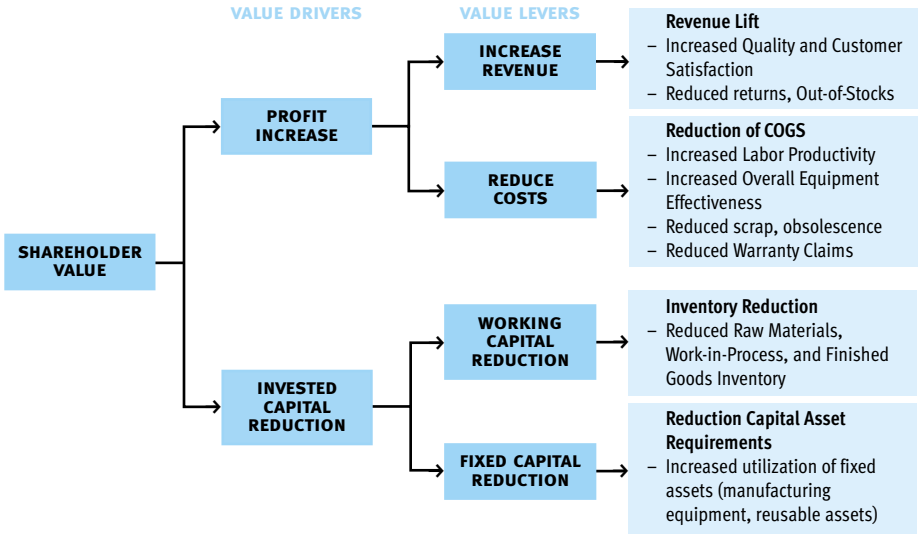
As discussed throughout this paper, the integration of Auto-ID technology into a manufacturing supply chain can streamline manufacturing and production operations through improved information and automation. There are numerous specific impacts of Auto-ID technology, including but not limited to:

- Increasing capacity utilization and yield
- Reducing cycle time
- Increasing labor productivity
- Improving product quality
- Ensuring timely preventative maintenance
- Reducing product obsolescence costs
- Tracking and managing spare parts inventory
- Facilitating statistical process control
- Enabling lot/batch track and trace
- Ensuring worker safety
- Reducing returns and warranty claims
- Reducing scrap, waste and obsolescence

These benefits can directly impact shareholder value levers, as shown in Figure 3.

Figure 3

SHAREHOLDER VALUE TREE



The following two scenarios will model how Auto-ID technology can have a measurable impact on a company's manufacturing operations and enable the downstream benefits of Auto-ID technology.

6.1. Scenario 1 – Paxko

Paxko is a global manufacturer of paper, plastic and aluminum consumer products and food service packaging with revenues of $4 billion. The company has 12 plants in North America, six in Europe, two recently-acquired plants in South America, and a newly-built manufacturing facility in China. All of Paxko's products are shipped to trading partners from distribution centers connected to the plant. Most trading partners are consumer goods manufacturers who use the product for the packaging of their own goods. The fastest growing and most profitable segment of the business, however, is the food service distribution channel.

In the late 1990s Paxko completed the installation of a common global Enterprise Resource Planning (ERP) application. Barcode labels are used extensively throughout its operations, but the Manufacturing Execution Systems (MES) vary greatly from factory to factory due to the acquisition of the various plants as part of the company's growth strategy.

Over a multiyear time frame, Paxko implemented Auto-ID technology across all of its plants. In addition to the specific benefits Auto-ID provided in the areas of production management, asset utilization, inventory reduction and labor productivity, Auto-ID now is enabling several of Paxko's strategic and application initiatives including:

- Lean manufacturing strategy
- Six Sigma analysis techniques
- Computerized maintenance management
- Linkage of MES information to ERP

The nature of the product Paxko produces lends itself to an above-average level of plant equipment and automation. This makes the first-pass yield already high, and thus, Auto-ID did not make a significant impact on improving quality. However, the availability and production rate of the equipment was below industry standards. In this area, Auto-ID was able to collect detailed, accurate and timely information about the manufacturing equipment usage for the computerized maintenance management application, which in turn increased overall equipment effectiveness.

This improved efficiency allowed Paxko to reduce cycle time and respond to trading partner requirements faster, increasing customer service and sales by 0.5 percent and reducing COGS excluding raw materials by 1 percent. Also, the improved equipment efficiency allowed Paxko to avoid the purchase of additional manufacturing equipment. By tagging the raw materials and work-in-process inventory throughout the factory, Paxko obtained better visibility and control, eliminating errors and obsolescence, resulting in a 5 percent reduction in inventory. Because of the improved visibility, Paxko was also able to dispose of some of the assets used to move raw materials between key suppliers and work-in-process materials within the factory, reducing fixed assets by 2 percent. The improvements in each of the major value levers enabled Paxko to achieve significant quantifiable benefits as identified in Table 1.

Table 1: Paxko Auto-ID Benefits by Factory

VALUE LEVER	CURRENT AMOUNT	ADJUSTMENT	%	AMOUNT		BASIS
REVENUE	$ 190,476,190	Increase	0.5	952,381	Recurring	Improved quality & customer service
COGS	$ 95,238,095	Decrease	1.0	952,381	Recurring	Improved equipment efficiency and labor productivity
CURRENT ASSETS	$ 19,047,619	Decrease	5.0	952,381	One-time	Reduced RM/WIP/FG inventory
LONG-TERM ASSETS	$ 62,857,143	Decrease	2.0	1,257,143	One-time	Improved plant and equipment utilization

As shown in Table 2, there are several major categories of cost which are described below:

Table 2: Paxko Auto-ID Costs Per Factory

* Read Point includes multiplexer, controller, cabling, etc.

