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Auto-ID on the Move: The Value of Auto-ID Technology in Freight Transportation

Michael Boushka, Lyle Ginsburg, Jennifer Haberstroh,
Thaddeus Haffey, Jason Richard, Joseph Tobolski

AUTO-ID CENTER MASSACHUSETTS INSTITUTE OF TECHNOLOGY, 77 MASSACHUSETTS AVENUE, BLDG 3-449, CAMBRIDGE, MA 02139-4307, USA

Early Adoption of Auto-ID Technology Makes Freight Fly at Trucking Company

CHICAGO – As one of the first trucking companies to become an early adopter of Auto-ID technology, AIDC Freightways is now reaping substantial benefits. After a thorough analysis of their situation and the development of a solid business case, AIDC Freightways decided to invest in electronic product code (EPC)™ and radio frequency identification (RFID) technologies.

Almost immediately after implementation, AIDC's expectations were exceeded. They instantly improved their yard management and fleet monitoring processes. Time to locate a container in one of their many yards used to be measured in hours. Now equipment can be quickly located for shipment or maintenance. As processes have become automated and streamlined, AIDC Freightways has been able to reduce labor costs and redeploy workers to improve customer service. They now plan to sell off select assets and postpone planned purchases of new equipment.

While AIDC Freightways is extremely satisfied with their investment in Auto-ID technologies, they realize that many of the significant benefits the technology can deliver will come when their trading partners also begin to implement. In the meantime, they've become an advocate for Auto-ID technology encouraging others to follow a similar path to adoption and benefits realization.

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 RFID 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, IL; Palo Alto, California; and Sophia Antipolis, France.

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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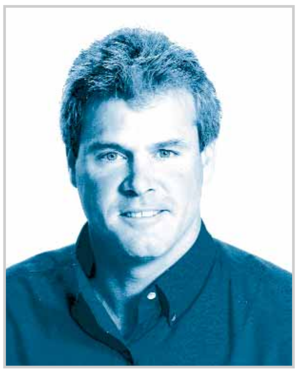
Biographies



Michael Boushka
Partner

Michael Boushka is a partner in Accenture's Products Operating Group and the Transportation & Travel Services industry group. Mike received his undergraduate degree in mechanical engineering from the University of Notre Dame and his masters of business administration degree from Kansas University. Since joining the organization in 1987, he has been primarily involved in the planning, design and installation of customer service and distribution systems for rail, less-than-truckload (LTL) and small parcel delivery segments of the transportation industry. He specializes in the management and delivery of large-scale development projects.

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 Retail, Consumer Goods, Transportation, Hospitality, Pharmaceuticals, Life Sciences, Automotive and Industrial industries. Lyle has a Computer Science degree from Northern Illinois University.

Jennifer Haberstroh
Experienced Analyst

Jennifer Haberstroh is an experienced analyst in Accenture's Products Operating Group and the Transportation and Travel Services industry group. Jennifer earned her undergraduate degree in international economics and international relations from The George Washington University. Since joining Accenture in May 2001, she has designed business process changes and performed software quality assurance activities related to small parcel sorting operations and air cargo container processing.

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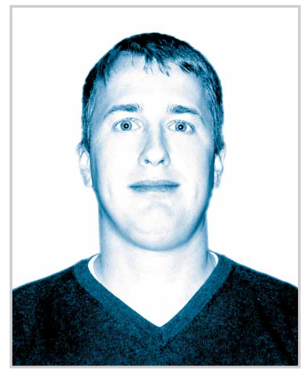
Biographies

Thaddeus Haffey
Manager

Thaddeus Haffey is a manager in Accenture's Products Operating Group and the Transportation and Travel Services industry group. Thaddeus earned his undergraduate degree in chemical engineering from Stevens Institute of Technology. Since joining Accenture in 1997, he has spent the majority of his time building custom applications for electronic data capture and package labeling in the small parcel delivery segment of the transportation industry. Most recently, he developed a system for delivery vehicle scheduling and utilization and electronic delivery information capture.

Jason Richard
Senior Manager

Jason Richard is a senior manager in Accenture's Products Operating Group and the Transportation & Travel Services industry group. Jason received his undergraduate degree in business administration from the California Polytechnic State University at San Luis Obispo. He joined Accenture in 1992, and has spent the majority of his career focused on major business process change and software application implementations for the transportation industry, primarily in the small parcel, air cargo, LTL and liquid petroleum distribution market segments.



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 M.S. in mechanical engineering and his B.S. in industrial engineering from the University of Illinois at Urbana-Champaign.

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Contents

1. EXECUTIVE SUMMARY

As the global economy grows, and the pace of business transactions accelerates, the freight transportation industry faces greater challenges and demands. Shippers and consignees' expectations for shorter delivery times and better availability of in-transit shipping information continue to grow. To meet these ever-increasing demands, the freight transportation industry must provide higher levels of service and guarantee higher levels of shipment security, while also providing adequate returns to shareholders. Auto-ID technology will assist in overcoming some of the barriers presented by current shipment movement processes.

Electronic Product Codes (EPCs)™ coupled with radio frequency identification (RFID) technologies – Auto-ID technologies – offer many benefits to the freight transportation industry. The use of these new technologies will allow freight transportation companies to better manage operating expenses and provide higher levels of service to their customers while operating more safely and securely. Major benefits include:

– **Asset Utilization:** Auto-ID technologies will allow freight transportation companies to save millions of dollars annually by identifying inefficiencies in their delivery operations and allowing them to easily and automatically track their assets from cardboard trays and rolling carts to trailers and aircraft. Auto-ID technologies enable the automation of processes such as the tracking and monitoring of trailers and containers, resulting in labor cost reductions.

– **Operational Efficiency:** These new technologies will provide even greater visibility to operations data. Misrouting and misdelivery of packages will be all but eliminated.

