MIT Center for Transportation and Logistics

Integrated Supply Chain Management Program (ISCM)
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Auto-ID Center

Auto-ID Technology: Transportation and Logistics Adoption Forum

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Report Overview

This document represents a report of the presentations and content of an MIT conference held on December 5, 2002 entitled "Auto-ID: Logistics and Transportation Adoption Forum." The conference was co-sponsored by the MIT Center for Transportation and Logistics and the MIT Auto-ID Center, and was intended to identify new applications of auto-ID technology in the logistics, transportation and supply chain domains.

This report is structured in two parts, reflecting an interpretation of the content in each presentation (A. Presentation Summaries) and a synthesis by the authors of the proceedings (B. Themes). As the reader will observe, there are many new issues for managers and leaders to consider, and much work to be done to develop comprehensive solutions to the problems and issues surfaced at the event. Hopefully this is a useful start for practitioners and academia to collaborate on creating new solutions to leverage the technology in these domains.

A. Presentation Summaries

1. Introduction to the MIT Auto-ID Center, Kevin Ashton, Executive Director, Auto-ID Center

The Auto-ID Center at MIT represents a confluence of interests and abilities. The result is a collaborative amalgam of users, vendors, and researchers dedicated to exploring the capabilities of the technology and driving contribution to the bottom line.

Motivation: Keeping Track of Business

Companies, such as Gillette and Procter & Gamble pump out billions of individually-saleable consumer goods each year. Tracking these items as they move from the factory to distribution to retail over a myriad of conveyances is a complex problem. Similarly, coordinating the materials so that the supply chain is optimized and everyone gets paid is a complex, multi-company problem. To make matters worse, companies have trouble with diversion, shrinkage, and counterfeiting. Companies need better ways to track their goods.

25th Anniversary of UPC: What's Next?

Bar codes, in general, and the ubiquitous UPC (Uniform Product Code), in particular, have revolutionized the tracking of products in many supply chains, especially CPG (Consumer Package Goods) in retail. But, as great as the UPC code is, it is still very rudimentary. Bar codes require line-of-sight scanning, and this often requires extra labor to maneuver each object into position and alignment with the scanner.

Worse, a given code might only say "I am an 8-pack of AA Duracell batteries" but fail to provide other pertinent bits of information such as "I will expire in 2007," or "I have not been paid for by a consumer,"

or "I have not been paid for by the retailer," or "I was made on assembly line 5 in a plant in Mexico on January 22, 2002," or "I am the same package that was scanned one second ago by a mistake-prone checkout clerk." With the 25th anniversary of the UPC in 1999, the Uniform Code Council was wondering what to do for an encore.

Sensible Sensing by Computers

As information technology becomes a greater part of everyday work and life, the gap between what is in the computer and what is in the real world becomes more apparent. Computers do not sense their surroundings, so they are dependent on external input in order to take appropriate action. Many researchers have worked on machine vision, replicating what the human eye does every day. Unfortunately, machine vision technology has not advanced to be as flexible, robust and implementable to achieve wide adoption and use.

On the other hand, computers are extremely good at sensing other computers and interacting with them. So, researchers wondered: "What if every object were a computer?" whereby in some form, all items could be computers which would be connected, and these computing devices could sense everything in their surroundings. How can one convert 'everything' into a computer or a computing device that senses? One way would be to use RFID technology (which requires a computer chip and a reader in its basic form), although the cost for such a system has been prohibitively expensive. This solution led to the question, "How do we make a computer chip small enough and cheap enough that we can put it on every object?"

Auto-ID: Launched and Growing

The Auto-ID center was formed to address three issues, namely companies' problems tracking items throughout the supply chain, the UCC's thoughts of the future, and MIT researchers' quest for computer sensing. The Auto-ID Center started on October 1, 1999 with just MIT, UCC, Procter & Gamble, and The Gillette Company as members. It has since expanded in all directions. The center has grown to 73 sponsors – 34 end-user companies and 39 vendor companies. The center has expanded from Cambridge, Massachusetts to labs in Cambridge, England and in Adelaide, Australia. More sponsors are joining and new labs are forming in Japan, China, and continental Europe.

Making it Real: The Ramp to Adoption

Many vendors are working to bring Auto-ID products and support service to market. This includes four makers of the reader and various chip makers who have found ways to make tags in volume at the target price of 5 cents per tag. Existing providers of RFID and barcoding systems are working on Auto-ID as the next generation of product identification technology for a wide range of supply chain and manufacturing operations. Paper and package makers are looking at how to incorporate Auto-ID tags into packaging.

A wide range of CPG makers and retailers are sponsoring and overseeing Auto-ID's development. Retailers include major global players such as include Wal-Mart, Tesco, Metro, Target, Home Depot, and Best Buy. Global CPG makers include Procter & Gamble, Johnson & Johnson, Unilever, Gillette,

Coca-Cola, Pepsi, and others. In total, sponsors of Auto-ID represent some $1.5 trillion of revenues. The point is that global companies from all sides of the value equation -- from providers to users -- are driving the ramp to adoption.

2. Update on Auto-ID Technology, Prof. Sanjay Sarma, Research Director & Founder, Auto-ID Center

Barcodes: So Close, Yet So Far

Bar codes suffer from "locational specificity" – the need to know where the object is in order to find out what it is. Thus, the users of barcodes go to a great deal of trouble to handle and orient objects for scanning and then to point the scanner at the barcode. Having to get close to the object limits the utility of the barcode, whereas wireless tags can be read at a distance and do not require line-of-sight.

Escaping the Functionality Trap

Why are current RFID systems so expensive, and what can be done to break through this price barrier? The economics of semiconductors are driven by two factors. The first is Moore's Law, the well-known rule-of-thumb proposed in 1965 by Gordon Moore of Intel where he predicted the "doubling of transistor density on a manufactured die every year." Effectively, this suggests that integrated circuits double in power each year at the same cost. Although the price of a piece of raw silicon has remained constant over the years, chip makers have found ways to pack exponentially greater numbers of transistors onto this valuable real estate. In theory, Moore's Law suggests the future potential of making very small, powerful chips at low cost.

The second factor is the lesser-known economics of chip handling. Paradoxically, smaller is worse because tiny chips are impossible to pick-up, manipulate, and put down easily. If a small amount of static electricity or surface contamination exists, the chip becomes attached to the handling equipment, making it difficult and costly to position properly. Thus, the smaller the chip, the more expensive the handling costs. Between Moore's Law and the economics of handling, it would seem that chips are stuck in the 10-15 cent range as the cheapest practical price point.

For the existing RFID industry, this has led to the functionality trap – adding more functionality to chips of a small but practical size. Existing makers have added increasing amounts of tag-memory and increasingly sophisticated levels of encryption. The result is that traditional RFID tags and readers are expensive and adoption is limited.

Some of the key breakthroughs for Auto-ID are new tag manufacturing methods that bypass the problem of handling very small silicon chips. For example, one firm uses what they call fluidic self-assembly. The company suspends thousands or millions of tiny chips in water and then washes the chips into small holes/holder spots. Other innovative techniques include using vibration or the same electrostatic technique employed in photocopiers and laser printers to pick up, move, and put down extremely small Auto-ID chips. The result is the ability to manufacture inexpensive Auto-ID chips that

are smaller than a grain of salt, without incurring high handling costs. The era of the 5-cent tag is coming.