Read Points (1)
Readers on fork trucks, fork carts, handheld readers, fixed readers

Read Points (2)
Readers on palletizers and exit to DC to initialize and record outbound product

Recurring In-Plant Tag & Other Maintenance Costs (3)
Replacing asset damaged tags, HW/SW license maintenance, depreciation, support & upgrades

CATEGORY	QUANTITY	AVG PER UNIT COST	TOTAL COST
Tags on assets and at "chokepoints" within plant	11,000	$ 5.00	$ 55,000.00
Read Points* (1) hardware & installation to control plant production	44	$ 3,269.00	$ 143,846.00
Read Points* (2) hardware & installation to enable downstream tag use	8	$ 3,269.00	$ 26,154
Computing Infrastructure	1	$ 60,000.00	$60,000.00
Business Process, Application and System Integration	1	$ 1,425,000.00	$ 1,425,000.00
Total One-Time Costs			$ 1,710,000.00
Recurring In-Plant Tags & Other Maintenance Costs (3)	1	$ 307,800.00	$ 307,800.00
Recurring Outbound Pallet & Case tags	1,524,158	$ 0.39	$ 594,422.00

- **Tags on assets** – Reusable assets such as carts, trays and racks that move between suppliers and Paxko as well within the Paxko manufacturing process have been tagged. These tags are ruggedized and installed to withstand the rough manufacturing environment, so they have a high average cost per unit of $5.00.

- **Read points to control plant production** – Read points consist of the reader, multiplexer, controller, cabling, structure, power source, other components and associated installation required to create a "whole product solution" to read tags. These read points are on items that are moving product within the manufacturing facility, such as fork trucks and pallet jacks, in addition to fixed readers in areas where there is not a controlled "chokepoint." This also includes handheld readers. The average price per read point is approximately $3,250, but the individual prices vary by application.

- **Tags at "chokepoints"** – Paxko wanted to track the interim movement of materials, work-in-process and finished goods between each stage of the manufacturing process, as well as inventory storage locations. Instead of putting readers at each of these "chokepoints," tags were embedded in the floor or racks as appropriate. This is much less expensive than putting readers in all these locations.

When the forklift with the mounted reader moves materials from one location to another, it reads the tags at the departure and destination location "chokepoint" and systematically records the movement and locations of the materials. These tags are ruggedized and installed to withstand the rough manufacturing environment, so they have a high average cost per unit of $5.00.

- **Computing infrastructure** – The hardware, data management software, storage and other components required average $60,000 per plant.

- **System integration** – Modifications of business process, applications, and integration of Auto-ID infrastructure and resulting information in systems such as MES, ERP, WMS, etc., are required per plant based on the fact that Paxko already had a high level of automation, barcode-based data collection and common ERP.

- **Read points to enable downstream tag use** – Paxko is putting tags on pallets and cases of outbound product. Fixed read points within the manufacturing process initialize the tags and record their shipment.

- **Recurring maintenance costs** – The maintenance of the applications, replacement of damaged tags on assets, support of the environment, license maintenance fees and depreciation of assets per plant.

- **Recurring outbound tags** – The tags on pallets are ruggedized, and tags on cases are embedded within human readable/barcode labels on cases so that companies that are not Auto-ID enabled can still obtain identification information.

The cost to implement and operate the Auto-ID infrastructure in each factory is not trivial. However, **based on a three-year rollout across all the plants and an internal rate of return of 8 percent, the projected 10-year Net Present Value is $26 million.**

Paxko also sees the addition of Auto-ID tags to its cases and pallets it ships to its trading partners as a way to differentiate its services from its competitors. This value-added component will enable major downstream benefits for the trading partners. Tagging at the pallet and case level has been included in the overall cost/benefit analysis. Paxko is in discussion with some of its trading partners about putting tags on products at the item level. It is anticipated this will start soon, when price points for tags drop and the sharing of costs and benefits among the trading partners can be agreed upon.

6.2. Scenario 2 – Northern Fine Foods

Northern Fine Foods (NFF) is a privately held manufacturer of processed meats (cold cuts, hot dogs and sausages) and cheeses with revenues of $2 billion. NFF has built a strong allegiance to the brand among consumers, and the company has grown steadily since it was founded in 1868. The company has been run by the extended family until recently, when outside management was brought in and given free rein to accelerate growth and improve profitability.

The first order of business by the new management team was to divest the meatpacking operations (two plants). However, NFF continues to obtain most of its raw materials from those plants as a result of a long-term purchase agreement that was part of the spin-off. The company's remaining five processing and packaging plants are all in the United States. The company distributes most of its product to North American grocery wholesalers and retailers through 12 distribution centers. Recently, the company signed an agreement with International Specialty Foods (ISF), a European manufacturer of gourmet

specialty cheeses. ISF will ship bulk quantities to NFF manufacturing facilities, where the cheese will be packaged and labeled. The product will then flow through the NFF distribution cold chain.

Most application systems used to operate the company have been custom developed in-house. The company has grown organically over the years, so the application systems are common throughout all facilities. However, the family-run business always operated as "lean" as possible, so the application systems and plant automation capabilities are far from "state-of-the-art." There is a significant amount of manual labor in the production processes.

The new management team invested the proceeds from the sale of the meatpacking operation into increased marketing and product development to drive volume and revenue growth. To meet the increased product volume and variety, the new management team realized improved production efficiency and quality control were needed at the plants. However, the company did not have the significant amount of capital required to implement factory automation. Also, with NFF now distributing product that is internationally sourced, the ability to comply with increasing regulatory requirements and visibility to inbound product was required. To meet these needs, NFF completed a multiyear rollout to implement Auto-ID technology across all of its plants and distribution centers.