Labor-intensive processes such as data capture, yard control and pickup and delivery will all be streamlined by Auto-ID technologies. Freight transportation companies will be able to quickly locate a shipment or a container and accelerate the entire delivery process so that drivers can increase the number of deliveries each day.

– **Safety and Security:** By positively identifying the contents of a package without a visual inspection, freight transportation companies will be able to reduce the risks associated with transporting hazardous materials and the liabilities associated with some regulated products. The data that will be available will also allow freight transportation companies to quickly reconstruct the exact route a shipment followed through their delivery network, detailing which containers and vehicles were used in its transport.

Most of the early adoption benefits for freight transportation companies will come from immediate improvements in asset utilization. When adoption of Auto-ID technology reaches critical mass within the supply chain, and more and more manufacturers use EPCs™ for product identification, freight transportation companies will be capable of shipment level tracking and will realize significant benefits in the areas of operational efficiency and safety and security. With critical mass, freight transportation companies will also see benefits in the areas of quality control, financial management and improved profitability.

2. ACKNOWLEDGEMENTS

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, CHEP, The Home Depot, Intermec, Matrics, Procter & Gamble, Savi Technology, Target Corporation, Unilever, Union Pacific Railroad, United Parcel Service, the United States Postal Service and Wal-Mart.

3. INTRODUCTION

Shippers are moving to shipment – level tracking (with an eye toward item level tracking in the future) to improve their entire supply chain and inventory management processes. Carriers will have to incorporate this new technology in order to be able to provide the necessary information to customers. Fortunately, this technology also provides benefits to carriers, which we will concentrate on in this paper. For a discussion of the impact on the retail supply chain or the consumer goods industry, please see the Accenture industry white papers, “Auto-ID on Delivery: The Value of Auto-ID Technology in the Retail Supply Chain” and “Auto-ID on Demand: The Value of Auto-ID Technology in Consumer Packaged Goods Demand Planning.”

According to our analysis, primary benefits the freight transportation industry will come from three key areas:

– Asset Utilization
– Operational Efficiency
– Safety and Security

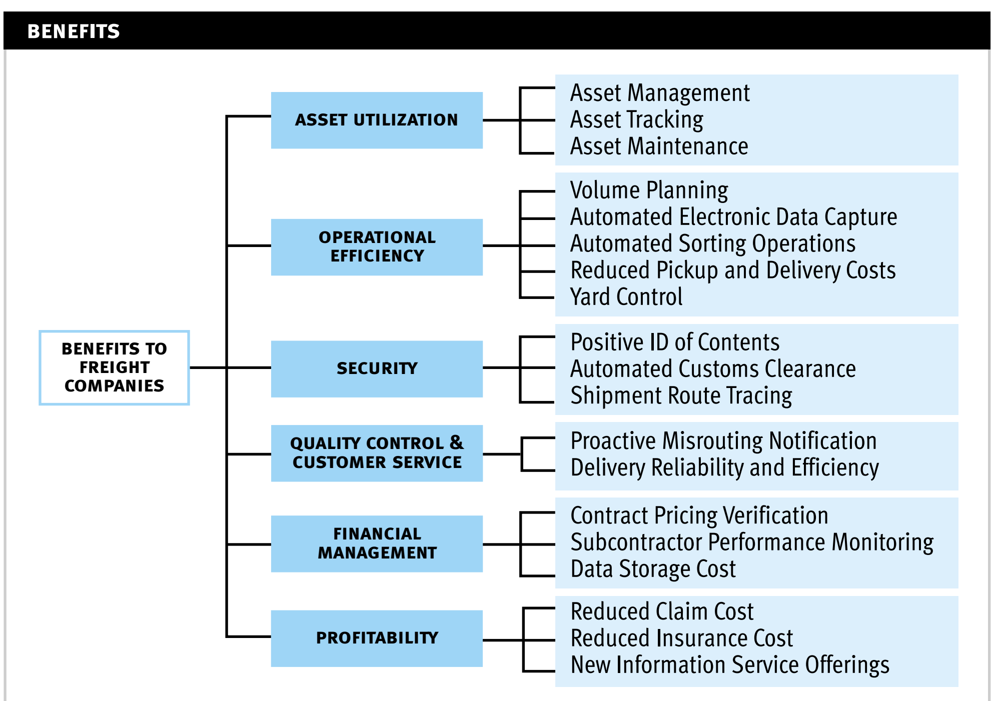
Once critical mass is reached in a supply chain, freight transportation companies will also realize additional benefits in the areas of:

– Quality Control
– Financial Management
– Improved Profitability

The chart overleaf summarizes the benefits we have identified.

There are sure to be changes coming, which we address in Section 4 – Beyond Tracking. Section 5 identifies challenges specific to carriers as they consider installing Auto-ID technologies. Section 6 summarizes our conclusions and section 7 will help you think through next steps as you consider implementation.

Figure 1



Case Study – Introduction

For the purpose of demonstrating the value to be gained through the use of Auto-ID technology, we have created a hypothetical transportation company, "AIDC Freightways", a moderately sized less-than-truckload (LTL) trucking company that maintains a fleet of 1,250 tractors, and has historically purchased 100 new tractors per year. Their fleet contains 4,250 trailers, and they purchase 250 new trailers per year. We will review several scenarios using AIDC as an example and will calculate potential business benefits, using simplified excerpts from Accenture's Silent Commerce Cost/Benefit Calculator.

4. THE BENEFITS OF AUTO-ID TECHNOLOGY FOR THE FREIGHT TRANSPORTATION INDUSTRY

Auto-ID technology will provide benefits to the freight transportation industry both in how they run their operations as well as deliver service to their customers.