Going Wireless Without Going Penniless

Inexpensive chips are only part of the solution. The tag's antenna must be inexpensive, too. By adapting standard printing technologies and using conductive ink, the antenna can be produced inexpensively, leading to a total tag cost of approximately 5 cents per tag once volume is achieved.

The readers that interrogate the tags are a major part of the capital cost of an Auto-ID system. Readers might be deployed to every loading dock, doorway, internal passage, shelf, bin, and point-of-sale (i.e., POS, check-out) point in a facility. Current RFID readers can cost thousands of dollars, making them cost prohibitive, despite the fact that the technology in the reader is no more sophisticated than that in a $100 cell phone handset.

As Auto-ID is adopted, reader prices will drop as they ride the typical price-volume curve enjoyed by all mass-produced products. Moveover, some existing systems, such as hourly inventory checking systems, could attach a single reader unit to multiple shelf-mounted antennae. Sharing a reader reduces the cost to equip a store or warehouse with Auto-ID technology.

Toward the goal of creating cheaper readers, the Auto-ID center has designed an "open-source" reader. This soon-to-be publicly-released design contains the tag reader, a built-in Linux-based computer, and an Internet networking interface. The cost of this design is about $100 once market volumes reach a 10,000 unit total. The intent is to encourage the manufacturing of inexpensive readers by sharing the development cost.

Dumb Tags, Smart Network

The most basic Auto-ID tag contains only a unique 96-bit identification (ID) number, referred to as an electronic product code (EPC), which is akin to an expanded version of the familiar UPC code. The EPC has 3 data fields for manufacturer, product code, and serial number. Unique IDs mean accurate item identification, better authentication, and instant item-level tracking. These unique IDs are the key to accessing and managing all of the information about the item, regardless of the item.

The underlying architecture borrows heavily from the web. For example, Auto-ID's ONS (Object Name Service) mirrors the web's DNS (Domain Name Service). The ONS lets someone look up an object by its EPC ID number to find the Internet addresses for information about that tagged item. PML (Physical Markup Language) is the HTML of Auto-ID – an XML-based language for describing objects. ONS, PML, and the aforementioned open-source tag reader can all operate over standard Internet protocols.

The Auto-ID system design attempts to leverage users' existing investments in networking and computing. Dumb tags and simpler readers keep the infrastructure costs low by moving the intelligence of the system into the network and servers. Using Internet protocols and data languages based on XML lets Auto-ID leverage these existing technologies as well.

Open Standards Open For Expansion

The system is very expandable. For example, although the basic Auto-ID chip just has an ID number, the standard does not limit the tags to this minimum. Tag makers can add functionality, if that is desired. For example, tags could contain temperature or shock sensors to enable monitoring of the handling of delicate or perishable items. Imagine not having to discard an entire shipment of frozen seafood because a few items on the outside of the pallet had thawed.

3. Field Test Update, Silvio Albano, MIT Auto-ID Center

The Auto-ID Center is coordinating a staged set of tests of the technology in the CPG-Retail supply chain. Participants include, on the CPG manufacturer side, Gillette, P&G, Coca-Cola, Unilever, International Paper and Johnson & Johnson. Retailers include Wal-Mart, Target, and Home Depot. These tests get the technology out of the lab and into the field to learn how the technology works in real life and what issues arise during implementation and use.

Phase I: A Few Good Pallets

Phase I tested the basic functionality of ONS and the event routing software technology. These are core software technologies for Auto-ID. ONS is the Object Name System, which converts Auto-ID EPC ID numbers into Internet addresses for the data that goes with the tagged item. The event routing software technology is needed to handle tag-reading events. As a limited test, the system was only used on pallets for a few products in a limited set of locations. The original plans for Phase I called for a single city, single facility test. But, companies' desire to get in on the ground floor led to a broadening of the Phase I test to include additional facilities and even additional cities.

Some of the Phase I problems were attributable to the limited nature of the test. For example, with readers installed at only one door some shipments did not get scanned when they moved through the wrong doorway. Also, makeshift antennas around the doorways were prone to damage by forklift operators.

The Phase I test ultimately proved the technology, with ONS and the event routing software working as expected. Despite the problems mentioned, the test achieved 97% reads, which though not acceptable in the real world, was satisfactory for the test. In addition, the test generated information that created awareness of the Auto-ID system capability.

Phase II: Pallets & Cases

The Phase II test involved putting tags on pallets and on cases and then aggregating the cases on pallets. The system cannot currently read every case on the pallet when there are 100 cases on the pallet, but by reading any one number, the system can identify pallet contents. Phase II also tested a "special order cage" where items specially-ordered by customers are placed and tracked for easy retrieval. This avoids the items being placed back on the shelf as regular inventory or getting misplaced before the customer picks them up.

Phase II identified a problem created by interference with existing RF systems. The Auto-ID system was debugged and a solution was found in which Auto-ID and RF systems shared the band. Although this solved the problem, it did require a firmware upgrade.

Phase II also addressed the reading capability issue (97% rather than 100%) raised in Phase I. The problem was solved by using a feedback loop system; the system reads a case and also reads an EPC number. If the system wasn't successful at reading an EPC number, the system rejected the case. This let the testers identify bad tags or tags that were not properly set up. At the end of Phase II, Gillette, Unilever and J&J were all achieving 100% reads when following proper procedure.

Phase III: Pallets, Cases, and Items

The most ambitious test, slated to start after the busy holiday retail season, will feature 300,000 low-cost tags and approximately 100 readers. This test will focus on using the low-cost tags at the unit level. The test will center on the effectiveness of the low-cost technology and different tag types. For example, there will be different tag types for Right Guard deodorant vs. Mach II packages (where the tag will be inside the package) and 2-liter Coke bottles (from which the tags will hang). The test will also use the new prototype readers.

Some sponsors are doing their own tests. For example, Gillette is testing an anti-theft "smart shelf" that detects anomalous patterns of item removal. If a person removes more than a few items at once (more than the a predetermined maximum per shopper), the shelf detects the removal, alerts security to investigate, and "thanks" the customer for the large purchase via a shelf-mounted digital display. The "thank you" effectively serves as a deterrent to would-be thieves, alerting them that the store is aware of their abnormally large selection. Gillette products like Duracell batteries and Mach III blade replacements are frequent targets of shoplifters due to their compact size, high value, and ease of resale, making this a high-impact application for the company. Dai Nippon Printing in Japan is also pursuing an aggressive test program with approximately 750 readers. Each sponsor company is evaluating how the technology will impact their business.

Other Tests

Japan Field Test: Companies in Japan will be conducting field tests, using tags that measure humidity and vibration (which is of particular interest in monsoon season).

The takeaway from the field tests is that the technology is working. There are still some challenges to work out, such as reading everything in a pallet all at once, but the technology is here and is working.

Mr. Albano also noted that the results of limited tests could sometimes be corrupted by the limited nature of the tests. Some of the problems seen in Phase I and Phase II testing arose from the fact that, for example, with readers installed on only one door during the test, pallets that went through the "wrong" door missed being scanned as mentioned previously. In a full-scale implementation, all doors would have scanners and so these missed scans would never occur. Thus, a pilot project might underestimate the benefits of a technology due to problems that would not occur after a full-scale implementation.