Auto-ID has had an impact in several key areas in the NFF manufacturing process:

– NFF had arranged with ISF to put Auto-ID tags on the cases of product being shipped. As the cases leave the European distribution center, the tags are read and accurate visibility is provided to their departure. NFF is now positioned to comply with FDA regulations starting in 2003 that require companies to provide notification when product is between eight hours and five days from arriving in the United States.

– The key raw ingredients NFF receives for the processed meat products arrive in pallet-sized containers. Previously, each container had a barcode label on it, but the label was used by the supplier and had no meaning to NFF. The dockworker receiving the product at NFF would affix another self-adhesive label on the container with a handwritten lot number, and would also record the lot number in a log book, which was later keyed into the legacy system by data entry personnel. Problems sometimes occurred when the label didn't stick properly and later fell off. If the container lost its label and couldn't be 100 percent accurately identified, it had to be discarded. Also, sometimes the information on the ledger was illegible or keyed incorrectly so the lot tracking information was inaccurate.

  NFF has now arranged with the supplier to ship the containers on pallets that have Auto-ID tags embedded within them. This provides the supplier better visibility and control of its containers and pallets, and NFF can use the Auto-ID tag to automatically record the container lot information. This requires less labor to read and record the lot information as well as increases the accuracy of the information, which leads to reduced waste, higher yields and increased efficiency.

– After receipt, the containers of raw materials are put into a staging area before the manufacturing process. Previously, the laborers moving the products were required to read the labels to find the container to use next, assuming the label was legible and had not fallen off. More often, the laborer felt they "just knew" which container should be used next and made the selection without closely reading the label. This resulted in situations where containers of raw materials were not selected before reaching their expiration and ultimately were discarded. Now, the information from the Auto-ID tags has been integrated with the Manufacturing Execution System (MES) and the laborer is directed to the next container to use. Also, alerts are provided if any container is in danger of having its contents expire.

– The contents of each container have certain characteristics and specifications that impact the other ingredients and processing time for the manufacturing of any particular product. Previously, the laborer visually identified the container based on the label, recorded the lot number that was being added to the process, and then moved the container into position so it could be lifted into the mixing equipment. Again, mistakes sometimes occurred, and the wrong ingredients were added to the process.

  These problems were often caught after the manufacturing process when quality assurance discovered the product was outside acceptable specifications, resulting in waste that reduced yield and machine efficiency. Now, the Auto-ID technology has been integrated with the MES system. If the wrong container is about to be added to the manufacturing process, the system alerts the operator and prevents the container from being lifted.

– The output of the mixing process is work-in-process products that are put on racks for various stages of cooking, chilling and aging. Previously, each rack had a unique identified label, and the laborer recorded the input and output of each rack at each step. Inevitably, errors occurred such as recording invalid rack numbers or taking racks out of the stage too soon or not soon enough. In addition, the labels often required replacement due to the repeated cycle of extreme temperature conditions.

  Now, Auto-ID tags on the work-in-process containers are automatically read at each step of the process. This enables accurate lot tracking with no labor effort. The integration with the MES provides alerts when the duration for a process step is not correct. Also, Auto-ID tracks the usage of the containers and processing equipment and provides an alert when maintenance is required.

NFF has found that Auto-ID enabled improvements in many areas of production efficiency, quality control, lot tracking and visibility, asset utilization, inventory reduction and labor productivity. The improvements in production efficiency and ability to better meet customer service requirements have resulted in increased revenues of 1 percent and reduction in COGS excluding raw materials of 2 percent. Better visibility to expiration dates on raw materials, work-in-process and finished goods inventory has allowed NFF to reduce safety stock buffers and working capital costs by 5 percent. In addition, better utilization of plant equipment and reusable assets has allowed NFF to reduce long-term capital by 1 percent. The improvements in each of the major value levers enabled NFF to achieve significant, quantifiable benefits as identified in Table 3.

Table 3: Northern Fine Foods Auto-ID Benefits Per Factory

VALUE LEVER	CURRENT AMOUNT	ADJUSTMENT	%	AMOUNT		BASIS
REVENUE	$ 400,000,000	Increase	1.0	4,000,000	Recurring	Improved quality & customer service
COGS	$ 240,000,000	Decrease	2.0	4,800,000	Recurring	Improved equipment efficiency and labor productivity
CURRENT ASSETS	$ 40,000,000	Decrease	5.0	2,000,000	One-time	Reduced RM/WIP/FG inventory
LONG-TERM ASSETS	$ 132,000,000	Decrease	1.0	1,320,000	One-time	Improved plant and equipment utilization

As shown in Table 4, there are several major categories of cost that are described on the next page:

Table 4: Northern Fine Foods Auto-ID Costs Per Factory

CATEGORY	QUANTITY	AVG COST PER UNIT	TOTAL COST
Tags on assets and at "chokepoints" within plant	17,100	$5.00	$85,500.00
Read Points* (1) hardware & installation to control plant production	66	$3,115.00	$205,615.00
Read Points*(1) hardware & installation to enable downstream tag use	12	$3,115.00	$37,385.00
Computing Infrastructure	1	$60,000.00	$60,000.00
Business Process, Application, and System Integration	1	$1,942,500.00	$1,942,500.00
Total One-Time Costs			$2,331,000.00
Recurring In-Plant Tags & Other Maintenance Costs (3)	1	$419,580.00	$419,580.00
Recurring Outbound Pallet & Case tags	7,561,728	$0.30	$2,268,519.00

* Read Point includes multiplexer, controller, cabling, etc.