4.1. Asset Utilization

4.1.1. Asset Management

Shipments destined for the same general area are typically consolidated into containers for movement through the delivery process. For this paper, a container is defined as any "parent" item e.g. a small tray, bag, rack, vehicle, trailer, aircraft, intermodal shipping container, or cargo ship that holds one or more "child" items during the transportation process. Tagging vehicles and containers with EPCs™ will allow these containers to be uniquely identified and tracked throughout the shipment cycle, through multiple facilities and vehicles without tagging every item. Armed with more accurate data, transportation company executives can make adjustments to fleet size to maximize vehicle utilization, while still maintaining delivery service levels.

By tagging individual containers with a unique EPC™, freight transportation companies will also be able to monitor the use of these containers over time. Containers that are not being used on a regular basis or are only used during peak shipping seasons can be identified. Freight transportation companies will then be able to determine whether these containers should be decommissioned or resold. Assets not being utilized can be removed from the balance sheet and alternative asset-financing methods, such as leasing more costly containers, can be employed during peak seasons.

4.1.2. Asset Tracking

Most freight transportation companies use a variety of containers to facilitate the movement of smaller packages. For this paper a package is an item (letter, parcel, case, etc.) that has been tendered to a transportation company for delivery and a shipment is one or more packages destined for the same consignee that were tendered to the transportation company at the same time and will be transported at the same service level i.e. Ground Express, etc. It is not uncommon for a carrier to use containers that range in size from small cardboard trays to large airline freight containers, with replacement costs ranging from seventy-five cents to several thousand dollars each. For this paper, shippers are defined as companies or individuals that have tendered a package for delivery, and a carrier is a company that performs the delivery service e.g. the transportation company.

It is not uncommon for carriers to purchase several thousand new airline containers annually, many of which are replaced due to damage or loss. EPCs™ would help determine where in their system these containers are being held or lost, providing better control over the significant recurring cost for this container type. By monitoring this information over the entire delivery network, a carrier would be able to reduce their inventory of containers by up to 10% and could evaluate alternate equipment financing methods to meet increased demand during peak seasons. When this concept is applied to all container types, across all modes of transportation, it is easy to identify millions of dollars of annual capital investment that could be more closely managed.

Case Study – Asset Tracking

AIDC Freightways makes significant equipment purchases each year due to business growth, equipment damage and in some cases, equipment loss. In an effort to monitor their asset movements more closely, the company implemented a real time location system (RTLS) to monitor their tractors and trailers within their freight terminal yards. By tracking their assets more closely with Auto-ID technology, AIDC Freightways was able to postpone the purchase of new equipment and more importantly, sell off a portion of their current assets. AIDC Freightways now plans to increase their usage of leased equipment to handle peak volume needs (turning their capital investment into a fully deductible expense). In the first year, AIDC Freightways will be able to sell 2% of their existing tractors, and 7% of their existing trailers. AIDC Freightways determined that with the improved asset tracking, they could resell $8.2 million of their existing assets. They will also be able to defer some future new equipment purchases. With an average tractor cost of $90,000 and trailer costs of $20,000, this minor percentage point reduction in assets has a significant positive financial impact and is expected to save AIDC Freightways $3.3 million on new asset purchases each year. It should be noted that although AIDC Freightways utilizes trailers as parent containers, other large freight transporting containers can also be substituted to achieve the financial benefits outlined in this example.

Table 1

ASSET UTILIZATION AND OPERATIONAL EFFICIENCY CALCULATION		
CAPACITY UTILIZATION	– Reduction of the number of required existing assets (Fleet and Trailer) which can be resold	$8,200,000
	– Reduction in the number of annual new asset purchases	$3,300,000
ASSET TRACKING	– Reduction in shrinkage of Trailer asset inventory	$150,000
	– Reduction in replacement expenditures due to damage	$172,025
COSTS	– Initial Tagging	$275,000
	– Reader Systems	$3,000,000
	– Controllers	$280,000
	– Installation	$400,000
	– Software & Integration	$2,000,000
	– Recurring	$17,500
TOTAL RFID COSTS		**$5,972,500**
ROI – YEAR 1		**198%**

4.1.3. Asset Maintenance

When every asset and its critical parts are uniquely identified with an EPC™, maintenance will become more efficient. The EPC™ included on a component part of a vehicle i.e. the engine, transmission, turbine, etc., will simplify the identification of which items require maintenance. By using the EPC™, the freight transportation company can gather more detailed information about their assets and track the maintenance performed on each item and its components. This information can then be used to analyze detailed information about parts that may be failing. For example, if it is found that truck transmissions are consistently failing and need a particular gear to be replaced, this data could be used to determine that all of the gears manufactured during a certain batch were out of spec. The freight transportation company could then alert the supplier of the defective part and proactively replace this part on other vehicles during scheduled maintenance, in order to avoid failures that could hinder operations or cause injury.

Not only will carriers benefit from EPCs™, but providers of shipping containers will also benefit. Companies that lease containers, such as pallets, trailers, or inter-modal containers to customers will benefit by using EPCs™ to uniquely identify their containers. By deploying readers at their own as well as at key customer locations, these companies will track containers being supplied to and returned from their customers. Many of these containers are returned in need of service or replacement. By identifying trends in the condition of containers being returned and which customers are returning greater amounts of damaged containers, these companies can take corrective action.

4.2. Operational Efficiency

4.2.1. Volume Planning

By using EPCs™ to identify containers loaded onto vehicles, operations personnel who know the destination of the vehicle and the volume it contains will be able to notify downstream locations of inbound shipments. This notification will allow these locations to better manage their personnel and equipment to handle fluctuations of in-system volume. The costs associated with unnecessary on-site operations personnel or on-line equipment can then be reduced, or a proactive decision can be made to bring additional personnel and equipment on line, to handle what would otherwise have been an unexpected surge in volume.