4. Introduction of Applications, Dr. Jonathan Byrnes, MIT CTL and John Wass, MIT CTL

Dr. Jonathan Byrnes and John Wass discussed applications of the Auto-ID technology. Their starting premise was: If this technology is feasible, what do we do tomorrow to get it happen?

The presenters identified three major areas for application of the Auto-ID technology:perpetual inventory, automatic scan, and product identification.

Perpetual Inventory

Currently, most companies have perpetual inventory systems, but the accuracy of those systems varies. There is a good deal of 'leakage' (i.e. inventory loss) in current systems. Also, given the limits of bar coding, companies do not track items on shelf. They track when an item moves through the system, such as the POS system, and then calculate the inventory based on which items left the shelf and went through a POS system. Over time, however, accuracy degrades when tracking inventory in this way, so companies do physical hand counts periodically. Counting inventory is expensive, as is reconciling inventory. With Auto-ID, each item can be tracked regardless of location (shelf, DC, in transit) and whether it is moving or not.

Finally, most companies don't know what inventory is en route to them. One value of Auto-ID is that by knowing that a shipment of products is coming, companies won't have to maintain high levels of safety stock/product inventory to protect against the uncertainty of supply, hence decreasing company inventory holding costs. Such benefits to the bottom line are clearly possible. For example, the grocery industry does not keep perpetual inventories at the store level, requiring that employees go to the shelf and compose orders daily. With Auto-ID, stores can gain real-time inventory status at all times and therefore can place orders using real-time inventory data rather than depending on physical counts.

Automatic Inbound and Outbound Scanning

The potential benefits for receiving-area applications is high, particularly in reduced labor costs. First, because Auto-ID does automatic scanning, labor won't be needed to move and handle items to bring them to a barcode reader. Auto-ID also facilities crossdocking: knowing that a shipment is coming and diverting it immediately to its destination without having to put the items away. Similarly, much labor is used taking pallets apart to check the shipments. Auto-ID would scan the items automatically, recording each item without tearing down every pallet. The speed of Auto-ID can potentially alleviate congestion on shipping docks.

Finally, at store checkout, the Auto-ID system can possibly save much and labor as well. Instead of a store clerk taking each item out of a shopping basket to scan it, put it back into a bag and into a cart, all the items could be scanned automatically in the cart when the customer leaves the store.

Asset Tracking and Returns Management

Unique identifiers bring a new level of accuracy to identifying products and assets. Auto-ID can help companies identify items in a shipment, containers on a ship, equipment in a hospital, etc. For example,

manufacturers could use product identification to control quality and track component parts to finished goods. Another hidden but large savings is in returns management. Retailers like Wal-Mart and Staples commonly have 5-10% of their product returned, and consumer electronics average 12-14%. Helping retailers validate returns and understand the source of legitimate product returns (e.g., knowing that the returned item was indeed sold by the company, as well as the specific item sale price) has an impact on profitability.

Two Approaches to Implementation: Selective vs. Comprehensive

Companies can approach implementation or rollout of Auto-ID technology in one of two ways. They can rollout the technology selectively within the organization, or they can rollout comprehensively outside the firm. A comprehensive rollout has two disadvantages that companies should consider. First, major modifications to existing systems will be required to accommodate Auto-ID. Data structures in existing legacy systems will have to be rewritten to take advantage of the new Auto-ID data. Second, the sheer volume of data that Auto-ID makes available will look like 'too much information' to some users, voiding the benefits of additional information to some users.

Because comprehensive rollout is a significant undertaking with high training and reconfiguration costs, selective deployment can be an early step. Companies can select specific assets or items to tag and track. Existing information systems can be used, and deploying the technology will be less expensive because it won't be necessary to wire an entire facility before seeing benefits. This kind of rapid implementation can possibly show a bottom line gain quickly and can possibly make subsequent deployment easier to justify.

The anticipated likely benefits of selective deployment include:

* fast payoff
* easy implementation (existing IT systems don't need to be changed)
* showcase proof of the concept to accelerate future applications development
* placement with users to explore and develop additional applications they invent.

How to Choose Items for Selective Deployment

High-Value Products: Companies can begin by choosing items that will have a big impact on profit, such as tracking expensive assets. They can put tags on certain items, such as large assets like trailers, containers, or mobile tools. This approach can bring significant savings for low cost and does not require existing information systems to be replaced.

Volatile, Fast-Moving Products: With fast-moving fashion and short product-life-cycle technology items, retailers can benefit from real-time awareness of sales trends and of product en route, reducing the need to guess when ordering. This is especially true for fast-moving products (retailers are stuck with inventory they bought that didn't sell if they 'miss the sales window' or estimate their needs poorly). Controlling and managing those products better translates into lower write-offs and markdowns of inventory.

High-Profile Products: Pharmaceuticals that are subject to recall or expiration can be tagged to make tracking and recall simpler.

High-Theft Products: Tagging items that are high-theft items and tracking them throughout the entire supply chain could significantly reduce loss. This application could be the largest cost reduction opportunity.

Selective Deployment Leads to More Applications

The fast pay-off of selective deployment combined with getting the technology implemented helps lead to other and more widespread applications. Quick wins build support for the concept. With experience with the technology, a company may be able to find other innovative and unexpected uses for it.

5. Department of Defense Vision of Auto-ID Applications, Dan Kimball, Dept. of Defense

The Depart of Defense (DoD) has the largest RFID system in the world today. Lessons from Desert Storm made clear the need for RFID technology. During Desert Storm, large numbers of containers were shipped to the field, but because the contents of the containers were not obvious, the materials could not always be rapidly and efficiently deployed. Sergeants at the receiving end knew in aggregate that some containers had food and others had clothes, but they didn't know which container had which, or where a given container was located within the huge staging areas. Thus, supply sergeants simply ordered more materials and the pile grew. Expenses rose and items became even harder to find.

RFID technology brought benefits by being nonintrusive and non line-of-sight, enabling officers to track containers and interrogate them at a larger distance. In addition, RFID tags store a larger amount of data than a simple bar code, enabling the DoD users to store the entire manifest of container contents on a tag. Overall, the potential advantages of RFID are timeliness, accuracy and efficiency.

DoD Applications of Auto-ID

Mr. Kimball went on to describe four applications that the DoD is pursuing related to Auto-ID. First, the DoD is exploring how to identify the location of material at all stages of its lifecycle, be it in process, in storage, in transit or in use. Second, the DoD is exploring Auto-ID as a solution for predicting the deterioration of explosives, propellants, and pyrotechnics. The tags, smaller than the size of a dime, contain the chip, antenna, and a 40-year battery (the battery recharges off of ambient radio waves in the air). The tag can be read inside metal and actively tells officers its location. This application cannot use a passive tag, because the energy emitted by the reader might set off the explosives. The tags are small enough to affix when manufacturing the weapon.

Mr. Kimball also discussed affixing Auto-ID tags to hazardous materials, knowing the chemical weight of the materials of each item and reporting it to the government. Federal regulations require that the DoD notify local authorities of any of a number of hazardous materials over a certain threshold, and this implies tracking all the materials, regardless of quantity, in order to know that a given location has not

accumulated too much of the regulated materials. Currently, the challenge in this area is being able to read the tags through liquid.