Read Points (1)
Readers on fork trucks, fork carts, handheld readers, fixed readers

Read Points (2)
Readers on palletizers and exit to DC to initialize and record outbound product

Recurring In-Plant Tag & Other Maintenance Costs (3)
Replacing asset damaged tags, HW/SW license maintenance, depreciation, support & upgrades

- **Tags on assets** – Reusable assets such as carts, trays and racks that move between suppliers and NFF as well within the NFF manufacturing process have been tagged. These tags are ruggedized and installed to withstand the rough manufacturing environment, so they have a high average cost per unit of $5.00.

- **Read points to control plant production** – Read points consist of the reader, multiplexer, controller, cabling, structure, power source, other components and associated installation required to create a "whole product solution" to read tags. These read points are on items that are moving product with the manufacturing facility such as fork trucks and pallet jacks, in addition to fixed readers in areas where there is not a controlled "chokepoint." This also includes handheld readers. The average price per read point is approximately $3,115, but the individual prices vary by application.

- **Tags at "chokepoints"** – NFF wanted to track the interim movement of materials, work-in-process and finished goods between each stage of the manufacturing process, as well as inventory storage locations. Instead of putting readers at each of these "chokepoints," tags were embedded in the floor or racks as appropriate. This is much less expensive than putting readers in all these locations. When the forklift with the mounted reader moves materials from one location to another it reads the tags at the departure and destination location "chokepoint" and systematically records the movement and locations of the materials. These tags are ruggedized and installed to withstand the rough manufacturing environment, so they have a high average cost per unit of $5.00.

- **Computing infrastructure** – The hardware, data management software, storage and other components required per plant.

- **System integration** – Modifications of business process, applications, and integration of Auto-ID infrastructure and resulting information in systems such as MES, ERP, WMS, etc. per plant based on the low level of automation, manual data collection and integration required with the custom in-house applications.

- **Read points to enable downstream tag use** – NFF is putting tags on pallets and cases of outbound product. Fixed read points within the manufacturing process initialize the tags and record their shipment.

- **Recurring maintenance costs** – The maintenance of the applications, replacement of damaged tags on assets, support of the environment, license maintenance fees, and depreciation of assets.

– **Recurring outbound tags** – The tags on pallets are ruggedized and tags on cases are embedded within human readable/barcode labels on cases so that companies that are not Auto-ID enabled can still obtain identification information.

The cost to implement and operate the Auto-ID infrastructure in each factory is not trivial. However, **based on a three-year rollout across all the plants and a 10-year time horizon, the total Net Present Value is $75 million.**

The implementation and usage of the Auto-ID technology infrastructure within the NFF plants has created significant benefits across the NFF enterprise. Tagging of the outbound product at the pallet and case level has been included in the overall cost/benefit analysis. This will provide significant benefits to NFF's trading partners. In the future, NFF plans to look into the addition of sensor functionality to the tags it puts on pallets and cases. The ability to guarantee the freshness of product may be a value-added service that the retailer and ultimately, the consumer would be willing to pay for beyond the cost of the tag itself.

6.3. Scenario Key Take-Aways

As seen in these scenarios, results are based on assumptions of many variables. It should be noted that the opportunity at any company will be unique and will also be based on that company's specific circumstances. A model, using Accenture's Silent Commerce Cost/Benefit Calculator, can be developed for any company if the data is made available.

When envisioning the use of Auto-ID technology, it's easy to begin by thinking about the many benefits to be had by tagging individual finished goods. As demonstrated in these scenarios, however, significant value could be obtained using the technology within the manufacturing process before the creation of the final product.

The benefits described in these scenarios are obtained from tagging the assets and equipment used to hold, move and process the raw materials and work-in-process being manufactured. It should be noted that the cost portion of the model does include tagging finished goods at the pallet and case level. There are soft benefits associated within manufacturing gained from the ability to track and recall product once it leaves the four walls, but there are no direct benefits from these finished goods tags included in the model. Nevertheless, just looking at the benefits from improvements within manufacturing can still justify the pallet- and case-level tags on finished goods.

If the models reflected item-level tagging, a positive ROI would be difficult to calculate based on today's tag price points and looking solely at the benefits obtained within the manufacturer's operations. However, significant additional benefits from item-level tagging can be obtained downstream, which if looked at in total could justify item-level tagging.

7. CONCLUSION

Based upon our research and field experience, we conclude that there are significant benefits to be obtained from the use of Auto-ID technology in manufacturing operations, regardless of a company's level of automation (although the level of automation will determine where the Auto-ID benefits can best be obtained).

The certainty created by the automated collection of granular, accurate and timely information within the manufacturing process creates opportunities for improvement in the following key areas:

- **Overall Equipment Effectiveness** – Depending on a manufacturer's level of automation:
  - Highly automated manufacturers will see the greatest impact from better MRO operations that increase availability and performance.
  - Less automated manufacturers will see the greatest impact from better production control, which increases quality.
- **Asset Utilization**
- **Product Tracking and Genealogy**
- **Inventory Tracking and Visibility**
- **Labor Productivity**

Manufacturing companies implementing Auto-ID technology could see significant improvement in their manufacturing operations and their financial profitability, justifying the expense of putting pallet- and case-level tags on their finished product for use downstream in the value chain.

A key issue for manufacturers and their trading partners will be how the cost of item-level tags get allocated across each participant in the value chain. At a time when companies are trying to avoid commoditization, manufacturing products with tags at the pallet, case or item level could be used as a way to provide a value-added competitive differentiation.