4.2.2. Automated Electronic Data Capture

Much of the detailed package-level data gathered by carriers to facilitate package sortation or customs brokerage, is provided by the shipper, or manually entered by the carrier's personnel. For international shipments, this data includes declared shipment contents, shipment commodity codes, etc. The reliability of this data capture can be greatly increased by reducing the number of times data must be manually entered into a system and by using manufacturer-generated data contained or referenced within the EPC™ (assumed to be correct). The labor costs associated with this redundant data entry can then be reduced. When the industry delivers tens of millions of shipments daily, saving a few seconds of labor per shipment results in a significant bottom-line impact.

Many government agencies require detailed information about a package's contents for the enforcement of tariffs and import/export restrictions. The information provided to the carrier by the shipper is typically used to meet these requirements. By being able to verify package contents more accurately without opening each one, inspectors, carriers and customs agents can reduce the costs associated with international shipping and be more capable of reaching superior service levels.

4.2.3. Automated Sorting Operations

The use of various bar-coding technologies forces restrictions on how a sorting facility operates. A one- or two-dimensional barcode requires line-of-sight and a specific orientation for optical scanning to be effective. To ensure proper alignment of these types of labels, packages must be manually introduced into a sorting facility. With low-cost passive RFID tags embedded in shipment packaging or labels, the package-induction process could be automated, allowing packages to be moved from a vehicle to a single point of entry into a sort facility, rather than requiring an employee to read a shipping label or manifest and make a decision as to which entry point is appropriate. Automated package induction will reduce the labor costs associated with this process, allowing the loading and unloading process to be automated. While there may still be a need for packages to have a human-readable label affixed, the type, size and content of this label could be reduced. This reduction in label requirements would present a cost savings both to the freight transportation company and the shipper.

4.2.4. Reduced Pickup and Delivery Costs

Auto-ID technology can significantly improve shipment loading and unloading for freight transportation companies (this technology also benefits the consignee [the individual or company to whom the package is being sent] – see the Accenture industry white paper "Auto-ID on Delivery: The Value of Auto-ID Technology in the Retail Supply Chain"). Assuming that the consignee has implemented a dock-door reader infrastructure for inventory management, freight transportation companies will realize benefits due to the consignee's investment (no cost to the freight transportation company). For example, when a vehicle delivers a shipment, readers installed at the receiving dock will capture the information embedded in the EPCs™ of the products being delivered, providing an automated record of inventory delivery, and enabling a quicker turnaround of the delivery vehicle.

In addition to the time saved at the dock, faster pickup and delivery times will also benefit vehicles waiting to be processed. Vehicles can spend significant amounts of time waiting for an available dock location, either in the yard itself, or in line outside the terminal gate. When pickup and delivery vehicles at the dock are turned around faster, more dock time becomes available, which will result in reduced driver wait time and better vehicle utilization. This results in the ability for the freight transportation company to increase its delivering capacity with its existing assets and labor, or to handle the same volume with fewer resources.

Case Study – Delivery

AIDC Freightways maintains a fleet of 1,250 tractors, 750 of which are used for pickup and delivery operations. Pickup and Delivery trucks are typically manned by a single driver, who earns an average of $60,000 per year. Thanks to widespread adoption of EPC™ inventory tracking, AIDC Freightways was able to increase the number of pickup and delivery actions by 10%. It is important to note that the freight company received significant benefit due to upstream and downstream adoption of Auto-ID technology. In this example, the costs of implementation were assumed by the manufacturer (who paid to tag the items) and the consignee (whose readers sped the shipment unload process). AIDC Freightways realized a benefit in terms of reduced labor costs due to the increase in delivery actions of $4.5 million. AIDC Freightways was also able to better utilize their assets due to the increase in deliveries with a $6.75 million reduction in the number of delivery tractors required and a reduction in dry delivery trailers of $8.5 million. Additional costs and benefits will be realized when AIDC Freightways extends their capabilities to automated bill of lading/shipping invoice validation and freight payment audit.

Table 2

REDUCED DELIVERY COSTS CALCULATION		
REDUCED DELIVERY COSTS	– Reduction in labor costs due to the increase in the amount of deliveries made per day due to consignee RFID infrastructure	$4,500,000
	– Reduction in the number of delivery tractors required due to the increase in the amount of deliveries made per day due to consignee RFID infrastructure	$6,750,000
	– Reduction in the number of dry pickup and delivery trailers required due to the increase in the amount of deliveries made per delivery vehicle due to consignee RFID infrastructure	$6,750,000
COSTS	– All costs assumed by other parties in the supply chain	**$0**

4.2.5. Yard Control

A major challenge for the freight transportation industry is yard control. The managers of a sorting facility need the warehouse or distribution center to ensure that the proper containers and vehicles are available in the correct location when they are needed. For a large facility, the task of moving these containers may take several people. The process of updating the whereabouts of a particular container or vehicle may also be manually intensive, due to the need to collect and verify the location and status data. The use of EPCs™ to identify each container and/or location at a facility will help automate this process and increase its accuracy. With accurate data capture the freight transportation company will be able to all but eliminate the manpower associated with maintaining this data.

Case Study – Yard Control

At an average freight terminal, AIDC Freightways employs five full-time workers for the sole purpose of monitoring and directing yard activities. Much of this time is spent locating idle trailers or determining which dock doors are currently available for use. After an RFID yard management system is implemented, real-time tractor/trailer yard locations and dock door availability status information is available to two office-based employees who are able to manage yard and dock activity from their desks. AIDC Freightways was able to reassign an average of three yard-management employees per terminal.

4.3. Safety and Security

4.3.1. Positive Identification of Package Contents

Security is an increasingly serious concern for the freight transportation industry. When potentially hazardous materials are shipped, the freight transportation company relies on the shipper to disclose the actual contents of the package to ensure it is handled properly. Assuming that the manufacturers of dangerous or controlled goods tag each item that they make and that the EPC™ is unique, genuine and tamper-proof, shipping companies will be able to use EPCs™ to confirm the identity of package contents. If the weight of an item is part of the data referenced by the EPC™, the package weight can be used as an additional mechanism to authenticate package contents. This concept may be extended beyond dangerous goods to any type of controlled substance, such as pharmaceutical, alcohol and tobacco products.