Fourth, tags help the DoD track items in repair, and ensure that parts from one helicopter remain together when that helicopter is reassembled. The benefits include: improved scheduling of repairs, knowledge of part location, and control of repaired item configuration. The DoD is also tagging high-value items and using automatic scanning and locating to eliminate the labor currently associated with manually tracking down lost items. If an aircraft carrier, which currently requires a complement of 6000 personnel, could function with 5000, the potential labor savings would be significant.

Mr. Kimball also mused on future applications, including a "telepathy tag." Such a tag does not exist (nor can we guess how it might work), but this illustrates how the DoD is considerate of adopting a technology that has potentially many undefined applications and the implications of those future potential applications on current choices.

Lessons Learned

Mr. Kimball concluded with some lessons learned and advice for others. First, when evaluating a new technology, it is important to look at the lifecycle cost, not just the acquisition cost. Currently, with the systems that the DoD uses, the tags are inexpensive but the interrogators (readers) are not. The DoD is spending $3 million per year on maintaining its infrastructure of interrogators in Europe, which means that maintenance costs are running 30% of installation costs annually.

Second, users need to be aware of regulatory issues, because these issues will affect application and use of the technology. For example, everything that is put on an airplane requires FAA approval. Also, using the tags for global application requires obtaining local government approval for the use of the RF frequencies.

Likewise, standards and interoperability are critical. The DoD believes that the cost of its membership in Auto-ID is a fraction of the cost of having to modify systems after a given standard has been adopted. By being aware of the standards as they are developing, and having some say in the standards as they evolve, the DoD will save much greater expense later. Air interface protocols and data formats must be standardized so that companies can buy a tag from one supplier and an interrogator from another and have them be interoperable.

6. Applications Insights -- Industry View, Mark Lewis, United Parcel Service

Mark Lewis explained how UPS is using tagging and the near-term applications of Auto-ID. UPS moves 12 million packages daily, with 1300 facilities in the US and operations worldwide. Currently the UPS label embodies UPS's information requirements, enabling sorting across facilities that may not be using identical information systems. UPS tracks the lifecycle of a package in transit, reporting physical scans, logical scans and derived scans. For example, packages are scanned at all departure, arrival, load and unload points. UPS also tracks signatures that verify receipt of an item, because customers use that data to close outstanding sales.

Mr. Lewis outlined the minimum requirements for tracking individual packages. First, the tag must be extremely low cost so that it can be attached to the package and be easy for customers to use. For on-the-road use, portable readers and spares are expensive. Another issue is how the tag gets read: who has access to the information? Finally, tags must be able to be read quickly over high-speed belts during sorting.

The near-term applications for Auto-ID include asset management, reusable containers, high-value items, time-critical items and access to real-time information that facilitates international/customs handling.

Mr. Lewis identified five barriers to the adoption of Auto-ID at the item level.

1. Infrastructure: UPS has 1.6 million customers, and it does not want to have to supply each customer with consumable tags. Currently, customers can print their own labels and affix them to a package. UPS wants to avoid supplying consumables, because consumables are an expense that goes right to the bottom line.

2. Multi-industry Adoption: RFID technology needs to move beyond consumer products because it has valuable applications in many industries. It provides visibility throughout the supply chain, including during transportation. That opportunity should not be missed by mistakenly thinking that the benefits will accrue only between manufacturers and retailers.

3. Customer Systems: Replacing existing systems with new technology will be an issue, especially for large customers like UPS.

4. Compelling Value: Simply replacing bar codes with tags that do not require line of sight is not a big enough benefit. Additional benefits have to exist in order to justify the investment.

5. Carrier Commoditization: Transportation and logistics companies today distinguish themselves by the level of information they provide. There's a fear of losing this differentiation and IT investment -- carriers don't want to be commoditized. Therefore, issues such as how to structure the information, who gets access to it, and when they get access to it, need to be resolved.

7. Breakout Group Presentations

To generate discussion and ideas, the audience was divided into 4 breakout groups. These groups each addressed the same 5 questions. The result was both a consensus on many of the questions as well as a number of interesting issues raised by each breakout group.

What are the High-Payoff Applications?

The groups described a number of high-payoff applications in transportation that the group believed could create greater visibility and faster cycle times. Ultimately, these applications should be explored in detail to assess requirements for implementation and to fully understand the costs and benefits of each application before making assertions of benefit. The examples and suggestions follow.

Carriers could track assets for better utilization and to help the carrier assess capacity issues. Information provided by Auto-ID would also help expedite border crossings by being able to clear customs and pay duties on loads ahead of time rather than waiting in line (potentially for hours). Shipment tracking could let carriers provide better service. Customers could enjoy greater visibility into shipment status, getting timely and more accurate advanced notices.

Auto-ID could also improve operations at the receiving end. Companies could gain an early warning view into product coming their way. Receiving docks could clear Bills of Lading faster and shorten the payment cycle. Supply tracking could facilitate cross-docking and accelerate flows in distribution.

Repairs, returns, and maintenance are also strong candidates for the use of Auto-ID. Advanced tags could be used for diagnostics, proactively signaling the need for maintenance or repair work. Companies could also minimize returns through greater visibility. For example, companies like Monsanto experience high obsolescence with aged seed product, so knowing seed inventory by age and location could prevent or reduce this loss. Improved visibility for repair and returns management could bring significant benefits. All industries could possibly benefit from improved customer service in the areas of tracking items for repairs and servicing.

Both retailers and manufacturers could benefit from timely, accurate inventory data. Auto-ID could be used for better replenishment processes and to enable quick response. Using real demand data to drive the replenishment process could possibly reduce stock-outs and increase revenues for manufacturers, retailers and third-party logistics firms alike. The groups were intrigued by Auto-ID for retail checkout processes. This could do more than reduce labor costs. Eliminating checkout lanes could save space by removing cash registers, resulting in more floor space available for merchandise.

Auto-ID could also ameliorate a range of problems facing many companies. Product diversion and loss due to theft could be reduced. Better tracking could reduce claims and chargebacks. Companies that need to recall products could also benefit by having clear data on where the defective products went. The healthcare industry could reduce errors and improve patient safety with better tracking of pharmaceuticals. Hazardous material reporting could also be facilitated.

Will Companies Share Information with Others?

All of the groups recognized the conditional nature of sharing information -- sharing on a "need to know" basis. Information sharing occurs now and is good, but it is slow. Auto-ID could improve sharing, if companies can figure out how to control access and solve the issue of who pays for the information. One group also noted that the new Internet-based Auto-ID standards may eliminate VANs (value-added networks), which could save companies those costs.

Sharing information raised special concerns. Obvious concerns centered on the issue of competitor's access to a company's information. For example, if Wal-Mart is selling one box of Duracell batteries per hour but Walgreens is selling two per hour, Walgreens would not want Wal-Mart to know that fact. Restricting information access was also seen as crucial to preventing criminal activity – ensuring that criminals did not know what was on the truck or in a building.

What are the Barriers to Implementing Auto-ID?