Companies should seriously look at the manufacturing area as one of the first areas on their adoption path of Auto-ID technology. It may not be the "glamorous vision" of tagging at the item level and having store shelf readers, but it provides a way for companies to obtain real benefits in a controlled, closed-loop system in the short term, while at the same time gaining experience with the technology. This experience will better prepare companies for more effective and efficient deployments of the technology across the broader value chain when tag and reader prices fall and make item-level tagging of finished goods more cost effective.

8. NEXT STEPS

8.1. Begin with the End in Mind: Investment-Grade Business Case

As technology advances to make the EPC™ and low-cost Auto-ID systems a reality, companies should begin readying themselves for this transformation. There are a few key activities companies can undertake to obtain greater improvements in manufacturing operations.

8.2. Identify Opportunities

In the near term, the best initial areas to begin implementation of Auto-ID technology include consumer products that carry high value, require controlled manufacturing and distribution, and feature collaboration of assets and information between trading partners. We anticipate that pallet- and case-level tagging will be cost effective for these product categories. We believe tagging individual consumer goods at the item level will not be cost effective in the near term for most high-volume, low-price point items. However, detailed cost-benefit analyses and business cases for specific applications will be required to evaluate the unique situation of each company.

8.3. Determine Deployment Models

To maximize possible benefits, companies will need to share information with their trading partners. Companies will need to determine if information will be shared with select partners or whether the application will become an industry standard that offers all participants similar information. The proprietary nature of the information, along with the relative costs and benefits of deployment through private systems, consortia or third-party service models, must be considered through a fact-based modeling process.

Based on this analysis, the partnering companies can select the model that best meets their organization's benefit requirements and deployment criteria. Most applications will be private, closed-system solutions in the near term. Over time, however, third-party solutions are expected to become more prevalent as the technology community commercializes Auto-ID standards.

8.4. Build Pilots to Test and Refine Deployment Models

A first step toward the deployment of systems is to build a pilot application to test and refine hypotheses about benefits, costs and work processes after implementation. As companies continue to improve their manufacturing capabilities through new systems and processes, they should look for opportunities to include Auto-ID technologies in controlled pilots. Pilot applications are vital to provide a realistic assessment of the application's potential benefits as well as the key process changes required for implementation. These pilots will allow a company to explore how the technology can be used to improve processes and to identify requirements for integrating with legacy applications and processes.

Pilots are "best practice" for learning how to effectively realize value from Auto-ID technologies. Conducting pilots early can give companies insights into issues or additional ways that specific operations and processes can be improved. Learning that takes place before full-scale deployment can help companies refine their business cases for specific applications, select the most productive applications and lower overall implementation costs.

8.5. Scale Volumes to Grow the Benefits

Where pilot tests show promise, the next step is to scale the deployment of the technology. Major retailers are actively pursuing Auto-ID technology. Manufacturers must be prepared to meet the requirements of the channel masters in order to become or continue their current status of preferred supplier.

Successful Auto-ID take-up will be comprised of several stages in an overall adoption journey. Accenture has used this approach and delivered innovations to numerous clients. We recommend that you consider the following stages:

- Business case value targeting and opportunity alignment
- Deployment model selection
- Piloting
- Integration with existing systems

9. APPENDIX

9.1 Auto-ID Primer

Introduction

Auto-ID technology consists of several parts: eTag – an electronic tag, Electronic Product Code™ (EPC™) – a unique identifier, Object Name Service (ONS), Savant™ Systems and Physical Markup Language (PML). By embedding the Electronic Product Code™ into products, intelligent and communicative objects result. This creates what Accenture refers to as a Virtual Double, where for every physical object there is an analogous data representation. In this sense, atoms and bits are aligned.

The Electronic Product Code™

The first component of Auto-ID technology is the EPC™. It is a string of numbers that provides a unique identification. For instance, instead of referring to a class of products (as Universal Product Codes do), the EPC™ refers to a specific instance of a product (see Figure 4).

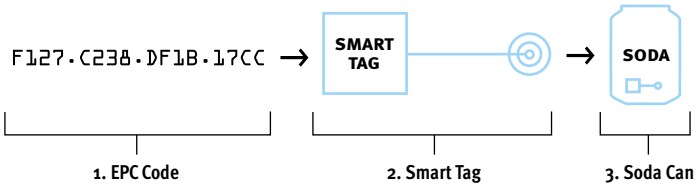
Figure 4:

1. EPC™ Code
Unique Number 96 bits long

2. Smart Tag
Made from a microchip with antenna – transmits EPC™ code

3. Soda Can
Typical Object becomes unique because of "Smart Tag"

INTRODUCTION TO AUTO-ID



To enable Auto-ID, the EPC™ is embedded in a memory chip contained within a smart tag on individual products. The chip is mated to an antenna. This allows for the smart tag to be scanned by a radio frequency "reader," which transmits the product's embedded identity code to a network, where the "real" information on the product is kept. That information is then communicated back from the network to provide whatever information is needed about that product. RFID is the basis for current Auto-ID technology. It is important to note that the baseline functionality of these tags provides read-only access to the EPC™. No information need be kept on the tag.

The Auto-ID Center standard does not preclude other tags with read-write functionality or even more advanced capabilities. However, as additional functions and capabilities increase, so will tag cost. Read-write tags also tend to be slower as well as shorter range than their read-only counterparts. Additionally, implementation of EPC™ does not depend on RFID technology; any way of being able to quickly and easily read a unique ID from a product will work. RFID is the most likely option today, but technologies not yet commercialized (such as amorphous metal threads or ultra-wide band) may also play a part (see Figure 5).