4.3.2. Automated Customs Clearance

In an extension of the package content identification benefit discussed above, the clearance of international packages through customs will be more easily facilitated with the use of Auto-ID technology. When customs agents perform searches of packages, they could use an EPC™ reader to compare actual package contents as reported by the EPCs™ against declarations made by the importer to the transportation company. If the declaration matches, the inspection could be immediately approved, making it possible for the inspector to move on to the next shipment, without spending time conducting a physical inspection of the packages' contents. The freight transportation company (or customs agents) would also be able to identify the package contents prior to customs receiving the package. By doing so, the freight transportation company could access secondary information about the products in a package associated with the EPCs™, such as weight or overall dimensions, and use that information to determine if any items have been omitted from the declaration or if any undocumented materials may be included within the package.

If the customs inspection process is already automated, the use of Auto-ID technology could enhance its efficiency. During an automated sort process, the actual contents of the package, as confirmed by the EPC™, could be compared against incoming package data. If the declared contents match the confirmed contents, the package could be automatically cleared through customs. If the declaration does not match the contents, or if there is a match and the shipment is a regulated item, then the shipment could be automatically routed to the inspector. Significant amounts of time and expense could be saved during the inspection process, while at the same time increasing the overall quality of the inspection.

4.3.3. Shipment Route Tracing

Auto-ID technologies, when used at the container level, will allow even small packages to be traced through a distribution network. If a package is found to be contaminated or even harmful, the information gathered by the freight transportation company can be used to more rapidly and accurately locate the potential source of the package and any handling points in the system. The data captured through reading the EPCs™ embedded in packages and containers can be used to reconstruct the route a particular package followed from origin to destination. Assuming that the data stored will contain the history of which other packages, containers and facilities the questionable package may have contacted, appropriate remedial actions can then be taken quickly and efficiently.

4.4. Quality Control and Customer Service

4.4.1. Proactive Misrouting Notification

Another part of delivery operations that will benefit from EPCs™ is proactive misrouting notification. Packages are often grouped by delivery location and pre-loaded into larger containers that are then loaded onto a delivery vehicle. The packages, larger containers and delivery vehicles would each be uniquely identified with an EPC™. The container's destination data would then be updated as its next stop is determined. Package EPCs™ would be read as they are loaded into a container. A reader on the loading dock in a sort facility, warehouse or distribution center would read the EPC™ on the container, prior to its being loaded onto a vehicle. The data stored for the package, container and vehicle would be used to alert operations personnel of potential mismatches that could be addressed immediately. The shipping company will be able to reduce both the instances of packages making extra trips within their delivery network and consuming additional capacity, and missed delivery commitments.

4.4.2. Delivery Reliability and Efficiency

By using Auto-ID technology, carriers will be able to increase the quality of the service they provide to their customers. They will be able to more accurately measure and analyze transit times by tracking containers and even individual packages through the delivery process. This improved operational data visibility will allow freight transportation companies to more closely monitor their daily operations and to focus on data analysis instead of data capture. Any inefficiency can then be identified and addressed before a shipment's delivery is delayed or missed. Analysis of the data collected over time will allow freight transportation companies to address chronic or recurring issues in their daily operations that may not have been previously obvious. For example, by reading vehicle EPCs™ automatically it will be possible to identify that a specific piece of equipment takes an extra hour to complete a particular route due to detours required to pass under several low-clearance bridges. The delivery company will then be able to increase efficiency by either finding an alternative optimal route for that piece of equipment or assigning it to another route.

4.5. Financial Management

4.5.1. Contract Pricing Verification

Freight transportation companies often rely on shipping information provided by their customers to generate an invoice. For example, a shipper of bulk marketing materials or catalogs typically provides the carrier with the data on how many packages or bulk-mail containers were tendered for delivery. These companies may receive discounts from published shipping rates based upon the volume shipped.

As the size of these shipments increases, so does the effort needed by the freight transportation company to verify the volume for billing. Auto-ID technologies would allow the shipper to gather the volume information quickly, accurately and automatically as the packages are loaded for shipment. With this additional information, the freight transportation company can bill the customer more accurately, protect its revenue stream, and adjust volume-based incentives appropriately.

4.5.2. Subcontractor Performance Monitoring

Auto-ID technologies will allow for better performance monitoring of sub-contracted carriers. One mail carrier uses commercial airlines to carry a large portion of its product. At this time, the performance of these third parties is difficult to monitor. By using Auto-ID technology based on the EPCs™ and RFID in lieu of barcodes, freight transportation companies will be able to capture more data on package or container movement without relying on third parties to provide it. Since the contracts with these other parties may be based upon metrics such as on-time delivery or guaranteed shipment on a particular flight, the information gathered from scanned EPCs™ will be used to ensure proper payment for services rendered. Long-term monitoring of this data will allow for its use in contract negotiations with third-party carriers.

4.5.3. Data Storage Cost

Without unique identifiers for every product, freight transportation companies need to store large volumes of detail data on each shipment's contents, especially for international shipments. Disk space is consumed by duplicate information, e.g. details on the same type of item in multiple packages. A standard EPC™ that identifies each item will allow the freight transportation company to cross-reference their data with that maintained by the item's manufacturer. Assuming a typical international package requires approximately 1000 bytes of data for the items contained in the package, an EPC™ is roughly 10% of this size. This cross-reference will reduce the amount of storage and movement requirements currently necessary for the freight transportation industry to handle these types of packages by approximately 90%. The freight transportation company can then look up needed data from the manufacturer's data referenced in the EPC™ when assembling information for shippers, customs or consignees.