The IT implications of Auto-ID ranged from what to do about legacy systems to what to do with all the new data and information generated by Auto-ID. The scope of infrastructure necessary for the data management was large, so issues of how to manage and store all the information, and how much information was too much, were noted as important to address. Transportation companies were especially concerned about the burden of the system on them. "No one wants to buy the hardware and do all the processing" was a common comment.

Buy-in by top management and functional silos concerned some groups. In some companies, management demands quick ROI based on facts, not dreams – these conservative cultures avoid the leading edge of technology. Rather than be a first adopter, they prefer to let someone else figure things out first. The barrier of conservatism was also reinforced by entrenched legacy systems and their attendant investments.

The breakout groups also worried about how Auto-ID might disrupt existing business processes. For example, manufacturing companies did not want to have to slow their throughput down in order to apply tags. Even if deployment were selective, some thought that it could be cumbersome if companies had to maintain two sets of processes in tandem.

Clarity of and compliance with standards were also a barrier. The standards would have to be global standards so that they could be used in international trade. Someone would need to assign tag numbers and keep numbers distinct. Some groups worried that intellectual property rights and royalties for patents could stifle adoption.

What is the Workteam Structure for Implementing Auto-ID?

Cross-functional teams were the universal norm selected by all breakout groups. These teams include functional experts and IT. For cross-supply-chain implementations of Auto-ID, the teams would include members from all companies involved in the initiative. Such teams exist already in CPFR (Collaborative Planning, Forecasting and Replenishment), and such teams could be leveraged for selective deployment of AutoID. A cross-functional team of key customers, 3PLs and manufacturers were seen as essential to the implementation. One group mentioned that even representatives from government regulatory agencies might be included. Although not an "all hands on deck" project, Auto-ID would draw on people from appropriate segments of the organization and the supply chain.

What is the Timeframe for Implementation?

Different groups presented different estimates for the timeframe of projects. For selective deployment or high-value pilot efforts, timeframes ranged in the 6-18 month timeframes. Group members believed that individual companies could drive the implementation quickly using selective deployment, but that the value of the system would have to be demonstrated. Broader deployment was seen as taking 3-6 years (1/4 the time required for UPC to become ubiquitous).

The determining factor was how fast other members of the supply chain adopted the technology. In particular, one group noted the crucial role of dominant supply chain participants – saying that Auto-ID

would be implemented when "P&G says we have to implement it." Another group noted that adoption could be driven by "when the government mandates it for homeland security reasons."

8. Summary, Dr. Jonathan Byrnes, MIT CTL

In the synthesizing discussion, Dr. Byrnes suggested using a matrix that depicts low-to-high value potential (or benefit potential) on the vertical axis and low-to-high difficulty of implementation (or hassle) on the horizontal axis. The best areas for early implementation were the high-value, low-difficulty-to-implement areas.

Some areas, such as labor savings, provided high value but had high difficulty-to-implement because they required the technology to be pervasive, the training to be extensive, and required interfacing with a variety of different existing information systems.

In contrast, using the technology to facilitate cross-docking at a single warehouse required much less technology deployment and connection. Similarly, using Auto-ID to avoid stock-outs at the shelf level provided high value and a medium amount of hassle.

The way to motivate management to support the new technology was to identify and explain the entire game plan, then identify one facility for a test. The test could be done within the walls of that facility, which would reduce the hassle factor by not requiring all doors and shelves to be wired everywhere first.

Some of the key learnings of the day were that the technology is there but that companies were not sure yet where to start applying it. Some of the issues raised were, “what happens if you don't act? What is the cost of doing nothing?” One company mentioned that they are currently investing in bar coding equipment, but that investment will become worthless in light of the superior Auto-ID technology, so not deploying the new technology immediately was not wise. "If the technology is proven, you'd be crazy not to implement it," was one member's view. Some believe that first-mover advantage could translate to increased market share and be a big differentiator for the company. "It's the difference between driving the bus and being hit by the bus," was another comment. Audience members also pointed out that waiting to deploy the technology until it is mandated by a big customer like P&G or Wal-Mart puts the company on the customer's timetable, not its own.

On the topic of selective deployment, one member suggested handling stockouts within a single store by wiring a few shelves. This would let the company test the system on a small scale while seeing gains in reduced stockouts and improved sales.

Large benefits will accrue to retailers who are able to deploy the technology and remove cash registers and cashiers. That will require major cultural changes, as well as reconfiguring the store and coordinating with vendors. The technology might move companies further in the direction of vendor-managed inventory, with all inventory on consignment.

Some of the biggest savings associated with Auto-ID are revenue-oriented, namely avoiding markdowns or out-of-stocks. Auto-ID is a strategic issue, Dr. Byrnes said, and it has as much to do

with sales and marketing as it does with lower operating cost structures. Using Auto-ID technology has the potential to differentiate a company in the marketplace. "Consider P&G coming to Wal-Mart and saying to them, 'you will buy more of my products because I will lower your cost structure,'" Dr. Byrnes said. "Think about the power of that concept. The system sells the product." Auto-ID has the power for far-reaching changes such as these, Dr. Byrnes concluded.

B. Themes

1. Benefits of Auto-ID

Throughout the presentations and audience discussions, numerous potential benefits for Auto-ID were mentioned. (As mentioned previously, the applications should be explored in detail to assess requirements for implementation and to fully understand the costs and benefits of each application before making assertions of benefit). These benefits that were referenced in the session can be divided according to their impact on various business metrics.

Revenue Enhancement

An empty slot on shelf means lost sales – one fact that Procter & Gamble is especially concerned about. Worse, stock-outs can encourage or force consumers to try other brands, reducing customer loyalty and reducing long-term revenues. Stock-outs can also impact a shopper's loyalty to the retailer, causing the consumer to shop elsewhere if a preferred brand or SKU is not reliably stocked.

Currently, retailers have no practical method for detecting stock-outs, other than labor-intensive manual scans of the visually cluttered store shelves. But, Mr. Wass and Dr. Byrnes noted that with Auto-ID and shelf-mounted reader antennae, retailers could keep an accurate perpetual inventory automatically. With such a system, any inventory shortages would be detected automatically (even before the last item gets to the POS) and generate a shelf replenishment alert in the stockroom. Low-cost, automated methods for perpetual inventory tracking will reduce stock-outs and increase revenues.

Cost Reduction

Auto-ID reduces cost in a number of direct and indirect different ways. For example, Auto-ID reduces handling costs by permitting non-line-of-sight scanning and simultaneous multi-object scanning. For example, Mr. Albano described the Phase II tests that proved that a doorway-mounted reader can read all the cases on a pallet as it moves to or from the loading dock. Phase III tests will demonstrate that Auto-ID can read the items in the cases on a pallet -- reading a hundred of tags per second.

Reductions in handling costs go beyond warehouse and logistics operations. For example, Dr. Byrnes discussed how checkout labor is a major cost for retailers. But with tagged retail goods, shoppers could conceivably check themselves out. Scanners in the shopping cart or in special automatic checkout lanes would scan the cart contents and let the consumer pay. At the very least, (or as part of a selective deployment strategy), cashiers would only handle selected goods (e.g., produce, bulk foods, or untagged items) manually.

Indirect cost reductions could arise from reductions to inventory. Auto-ID enables accelerated handling processes and timely data on inventory. This allows supply chains and retail stores to operate with leaner inventory levels. If a business actually knows its inventory, it needs less safety stock to cover errors or uncertainties in that inventory.