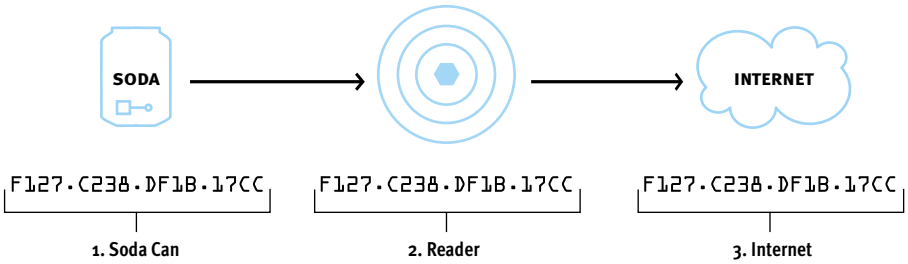
Figure 5:

1. Soda Can
Transmits EPC™ Code from embedded "Smart Tag" on side of can

2. Reader
Could be found in shelving, appliances, etc. Transmits EPC™ to Internet

3. Internet
Uses EPC™ to access unique object information

TRANSMITTING EPC™ CODE



The Object Name Service

The next step in the Auto-ID chain is the Object Name Service (ONS). The ONS tells computer systems where to find information about any object that carries an EPC™. ONS is based in part on the Internet's existing Domain Name System (DNS), which routes information to appropriate network interfaces. The ONS will likely be many times larger than the DNS, serving as a lightning fast "post office" that locates data for trillions of objects carrying an EPC™.

The Physical Markup Language

Physical Markup Language (PML) is a new standard "language" for describing physical objects in the same way that Hypertext Markup Language (HTML) is the common language on which most Internet Web pages are based. Almost anything can be contained within the PML description of an object: its physical characteristics such as weight or caloric content, repair instructions and audit trails. PML will allow for manufacturers to specify and customize the information tracked on products. There will not be a vast repository of PML descriptions. Ultimate implementation of the PML descriptions will result in highly distributed data. Manufacturers, retailers and consumers will all have unique views to data. One probable outcome of Auto-ID technology is that in the same sense that product is shipped, so will access to information or the information itself.

Applications

Auto-ID applications are numerous. They include manufacturing process control (flexible manufacturing, outsourcing), inventory management (retail stocking, spare parts, and back-room supplies), supply chain optimization (distribution center operations, transportation, ordering and replenishment), regulatory compliance (customs, security, tariffs), recall management and recycling.

In all these areas, Auto-ID offers the potential for significant savings, as well as new sources of incremental revenue. New services will start to emerge as objects start to become smart and interactive. As the technology becomes pervasive, benefits will extend throughout the entire value chain.

Auto-ID technology has the capability to redefine the global marketplace by embedding intelligence, identity and Internet connectivity into everyday objects. The EPC™ unites elements of the entire supply chain, making it an interactive, dynamic cycle from raw material and distribution to point-of-purchase and recycling, and back to raw material. Products equipped with smart tags will interact with manufacturers, their trading partners and each other to form an optimally efficient cycle of direct, real-time supply and demand.

9.2. Challenges

As with any revolutionary technology, there will be challenges to overcome in Auto-ID implementation. Some challenges are technological in nature, some economic, and some societal. The following topics outline these challenges and seek to address how to overcome them.

Accuracy
Readers cannot be guaranteed to be able to communicate with all tags in a volume 100 percent of the time. Environmental issues, the makeup of the products being tagged and the volumes of tags to be read all impact read accuracies. Nothing is foolproof. The degree of concern is proportional to how much an enterprise relies on absolute data.

RFID offers many advantages over manual or semi-automated data collection processes. Any shortcomings in accuracy can be mitigated through the use of redundant readers, information auditing and process redesign. If tagging at the pallet and/or case level, fewer tags will need to be read and accuracy will increase.

Interference
As readers proliferate, more occurrences of interference will be documented. Depending on the frequencies and powers used, devices such as phones, wireless handsets and industrial equipment may be affected. Since such a widespread penetration of RF technology has not been undertaken before, it is difficult to state explicitly what will be impacted. Good engineering and proper tuning will be important in overcoming this challenge.

The perceived health risks of this much RF may also come into play. While there is no evidence that there are any negative effects at the power and frequency levels associated with RFID, no one has rolled out such large-scale implementations yet. More research and monitoring will need to be conducted to address the public's concerns in this matter.

Performance
Smart objects will generate tremendous amounts of data. This much data will not be accessible if stored in a massive central repository, so some distributed data will be necessary. How will this distributed data be managed? Will it be accessible? How will it be accessed? The Auto-ID standard calls for read-only tags with a unique identifier. However, it is not hard to see mission-critical applications where this is not a viable option. For instance, in field service, remote locations, or even on airport ground areas, speed of network access cannot be guaranteed, and it will be much more convenient to have data on the tag.

Speed of information access is important. Subsecond lookup times will be expected in many applications. Where data is kept, as well as the networking infrastructure and computing platform, will greatly influence this speed. Simply put, for EPCs‰ to work, the data associated with a given EPC™ must be available on demand.

Frequency Availability
Since RFID uses unlicensed RF spectrum, the available spectra that is usable for RFID is an issue. Although there are some frequencies that are common, there is no universal standard. 13.56 MHz and 2.45 GHz are both worldwide standard ISM frequencies. These are available in most parts of the world, albeit at slightly different restrictions. However, more useful in terms of read range and speeds are tags operating at roughly 915 MHz or ultra-high frequency (UHF). The UHF spectrum around 900 MHz is not universally available at the same frequency and power levels worldwide.

This will be addressed through two potential methods. The first alternative is multi-frequency readers. Overall RF system design (integration of antenna, readers and tags) is the most difficult part of the problem. The second is to select a common frequency. Obviously, since this involves millions of stakeholders, the lead time on this will be considerable. This does not, however, deal with the fact that not all frequencies work well for every application (although some work well across virtually all applications).