4.6. Improved Profitability

4.6.1. Reduced Claims Cost

While moving large volumes of packages around the globe, some packages do get misplaced or damaged. By using RFID tags where line-of-sight is not required, smaller packages will become more "visible" and misplaced packages will be more easily located. Additionally, if the products within a package have been tagged with an EPC™ and those tags have been read at least once during the delivery process, the value of the package contents can be more accurately determined. If that package is damaged or misplaced, an appropriate payment of the lost product's value, if insured, can be made.

If a package is delivered to an incorrect location and is tagged with a unique EPC™, it can be more easily located and identified. For example, if a customer orders a product and it is delivered to an incorrect address, the freight transportation company will be able to quickly locate the item. Once identified, the product can be retrieved and sent to the correct location. By doing so, the freight transportation company will be able to keep a manufacturer from sending a replacement item to their customer and will avoid having to reimburse the shipper for the value of the package and/or shipping charges.

As the value of the package contents increases, the savings in this area become more apparent. By obtaining an automatic reading of items uniquely identified with an EPC™, the freight transportation company will be able to positively identify what items were actually tendered for shipment. If either the shipper or consignee makes a claim for a lost item, the freight transportation company will be able to determine if the item was actually tendered and if not, where in the delivery process the loss occurred.

4.6.2. Reduced Insurance Costs

By reducing their total number of claims, both legitimate and fraudulent, freight transportation companies will be able to reduce the cost of insurance premiums. For freight transportation companies that use a third party for insurance of lost or damaged goods, the reduction in premium costs would represent a savings. Some freight transportation companies offer additional insurance that may be purchased by a shipper. If the likelihood of loss is reduced, these premiums may be lowered to offer a savings to the shipper or to encourage more shippers to purchase this additional coverage. Alternately, the freight transportation company may retain these savings and increase their own margins.

Case Study – Insurance

Like many freight transportation companies, AIDC Freightways damages or loses shipments in transit each year. In order to combat these losses, which result in claim payments and insurance premiums, AIDC Freightways implemented Auto-ID technology. The company can now track and locate individual shipments, and reduce the number of misplaced or misdelivered shipments. AIDC Freightways has reduced claims associated with misplaced packages by 98%, a savings of almost $1 million. When this situation cannot be avoided and a claim must be paid, AIDC Freightways can avoid over-compensating the claimant, by using the damaged shipment's EPC™ to determine a fair replacement cost. By better managing its lost and damaged freight claims, AIDC Freightways has also reduced the insurance premiums it pays to its insurance providers by $200,000, and can improve the profit margin it makes selling shipment insurance to its shippers and consignees. Note that in order to verify claims related to product damage, the company must have the ability to verify EPCs ™ at the item level and detailed product information would need to be made available to AIDC Freightways at the time the claim is processed.

Table 3

PROFITABILITY CALCULATION		
REDUCED CLAIM COSTS	– Reduction in claim costs due to decrease in misplaced packages	$980,000
	– Reduction in claim costs due to more accurate value determination using EPC™	$101,000
REDUCED INSURANCE COSTS	– Reduction in insurance premium costs by reducing total number of claims	$200,000
COSTS	– Initial Tagging	$2,600,000
	– Reader Systems	$3,500,000
	– Controllers	$700,000
	– Installation	$1,000,000
	– Software & Integration	$2,000,000
	– Recurring	$13,000
TOTAL RFID COSTS		**$9,813,000**
ROI – YEAR 1		**13.05%**

4.6.3. New Information Service Offerings

Once EPCs™ are used to identify the majority of manufactured goods, there will be an opportunity for freight transportation companies to offer new services to their customers. By reading the EPCs™ from package contents or receiving them electronically from the shipper with other package-level information, the freight transportation company will be able to provide more information to consignees about their anticipated delivery. By knowing the EPC™ of package contents, freight transportation companies could provide consignees an on-line link to product information. In this way, the consignee could look up information about products prior to their arrival. For example, if an appliance requiring installation preparation were in-route, the freight transportation company could provide links to the product information provided by the manufacturer based upon the EPC™. With access to this information the consignee could begin making the necessary preparations before the appliance arrived. These services could be offered as a subscription to larger consignees, such as major retailers, and manufacturers who send their products directly to the end consumer.

5. BEYOND TRACKING

In the future, RFID tags may be enhanced to support sensors for the ambient conditions of a package. If perishable or temperature-sensitive materials are being transported, the sensor can gather information about the temperature at which the package has been stored. This ability will allow freight transportation companies to monitor and adjust their operations to ensure merchandise is not damaged or spoiled in transit and further reduce claims for replacement. Their customers will also be able to validate that a requested service, such as refrigerated transport, was provided. This monitoring concept can be extended to actuators, which could take corrective action when a shipment was detected to be outside of a specified tolerance. For example, if an on-tag sensor for a food or health product shipment determined that it had exceeded a temperature tolerance, it could take action by sending a request for service to a refrigeration unit or operator's console. For more in-depth information about the future of these technologies, Silent Commerce and other innovations please visit Accenture Technology Labs' website at http://www.accenture.com/SilentCommerce.

6. CHALLENGES FOR FREIGHT TRANSPORTATION

There are a number of challenges that will need to be overcome before freight transportation companies can realize the full range of benefits offered by Auto-ID technology.

6.1. Pre-Existing Automatic Identification Standards

Certain segments of the freight transportation industry have already taken steps to create standards for the automatic identification of assets. Industry-specific standards are growing in acceptance and in some cases, have a wide implementation base.

For example, in 1991, the American Association of Railroads (AAR) adopted a mandatory standard for equipment tracking. A common standard was crucial because rail carriers share railcars and tracks. The standard in place requires that all pieces of interchange equipment be RFID tagged. Currently, approximately 95% of all railcars in interchange service on major North American railroads are tagged and tracked, with more than 12,000 reader sites, and 5.2 million tags in use. The Chinese rail industry recently adopted a similar standard, which integrates the North American standard's specifications, in a slightly different physical configuration. In another case, the Automotive Industry Action Group (AIAG) recently adopted an RFID standard for automatic identification of wheels and tires – a product standard that will undoubtedly affect many freight transportation companies.