Reducing Diversion and Shrinkage

Crime impacts all points in the supply chain. Tagging and tracking items makes it harder to divert the items, harder to sell stolen goods, and harder to shoplift from stores. For example, Mr. Ashton described Gillette's new "Smart Shelf" that will detect unusually high removal of stock from the shelf. Batteries and razor blade replacements are popular with shoplifters due to their small size, high value, and ease of resale. By continuously scanning the shelf, the system will know if someone has taken multiple packs at once. The system will alert security, get the person's picture, but also display a "Thank you for buying 5 packs of Duracell batteries." The thank-you acknowledges legitimate buyers while causing shoplifters to think twice stealing the items.

Auto-ID can also deter would-be truck hijackers or those who might divert goods from warehouses for resale into the normal retail supply chain. Timely tracking of the flow of goods and inventory on shelves let supply chain managers pinpoint any diversion. In addition, as more retailers use Auto-ID, diverted stock will not be able to avoid the ubiquitous readers. If someone scans a "stolen" item, the authorities can be alerted. Moreover, the police will be able to prove that a given pack of Pampers was on the hijacked truck when authorities apprehend the hijackers.

Finally, during the breakout session, a number of participants discussed how industries ranging from fashion to industrial parts to pharmaceuticals face the problem of counterfeiting. Counterfeiting reduces revenues to legitimate makers, sullies the reputation of the brand, and can be life-threatening (in the case of substandard industrial parts or counterfeit medicines). A unique ID and secure database make it harder for counterfeiters to pass on fakes as the real thing. Even copying a valid ID number will not work, because having the same ID object appear in two places at once will raise suspicions (e.g., showing up in Store "B" after it was sold in Store "A").

Supply Chain Acceleration

Auto-ID can possibly enable supply chain acceleration by providing timely data and by accelerating key processes. Automated scanning could accelerate inbound processes because of reduced handling time spent cross-checking orders. Tracking of inventory on shelves could lead to faster recognition of low or out-of-stock conditions. Tracking of inventory on shelves could also help companies quickly locate wayward stock or accelerate pick-and-pack processes. Automated scanning of outbound shipments could automatically trigger advance shipment notices (ASNs) so that the customer knows the shipment is on its way as soon as it clears the loading dock door. Scanning at every point in the supply chain could help companies track and accelerate distribution processes.

Process Quality Improvements

Amid the flow of goods and information in the supply chain lie numerous source of potential errors. Discrepancies in orders, shipments, and payments can occur at any point along the supply chain. Auto-ID could help provide more accurate data on the exact composition of shipments, case contents, and orders. The technology would contribute to accurate tracking of inbound and outbound flows as well as automatic payment and billing processes. This would reduce the frequency of errors by ensuring the integrity of shipments and orders as they move through the supply chain. The result: high quality of service to supply chain partners, fewer chargebacks, and less labor wasted on reconciliation. Dr. Byrnes noted that better, more-timely information could reduce the dreaded bullwhip effect that amplifies volatility in the supply chain.

Auto-ID could also aid in better individualized customer service. For example, one retailer noted the technology's potential application to the retailer's fur coat storage business, helping the company track its customers' coats. Another fashion retailer is considering the CRM (Customer Relationship Management) possibilities of Auto-ID tracking of a customer's purchases to help that customer find other clothes that match and fit. Finally, Mr. Albano indicated Home Depot's test of Auto-ID is for special orders – ensuring that special customer orders don't get intermingled with regular stock when they reach the store. Auto-ID has obvious applications to tracking individual items on behalf of individualized customer services.

Risk Reduction

Better data at the level of individual items can also help companies reduce risks and potential liabilities. Both Mr. Ashton and Mr. Albano identified the potential to improve the freshness of inventory or cull expired goods from shelves. Combined with shelf-mounted Auto-ID readers and perpetual inventory systems, warehouses and retailers could get timely data or alerts about stock that is nearing expiration or has passed its "sell by" date.

Auto-ID can also support more efficient product recalls. For example, Ford expressed interest in tracking the individual components that go on its cars – helping the company implement minimalist recalls of only those individual cars that might have defective individual components. Too often, food companies or manufacturers are forced to recall large numbers of items because they have no ability to distinguish one individual item from another. Thus, they are forced to recall all the product that might contain the defective component or the suspect ingredient. Finally, Auto-ID tied to CRM would help companies find customers or alert them to safety issues after the sale.

2. Application by Function

Applications of Auto-ID can also be divided by "how" the technology is used.

Tracking the Flow

A natural application of non-line-of-sight scanning is in tracking the flow of goods in the supply chain. Auto-ID has the potential to scan all the items on a pallet as it moves into, through, or out of a

warehouse. The advantage over barcodes is the elimination of dwell time and handling because Auto-ID tags do not require what Prof. Sarma called "locational specificity." Forklift drivers need not stop to log what they are carrying or where they are carrying it. Readers around every portal could automatically log the passage of goods in warehouses, cross-docking facilities, and retail loading docks. The result could be a much clearer picture of supply chain flows and better control over the movement of goods. Portal-mounted scanners could also reduce diversions and shrinkage -- noting exactly which items were removed through which doorway and at what time.

Monitoring Inventory Status

Automated, on-the-shelf monitoring of inventory is one of the more innovative and new applications of Auto-ID. An Auto-ID system could provide timely, accurate inventory counts without any of the labor costs associated with manual inventory counts. Such a system would use a modest number of readers that connect to a switched array of shelf-mounted antennas. Rather than rely on the integrity of inbound and outbound tracking, inventory monitoring would provide incontrovertible data on what is in stock and where it is located. The system could also help locate wayward or misplaced shelf stock.

Supporting Point Functions

Although many Auto-ID applications involve large numbers of readers covering massive distribution facilities, not all applications require massive infrastructural investments. Some applications are point-uses: a single reader at a single point of use. Gillette's smart shelf, with its anti-theft function, is an example of this. Local tracking of stock removal and local alerts mean that the system can work without massive integration with back-office IT infrastructure. The Navy is also looking for that type of point solution for the storerooms of ships, according to Mr. Kimball. Faster check-out/check-in processes would help the Navy reduce shipboard labor. Point solutions are another good example of selective deployment as defined by Dr. Byrnes.

Assembly/Aggregation/Disaggregation

Packing facilities and assembly workstations are a natural point-of-use of Auto-ID. Any time that aggregation or disaggregation occurs, tags on the items and on the assembly could help track what went with what. In logistics, the technology could help track which items were loaded into a pick-and-pack bin for a special order, document which items were loaded into a case, or document which pallets were loaded into a truck. The Phase II tests, described by Mr. Albano, test the tracking of cases on pallets.

In manufacturing, Ford Motor Company noted the need to track the parts assembled onto its cars. Item-level tracking could help with quality efforts and product recalls – pinpointing exactly which cars received which component parts. Dan Kimball of the DoD said that the DoD has this application in the Army's helicopter maintenance bays. The Army needs to track specific parts for each specific helicopter because despite being from the same design, the parts are not entirely interchangeable, with the original matched part-helicopter combination working far better than other combinations.

3. Application by Industry

Auto-ID has applications in a number of different industries.