Security

Security is paramount, and contains many levels. There is read security (or being able to read the tag), security of the data, and many other security issues. For users of the technology to feel comfortable, there will need to be assurances that no one will be able to "hack" into a smart object. As long as tags are read-only and are difficult to counterfeit, then security will be somewhat a given. Users of Auto-ID technology will also need to rely on the security of Auto-ID data on the network.

Data Ownership

Related to security, data ownership is an issue. Who "owns" the massive amounts of event information associated with an object? It is clear that the manufacturer owns the design specs and other PML type data for a given product. It is clear who owns captured data – the owner of the reader that reads the tag. It is less clear, however, how information will be shared.

Many parties will be privy to and will update the data for an object as it passes though a supply chain. Will those collecting the data even want to share data (consider a shipper with less than stellar turn-around times – would they be interested in sharing item-level tracking information?). Does an end-user (consumer) ultimately "own" a product and its data, and if so, how does use of that data for process improvement or data mining impact privacy?

Lastly, although killing a tag when purchased has been discussed as an option, this method eliminates future recycling benefits, and also introduces the potential of tags being killed maliciously or by accident, before they should be.

Privacy

Finally, a large, mostly perceived risk in Auto-ID, falls within the area of privacy concerns. The idea of tracking products into the home is troubling to most concerned parties. Consumer fears in this area are sparked by a lack of understanding of the limitations of RFID. Education is the key here – as people learn about when and how the technology works and what exactly is stored on the tag, the privacy concerns may lessen. Also, as consumers see value in the technology, acceptance will increase. For instance, consider stored warranty information that can help a consumer if repairs are needed or recycling information that can earn them a credit for being environmentally conscious.

Even with education, there are some legitimate competitive issues. Retailers may see the technology as an aid to their competitors. For instance, since the EPC™ will be global and unique, it may be possible to determine specific product information from the EPC™ given enough data. Imagine knowledge of your competitors' shelf assortment and inventory levels gained through a store walkthrough, accompanied with a hand-held reader. This information is available now. The technology simply makes it easier to obtain.

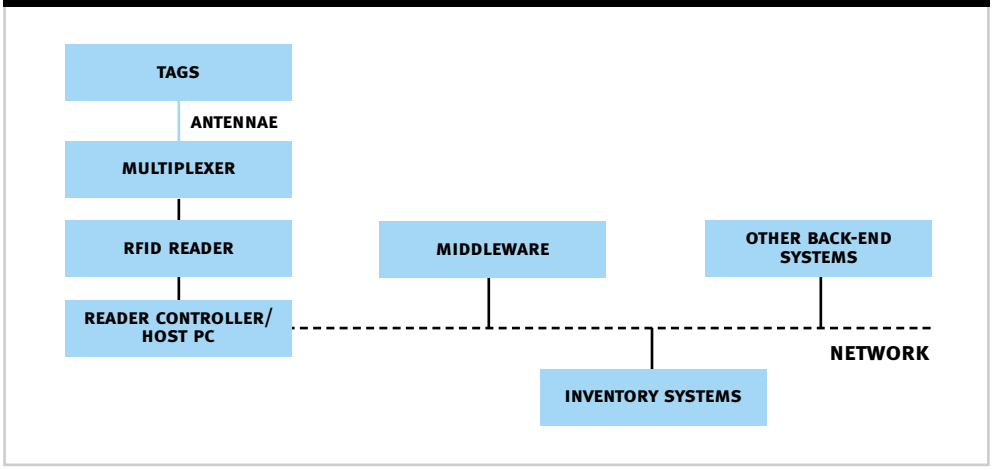
9.3 The Elements of Cost

The Basics of Cost

Radio frequency identification (RFID) tags are the most frequently cited cost component in Auto-ID implementations. This is not the whole story. Tags, readers, antennae, controllers, middleware, operations and maintenance all contribute to the total cost of ownership. Only by factoring in all of these components, tailored to a given situation, can costs be accurately estimated. Figure 6 gives a schematic of the various components of an Auto-ID system rollout. This section outlines each of these components and offers recommendations to calculate the overall cost in a business case for Auto-ID.

Figure 6

REPRESENTATIVE AUTO-ID IMPLEMENTATION



Tag Costs

RFID **tags** are usually the first of the costs associated with an Auto-ID system. There are as many tag variants on the market as there are potential applications. Changes in form factor, memory capacity, read or read-write capability, active or passive configurations and range, all impact the cost of tags. When calculating tag costs, the application requirements are the primary driver.

The target cost of an Auto-ID Center compliant tag is five cents, i.e., read-only containing an EPC™. Note that this cost is a future "volume" target. By way of comparison, commercially available read-only tags in the UHF spectrum today cost approximately 50 cents per tag, in volume.

The cost of the tag is not the final figure. Conversion costs must also be factored in. Conversion in this case means application of the tag to a product's packaging, to the product itself, or to cases or pallets. It also implies associating the EPC™ code with the actual product, known as "commissioning." Commissioning may mean writing the preassigned EPC™ to the tag (or programming) or alternatively, reading the predefined EPC™ value on the tag. Then the proper PML associated with that particular EPC™ should be updated.

The product being tagged will greatly influence conversion costs; will the tag require a standoff (in the case of metal mounts)? Will the tag need to be concealed? Will the tag antenna be printed or metal coil? These factors will increase the baseline tag cost. How much of an increase depends on the application. If the tag requires a printed label, then a label printer/RFID writer may also need to be purchased.