In Europe, the International Organization for Standardization (ISO) has already released a standard 'license plate' for the unique identification of transport units. They define a transport unit as a shipping container or an aggregated shipment that moves as a single item – a standard pallet of product, for example. While their current standard presents the license plate in 2D barcode format, their intent is for this same data format be carried forward to RFID tags, or other forms of automated data capture.

These cases highlight scenarios in which transportation industry companies have already implemented automatic identification standards. In order to facilitate adoption of their new standard, the Auto-ID Center will need to take these existing standards into account, possibly by making the EPC™ backwards-compatible with current practices.

6.2. Pre-Existing Automatic Identification Processes and Infrastructure

Most freight transportation companies have already made significant investments in automated shipment identification technologies. These technologies range from the simple automated tracking of waybill numbers to complex, technology-intensive customer shipping and web-based tracking applications.

In the small parcel segment, companies generally have enough barcode scan events built into their shipping process so that they can determine a shipment's likely location based on its last known scanning point. Parcel companies are able to determine, with a fair degree of precision, which facility, vehicle, or shipping container a particular item is located within, and possibly even the last person or machine to handle the shipment. They generally believe that tracking at this level of detail is able to provide shippers and consignees with enough shipment location visibility for their purposes.

In a bulk transport mode like the rail industry, containers are typically loaded and closed at the point of manufacture, and are not opened until they arrive at their final destination. Consider a situation where, similar to the small parcel example above, the shipment contents are associated with the container or shipment ID at the point of origin. Without any shipment breakdowns or consolidations taking place, there is no real need to track the contents of a container (individual or aggregate EPCs™), if the location of the shipping container itself can be easily determined.

Given these beliefs and previous investments, only a strong demonstration of ROI will convince carriers to switch to this technology.

6.3. EPC™ Proliferation

For carriers, item level tagging creates some specific challenges. In order for a carrier to rely on EPCs™ for activities such as high-value item tracking and dangerous goods handling, those categories will need to be highly tagged. In order to rely on EPCs™ for an activity like package sorting, the level of EPC™ use will need to be even higher (some estimates put that level at 98% of all shipments). Without this high saturation of EPC™ tags, the costs of exception handling (for those items not tagged) could easily outweigh the benefits. As a result, carriers will be reluctant to invest in Auto-ID technology in certain areas of their business until the saturation rate reaches a high enough level.

Please see the Appendix for a discussion of additional challenges associated with adoption of Auto-ID technology.

7. CONCLUSIONS

By beginning to adopt Auto-ID technology today, freight transportation companies will be able to operate more efficiently by tracking their assets' locations and use. By doing so, less investment in new equipment and more efficient use of existing equipment will be possible. Very soon this new technology will mean that sorting and delivery errors will be minimized. Manual effort and human error will be reduced through automation of existing manual package labeling, identification, and sorting processes.

Positive confirmation of package contents and the ability to reconstruct the path a package followed will increase the level of security in the freight transportation industry. The quality of electronic data captured about a package will facilitate more efficient and thorough package inspections by freight transportation companies and regulatory bodies.

By using EPCs™ to monitor the performance of subcontractors and verify bulk shipment volume, greater financial control will be possible. EPCs™ can reduce the amount of data that freight transportation companies will need to store and maintain, further reducing operating costs. The EPCs™ embedded in package contents will allow for quicker and more accurate claims payment processing. The access to additional information about a package's contents will allow freight transportation companies to increase revenue through new information services offerings.

The benefits in security and financial management will come from the positive identification of a shipment's actual contents, and will not be realized until the vast majority of manufacturers use Auto-ID technology to identify their products. Access to the information about package contents must also be appropriately controlled before freight transportation companies will be able to use the technology.

The current widespread investigation of Auto-ID technology by freight transportation companies is largely centered on improving internal operations such as asset tracking, asset maintenance and yard control. Adoption in these areas represents an immediate benefit to asset utilization and operational efficiency, and because the use is isolated to internal operations, the implementation is less affected by the proliferation challenges posed by external issues such as standards and data access. Demonstration of ROI in each area of operations will speed acceptance by carriers.

8. NEXT STEPS

As technology advances to make the EPC™ and low-cost RFID systems a reality, freight transportation companies should begin readying themselves for this transformation. Before beginning the journey to full Auto-ID implementation, freight transportation companies should begin to closely monitor their customers for take-up.

Once a carrier's customers have invested in Auto-ID infrastructure, freight transportation companies will need to adapt quickly to meet the new demands of their customers. There are a few key activities companies can undertake to prepare for immediate and coming changes.

8.1. Value Targeting

Value targeting allows companies to identify the most promising benefit categories from EPC ™ or RFID technology. It allows for the development of more detailed cost-benefit analyses and business cases for specific applications. For freight transportation companies, these may include applications to monitor container location and utilization, to track sub-contractor performance and to verify high-volume shipper billing. Effective value targeting requires detailed data-driven analyses to generate clear hypotheses about how particular companies can realize value from specific applications.

Case Study – Conclusion

We hope that the situations encountered by our hypothetical LTL carrier, AIDC Freightways, demonstrated some of the possibilities Auto-ID technology offers freight transportation companies. While we included only a few simplified versions of the calculations from Accenture's Silent Commerce Cost/Benefit Calculator, we feel that there is compelling evidence that these benefits are available across all transportation modes. Whether your company needs to better manage cardboard trays, ocean containers, or locomotives, there is significant value waiting to be realized across the freight transportation industry.