CPG-Retail SC

Because Auto-ID is a natural replacement of the ubiquitous UPC code, it is not surprising that the CPG-Retail supply chain is a major supporter of Auto-ID. Retailers like Wal-Mart, Target, Tesco, Metro, and Home Depot as well as CPG makers like P&G, Gillette, Kimberly-Clark, Coca-Cola, and Pepsi are all sponsors of the center. Auto-ID could help the CPG and Retail sector manage inventory and the flow of goods from end-to-end. Once broader penetration is achieved, retailers could reduce labor costs with automated self-service checkout. Gillette is even working on an anti-theft smart shelf for high value retail items like batteries and razor cartridges.

Logistics and Transportation

Any company that moves large numbers of items every day needs advanced tools to cheaply track and locate those items. Many logistics providers could use Auto-ID to track shipments. Postal services and package delivery companies have high-intensity tracking needs. For example, the US Postal Service handles approximately 200 billion items each year. The key for Auto-ID is to reduce handling costs through more automated scanning while not adding too much to the cost of infrastructure or the cost of each item carried. Thus, the key is getting the cost of the tags down so that UPS can use it on every low-cost ground shipment or that the US post office can afford to put one in every postage stamp.

Many logistics operations use (and reuse) specialized containers, holders, or packaging. Tagged containers are also a useful proxy or first step in moving to operations with tagged objects. For now, the most immediate applications in logistics will be tracing reusable and returnable packaging. Tracking palettes (e.g., those made by CHEP with embedded Auto-ID tags) has the smaller scale and higher value of a selective deployment described by Dr. Byrnes. Where the returnable container is used in the supply chain, reverse logistics, retention fees, and lost container replacement fees become important issues. Tracking who has the container and when they have returned it is an apparent application for Auto-ID.

Durables Manufacturing

The manufacturing and repair of complex durable goods includes managing the parts that go into those goods. From Ford Motor Company to the Department of Defense, tracking parts during assembly, out into the field, and during repair are an important issue. By tagging parts and tracking what was assembled with what, organizations could keep better track of components at all stages of the product's lifecycle. Applications include minimizing the scope of product recalls, tracking parts during repair processes, and maintaining inventories of used-but-refurbished parts.

Healthcare

Auto-ID could be used to track pharmaceuticals in the healthcare supply chain. This could support FDA mandates, aid efficiencies, and prevent the sale of expired medicines. Auto-ID could also help

hospitals and clinics to track mobile medical equipment – improving asset utilization and reducing the labor of finding lost equipment. One participant also noted the potential of Auto-ID combat counterfeiters that steal and refill empty containers from hospital dumpsters. By logging empty containers out of the system, those containers could not be refilled with counterfeit medicine and resold.

Individualized Customer Services

Some companies provide services that involve handling products owned by the customer (e.g., repairs, alternations, or fur storage). Examples include repair services, cleaning services, and storage services. Logging the receipt of goods, intermediate process steps, and retrieving the customer's item all imply accurate tracking of all customer items. Lost or misplaced items are a major service problem – no clothier wants to say that they can't find your pants or your fur coat. At the same time, service providers need to manage the high labor costs of handling customer items.

4. Costs

The cost structure of Auto-ID is a major concern because it affects ROI. The following section discusses some of the cost elements of Auto-ID, working from the tag chip outward. Mr. Ashton said that every penny counts, especially for applications that involve tagging every item in a retail store or small-package delivery service.

Tags: Cheap Chips

The price barrier on traditional chip manufacturing and packaging is about 10-15 cents per chip. Prof. Sarma described that this was due to the handling costs on very small chips. Although Moore's Law means that semiconductor makers can pack the electronics into smaller and smaller bits of silicon over time, handling very tiny chips is costly. The optimum size and functionality of chips currently translates into a chip with a cost in the 10-15 cent price range.

Innovative handling of tiny chips using water, vibration, or electrostatic handling techniques represent new ways to potentially fabricate chips without the costly handling. For example, one firm has a manufacturing process that washes the sand-grain-sized chips into the little holes of the substrate that carries the chips. The result is a lower cost which translates in to a cost reduction of a few pennies. Moreover, technologies such as this support the high volumes needed by the Auto-ID marketplace. The video tape about the state of the Auto-ID industry noted that this new technology is being used in a factory for Auto-ID chips designed to manufacture approximately 80 billion chips per year.

Tags: Cheap Antennae

A tag is more than a patch of silicon, however. A functioning tag also needs an inductor or antenna to interact with the wireless reader that will interrogate the tag. Existing RFID technology has often used wire coils or printed-circuit coils to create the inductor/antenna. For Auto-ID, numerous printing and packaging companies are developing cheaper approaches to making this crucial component of the tag. For example, conductive ink can be used to "print" the antenna at a very low cost point. Overall, Prof. Sarma estimates that the total price of the tag (chip and antenna) will be 5 cents per tag.

Readers

Readers are a substantive part of the infrastructure costs of Auto-ID. Depending on how Auto-ID is used, readers might be installed at every door of a distribution operation, on every shelf in a warehouse or store, or at multiple points along every conveyer line. Current RFID readers can cost $5000 to $7000 each. Prof. Sarma thinks this represents deep profit margins for the sellers because the core technology of these readers is less sophisticated than that in a $100 cellular phone handset. The cost for Auto-ID readers is expected to drop as volumes increase.

Moreover, for some applications, a single reader can cover a very large area, according to Prof. Sarma. By installing multiple cheap antennas and switching the reader between them, a company can do inventory monitoring without buying too many readers. In choosing Dr. Byrnes' selective deployment strategy, a company would look for applications that require a smaller number of readers.

To accelerate the downward spiral of prices, the Auto-ID center has designed an "open-source" reader. This design will have a $100 unit cost once market volumes reach 10,000 units. Although sponsors have exclusive access to the design for some months, the Center will release the design to the public to stimulate the development and manufacture of cheaper readers.

Networking

Readers need a connection to corporate intranets. Fortunately, Auto-ID technologies are designed to leverage inexpensive and widely-used Internet technology. Thus, the system does not need its own proprietary network. This will make information sharing with Auto-ID cheaper than that with EDI (electronic data interchange) or VANs (value added networks). Reader manufacturers are also considering wireless networking for mobile scanners.

Back-Office Integration

One cost issue that remains unresolved is the cost of back-office integration, an issue discussed by Dr. Byrnes. Auto-ID provides a new level of detail and intensity of data. With the additional data, companies must find a way to convert the data into information and into knowledge that may be used to support sound management decisions. Unfortunately, legacy systems may not be equipped to handle the volumes of item-level data that Auto-ID can generate. Potential changes included restructuring legacy data fields, connecting new data streams to old back-office applications, and creating new management decision processes to take advantage of Auto-ID-derived data. Just as the UPC led to a new generation of POS applications, EPC may possibly lead to a coming generation of POS and supply chain applications.

Maintenance

Mr. Kimball mentioned that the lifecycle costs of these technologies are more than just the cost of the new equipment and the tags. Maintenance of the readers can be a major cost and effort, especially in rugged environments. Although modern solid-state equipment can be intrinsically reliable, the stress of real-world environments takes its toll on the equipment. Salt-spray, water, theft, predictable physical wear-and-tear (e.g., from errant forklifts and clumsy operators), and power surges can all damage the

equipment. Dr. Kimball's experience is that annual maintenance can run 30% of the installation costs, although he admitted that the DoD operates in some especially stressful environments.