Reader Costs

Readers energize passive tags with energy, receive the results and very often, handle the low-level anti-collision algorithms that allow readers to read more than one tag at a time. Readers are generally controlled via application programming interfaces (APIs) that are provided by the reader manufacturer. Generally, the API also allows for configuring the reader's read cycle, power or other settings. The API for a given reader may have additional costs associated with it, although many providers bundle the software.

Reader costs vary as a function of range, speed, robustness, network readiness and antenna capability. The longer, faster or more hardened a reader is, the higher the cost. For readers at the lowest end, a PDA application may run $200 USD. For shelf or forklift installations, readers may reach $2,500 USD, and for high-speed conveyor or dock door applications, from $2,500 up to $10,000 USD. These ranges are based on today's commercially available equipment, although they will drop as volume of readers produced increases.

Antennae and Multiplexers

Antennae are another component of the reader subsystem. Whether it is a shelf, mat, portal, wand or directional antenna, different antennae will be required for different applications. These can range in cost from $25 to $500 USD, depending on application and base operating frequency

Depending on how many antennae are required, one or many **multiplexers** may be necessary. A multiplexer allows many antennae to be physically connected to a reader. Expect to pay $500 to $2,000 USD per multiplexer, depending on the number of ports. A configuration using multiplexers may also require an additional communications card such as an RS-485 (roughly $250 USD) on the controller.

Lastly: **cabling**. As in high-end audio, cables really do matter. Although there are generally fewer limits on the distance between reader and controller, there are signal degradation effects in the cables connecting readers and antennae. High-grade RF cables for this purpose can be expensive. Look to spend up to $10 USD per linear foot, keeping in mind distance limitations.

The entire reader/antennae/multiplexer setup may be referred to as a "read point."

Installation

Installation is the next major cost. Physically mounting antennae, power supplies, multiplexers and readers can be costly, depending on the environment. Many readers will need to be installed in warehouse or industrial environments. Still others will be installed on equipment such as forklifts or various handling equipment. Retrofitting existing sites or material handling equipment can add to the cost.

Readers and antennae may need to be concealed if aesthetics are to be considered (such as in a retail environment). In the case of a warehouse or plant installation, equipment may need to be hardened to handle the environmental abuses that come with such locations. Power drops, often at union rates, must also be provided to the location of the readers. Depending on the environment (for instance, retail stores may not have power available at all merchandise locations) this cost may be considerable.

As with power, network capability may also be required. This is a "may" because the reader and controllers may utilize existing wireless LAN capability to communicate with other systems. Otherwise, some sort of connectivity will be required between the controller and the reader. This can be Ethernet (CAT-5) or other serial communication. This cabling must also be installed, shielded or concealed, depending on application.

Controller costs

For every reader or group of readers a **controller** will be required. A controller is simply a computer, running software to control the reader. Initial processing, event firing and some diagnostics run on this PC. The controller need not be a very high-end PC unless it needs to be hardened for factory or other industrial applications. Approximate cost: $1,000 to $3,000 USD.

Tuning

Another cost in an RFID solution is the **tuning** phase. Every physical environment will interact with radio frequency waves in a different fashion. The RF field will need to be measured for dead spots and adjustments made. This cost is highly variable, given the expertise needed, selection of reader systems, and the vagaries of RF fields.

Software Costs

The next level up from the hardware is the controlling software, or **middleware**. This software translates tag reads into business events. Middleware is where much of the action takes place and is justifiably receiving a lot of attention.

The middleware will be a distributed system. At the very least, it will run on one or more servers plus the software running on controllers. All middleware serves pretty much the same function: it translates tag events into business events, aggregates data from item-level actions to those used in current Enterprise Resource Planning (ERP) and Warehouse Management Systems (WMS) systems, and provides publish and subscribe interfaces, so that applications may register interest in business events. The middleware will provide abstraction layers for connecting various types of readers and will provide for basic business rule engines. Furthermore, middleware should provide for read point monitoring and diagnostics.

However, it is important to realize that almost every implementation of middleware will be highly dependent on business rules, existing systems and the desired level of control. Commercial variants of middleware include the Savant™ from the Auto-ID Center, Accenture's Silent Commerce Infrastructure, ConnecTerra, SAP's Adaptive Networks and Savi's SmartChain and UDAP. These all vary in cost, from free (in the case of the Savant™) on up, however their capabilities also vary greatly.

Integration Costs

No matter what the middleware chosen, integration costs will be a large factor in an Auto-ID implementation. It will be in the order of magnitude of the cost of readers and installation combined, depending on the number of legacy systems affected. It goes beyond simple integration. Some systems may need to be replaced altogether if they are not capable of taking advantage of incrementally large volumes of real-time data from Auto-ID technology.

Maintenance

In addition to one-time costs, the ongoing **maintenance** and upkeep of an Auto-ID system should be factored into ROI calculations. Factors influencing maintenance include hardware upgrades, replacement of failed or damaged equipment, ongoing firmware and middleware upgrades and any software or licensing fees. Also, ongoing tag purchases and battery replacement (for active tags) should be factored into operations and maintenance costs. A standard software license and maintenance agreement usually runs approximately 10 percent per year. This is a good estimate for these systems. Finally, since so much physical infrastructure is involved, the depreciation of equipment must be factored in as a cost item.

Workflow

The last pieces of the puzzle are the **process** and **human elements** of Auto-ID. Many existing processes, especially intercompany processes, will need to be redesigned. Current batch, or paper-based processes will need to be eliminated and reinvented. Essentially, new workflows may need to be created.

When more information is available through Auto-ID, increasing peoples' ability to act on that information must also be enhanced. Training of personnel in new processes and technology should be added into overall implementation costs. Journey management will become a necessary discipline in order to fully address Auto-ID implementation at scale.

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