8.2. Aligning Opportunities and Deployment Models

For each of the different opportunities identified in the value-targeting exercise, companies can decide if the benefits are proprietary to their company, shared with select partners or whether the application will become an industry standard that offers all participants similar benefits. They can then analyze the relative costs and benefits of deployment through private systems, consortia, or third-party services models. Based on this analysis, they can select the model that best meets their organization's benefit requirements and deployment criteria. Most applications will be private solutions initially. Over time, however, third-party solutions are expected to become more viable.

8.3. Building Pilots to Test and Refine Deployment Models

A third 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. 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 freight transportation 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 vital 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.

8.4. Scaling to Grow the Benefits

After pilot results have determined the most effective use of Auto-ID technology, the next step is to scale the deployment of the application across the company and, if appropriate, with key large-volume shippers. Freight transportation companies are most likely to work internally within a few years of system availability. Freight transportation companies will not begin large-scale implementation of the technologies until the vast majority of manufacturers and shippers are using this technology.

Successful Auto-ID take-up will be comprised of several stages in the overall adoption journey.
We recommend that you consider the following stages:

– Business case value targeting
– Opportunity alignment
– Deployment model selection
– Piloting
– Integration with existing systems
– Implementation at scale and across trading partners - open systems.

9. APPENDIX

9.1. Auto-ID Primer

Introduction

Auto-ID technology consists of several parts: eTag – an electronic tag, 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 2).

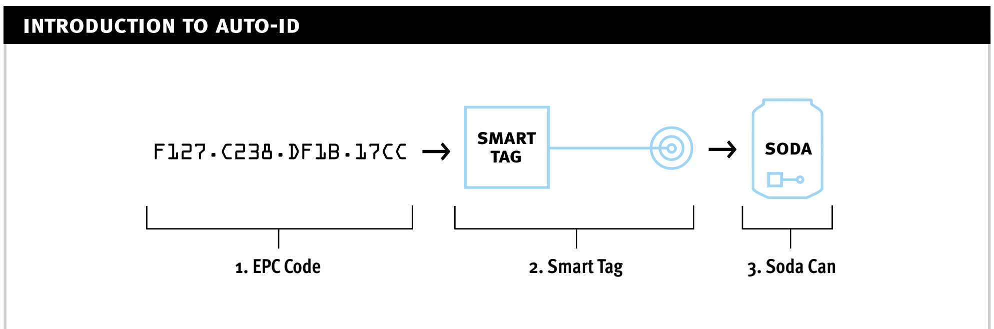


Figure 2:

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"

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 3).

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™.

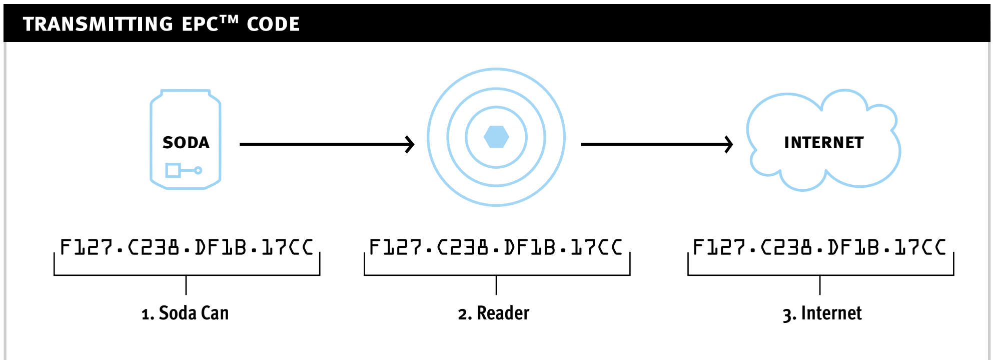


Figure 3:

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

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% of the time. Environmental issues, the make-up 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. Sub-second 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 Industrial, Scientific and Medical (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 read 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.

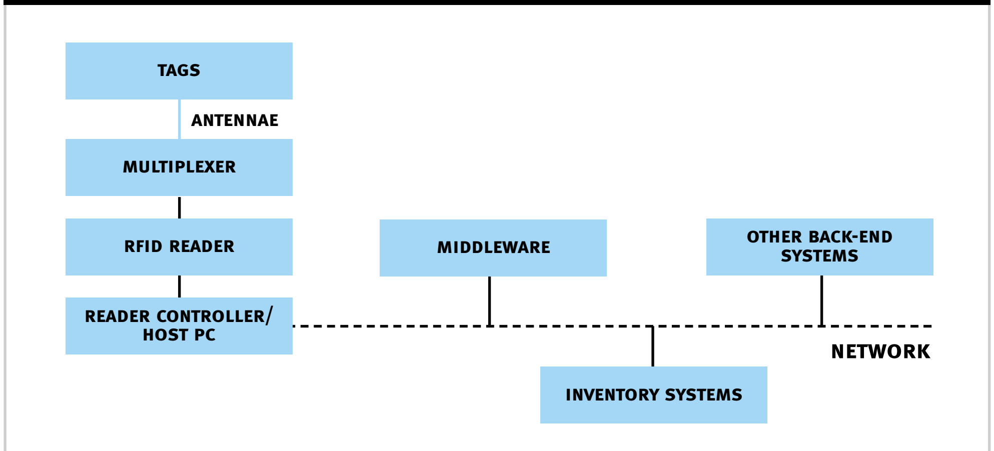
Even with education, there are some legitimate competitive issues. Retailers may see the technology as an aid to their competitors. For instance, since the EPCs™ will be global and unique, it may be possible to determine specific product information from the EPC™ given enough data. Imagine knowledge 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 4 gives a schematic of the various components of an Auto-ID system roll-out. This section outlines each of these components and offers recommendations to calculate the overall cost in a business case for Auto-ID.

Figure 4

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 fifty 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 pre-assigned 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 $2500 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 $2000 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: $1000 to $3000 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), 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% 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 inter-company 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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