5. Vendor Infrastructure

Before any new technology can be adopted, it needs an infrastructure of vendors – a network of product makers and service providers that have the ingredients for users to make full use of the technology. In the case of Auto-ID, the growing list of 39 vendor sponsors defines this network of providers. These vendor sponsors have taken an active role in standards setting, technology development, and creating new, low-cost manufacturing technologies. These vendors are now engaged in proof-of-concept testing that is currently between its second and third phases of testing.

Moreover, with open standards, and even an open-source tag reader design, other companies will be joining the network or supporting this new technology. Although the Center's sponsors receive private access to the Center's work some months prior it being made public, the Auto-ID Center publicly publishes its results. This dissemination of technical information will drive adoption of the technology. The end result is multiple sources of interoperable components, a growing diversity of variants (e.g., different tag packaging for different applications), and a growing array of service providers. The point is that this vendor infrastructure is developing depth and is in the early stages of the ramp-up to full volume production.

6. Usage Infrastructure

Supply chain initiatives, especially, also need a usage infrastructure because more than one company is involved in the initiative. For Auto-ID, one company might be tagging the items (e.g., a CPG maker), while other companies need to have compatible readers to access the data associated with those tagged items (e.g., carriers, distributors, and retailers).

Grand Plan: Ubiquitous Tagging & Reading

The grand plan for Auto-ID would see tags on every conceivable object and saturation scanning a replacement for the venerable UPC barcode. Every individual retail/CPG item would have at least one tag, and every location in the supply chain would have readers. Yet, adding tags and readers at every point along the supply chain and retails environment is no small challenge, requiring a major capital investment for the readers alone. The goal of 5-cent (and cheaper) tags and ultra-inexpensive readers is crucial to driving adoption in CPG.

Who Pays for the Grand Plan?

Once tagged, all of the downstream customers can use tags to improve supply chain operations. If multiple participants gain value from Auto-ID, who pays for the tags and readers? For example, if an LTL (less-than-truckload) carrier reduces costs by reading the tags on Gillette products to aid in routing

small shipments, who pays for the tag? For example, might carriers charge less to ship tagged products?

As one break-out group member noted, adoption will occur when 'P&G says 'do it.'" The power of dominant players, either CPG makers or major retailing chains, to drive adoption should not be underestimated. As market participants come to understand the value of the technology, they will likely negotiate it into their supply chain relationships. Tagged and untagged goods may be treated differently with different pricing, different service fees, and different charge-back or penalty structures.

Selective Deployment

Dr. Byrnes recommended selective deployment to cope with the barrier of high infrastructure investments – finding a high-value, limited scope application of Auto-ID. For example, some applications, such as tracking reusable/returnable packaging, containers, and pallets, involve less extensive user infrastructure. Tags on a small number of reusable assets and readers at a small number of selected handling locations for the containers would let a company get value from Auto-ID and test the technology. Mr. Albano also noted Home Depot's test of Auto-ID for special customer orders – tagging the special orders and scanning for the entry of the orders at the store's receiving dock. A selective deployment can have value even without 100% penetration of tags and readers.

7. Regulatory Issues

With respect to Auto-ID, the government both facilitates and hinders advancement.

Mandates that Motivate Adoption of Auto-ID

Current regulations or potentially forthcoming regulations require the intensive tracking that Auto-ID addresses. The government has increasing concerns about security, hazardous materials, errors in healthcare, and product safety. These concerns all lead to mandates to track products, report inventories, prevent diversions, and execute timely product recalls. Tracking at the item level would be a major contributor to supply chain integrity, accountability, auditability, and controllability. Government regulation may possibly motivate or mandate new levels of tracking and supply chain visibility.

Regulatory Obstacles to Global Use

Government regulation also interferes with Auto-ID in some areas. Some applications (e.g., use on-board aircraft or in healthcare) may require special certifications from appropriate regulatory bodies. Allocation of frequency bands is a major issue, especially for global supply chains. Users of the readers and tags will likely need authorization to use the devices in each country or locale. For example, Mr. Kimball of the DoD noted that a radio frequency device bought and legally usable in Rome, Italy may not be legally used in Sicily. The RF spectrum is a precious public resource, and each government has its own approach to allocating or selling slots in the spectrum.

8. Sticky Issues

Tag Durability

Some in the audience expressed concern about the durability of the tags. Fragile tags would be unacceptable. Yet Auto-ID tags are designed to be more robust than the more complex tags used for some existing RFID systems. For example, CHEP is designing new pallets with built-in Auto-ID tags. Tags are melded into the plastic frames of the pallet, two tags per pallet. The design is extremely robust – the tag should survive all but gross structural damage to the pallet. For CPG tags, the very small size of the silicon chip makes the tag quite robust. Various vendors, from label makers to traditional RFID tag makers, to packaging makers are all working on tags. Because Auto-ID relies on an open standard, tags and readers will be interoperable.

Hidden Tags

Although Auto-ID tags don't require line-of-sight to be read, the radio waves emitted by the reader do need to reach the tag. For most items this is not a problem, but liquids and metals do interfere somewhat with the RF waves used by the technology. This problem is most acute with densely packed metal objects or liquid containers. With no airspace between the objects, the RF signal cannot reach tags on objects in the middle of a case or pallet. The DoD has devised tags readable through metal, but the cost needs to come down before widespread adoption.

Tagging Reading Range

The current range for Auto-ID readers is about 6 feet. This is adequate for many materials-tracking and inventory applications. Yet some audience members had hoped for more. For example, tracking trailers in a freight yard would need technology with a 300-foot range. Larger, directional antennae could solve the problem, but would be awkward. Auto-ID is not designed to replace every RFID or satellite tracking technology. Some applications will still require unique solutions, such as the active RFID tags (with a 40-year battery life and embedded sensors) that are needed by the DoD for tracking the status of aging ordinance.

Two Systems is Too Many

For selective deployment and during any transition phase, the audience also worried about the cost of running two systems. Phasing in and phasing out key information systems can be quite hard. Training people to use two different systems also creates greater chances for error. In some cases, the old systems are never replaced entirely. For example, UPS still uses 3 different bar-codes because of legacy technology – it is easier to print an extra code on the shipping label than to replace all the scanners that use the alternative bar-codes.

Sharing

Each company that touches or scans an Auto-ID tagged item is both a user and creator of information about that item. This begs the question of whether and how much companies will share information.

Too little sharing would stunt the value of Auto-ID. Too much sharing would lead to information leakage to competitors or criminals.

The breakout groups tended toward a belief in sharing, but on a "need to know" basis. As with current supply chain information-sharing activities, most felt that sharing for logistics efficiency was highly likely. Also, retailers might share more data with manufacturers to aid in forecasting. One breakout group noted the problem of distributors failing to pass manufacturer-provided data on to retailers, and the resulting problems of over-recalls created by poor data sharing.

Security and access control issues are not the purview of the Auto-ID Center, although this issue concerned many participants. Companies such as SAP, Sun Microsystems and other software vendors are working on access control and standards for secure data sharing. As with all aspects of Auto-ID, the key to widespread adoption is open standards to permit interoperability.