RFID Checklist:

RFID Markets and Solutions for 2008

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ChainLink Research, Inc. is a Supply Chain research organization dedicated to helping executives improve business performance and competitiveness through an understanding of real-world implications, obstacles and results for supply-chain practices, processes, and technologies. The ChainLink Inter-Enterprise Model is the basis for our research; a unique, real-world framework that describes the multi-dimensional aspect of links between supply chain partners.

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Executive Summary

RFID technology, implementation experience, and value realization have evolved quickly in the last few years. With global standards—not just for hardware, but also data—the confidence of the user community should be high. Read range issues and assurance of reliability are behind us. Today's obstacles in implementation are merely a lack of imagination. Particularly in closed loop applications, companies are experiencing project success and value from these implementations. However, since the market is still young, the question arises: are they buying and applying the right technologies, paying the right prices for hardware, approaching their projects in the most skillful way onto the fast lane to results? The use cases on RFID are fascinating. In 2008 this trend should continue, with more firms providing implementation services, and more end-users not just shopping for solutions, but who are really diving in. Our research has shown a trend towards RFID budgets increasing year by year.

So what will happen in 2008? What do I need to know now? This paper will address these questions. This is not designed to be a bombastic vision document on how RFID will change the world ten years from now—but what you must know *now* for successful purchase and deployment between now and the end of 2008. What are your choices now? How should you truly think through your options, focusing on the most appropriate technologies to create a real solution? In this report we will address these questions based on research from the user community, as well as insights into emerging product categories. We will also provide a market outlook to understand the context of where we are now, and where we are going *next.* This is useful, since, in spite of some opinions, we are moving at a faster pace than many have stated. Being prepared can make a huge difference in success.

In this paper we will discuss:

- **Market Outlook:** We will focus on the RFID passive market[1].
- **Evolution of the RFID products for 2008:** Here we will discuss the RFID passive hardware market and applications driven by RFID. Today there are significant changes in form factors and versatility in packaging and application use. What are those changes? What is that technology? What is the market outlook based on revised categories of technology?

1. For information on the Active market, read the *ACTIVE RFID* report, August 2007: www.chainlinkresearch.com/research/detail.cfm?guid=1A6F1E1B-3048-785E-31DE-8547E5D8C93A

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- **RFID Business Solutions:** What do those changes mean in terms of business solutions? What can you do now with this more powerful, more mobile, less expensive technology?
- **RFID Checklist:** How to go about making the right selections. Simple ways to navigate forward with the rich selection of features in tags and readers.
- **Value Now:** There are stages of value realization that the user community is experiencing. Most users now are using RFID for internal process improvements vs. mandates. We will review these as a model for positioning ROI.
- **Conclusions:** Getting Started in 2008. What steps your organization should take in solution, project management, etc. in order to have a successful implementation.

This report is the culmination of research studies that we have done in the last year with over 1,500 end-user firms on their RFID plans and experiences, in several industries and sectors. Here we will cull out what is most relevant for evaluating and qualifying RFID between now and the end of 2008.

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Introduction: RFID Market Outlook

You know that when every industry magazine you pick up has an article on RFID—from games and entertainment, to food safety—that you're onto a big market! The RFID market continues to grow at a healthy clip with sales increasing by $1.2B and growth rates of over 23% (see figure 1). The road to the ubiquitous market penetration will, like most technologies, take some hard lessons, twists and turns, with the end products in use today making the stuff we used in the beginning look antiquated—old clunkers, if you will.

If we look at the continuum of so many technologies—the path from large fixed platforms to smaller form factors; and mobility is the path forward—mainframes to *ipaqs,* EightTrack to MP3; then RFID is no different. We have need for all sizes. Just as in the computer industry we have big enterprise servers, mainframes, all the way down to sub-laptops—the RFID market has grown up and now provides all these choices.

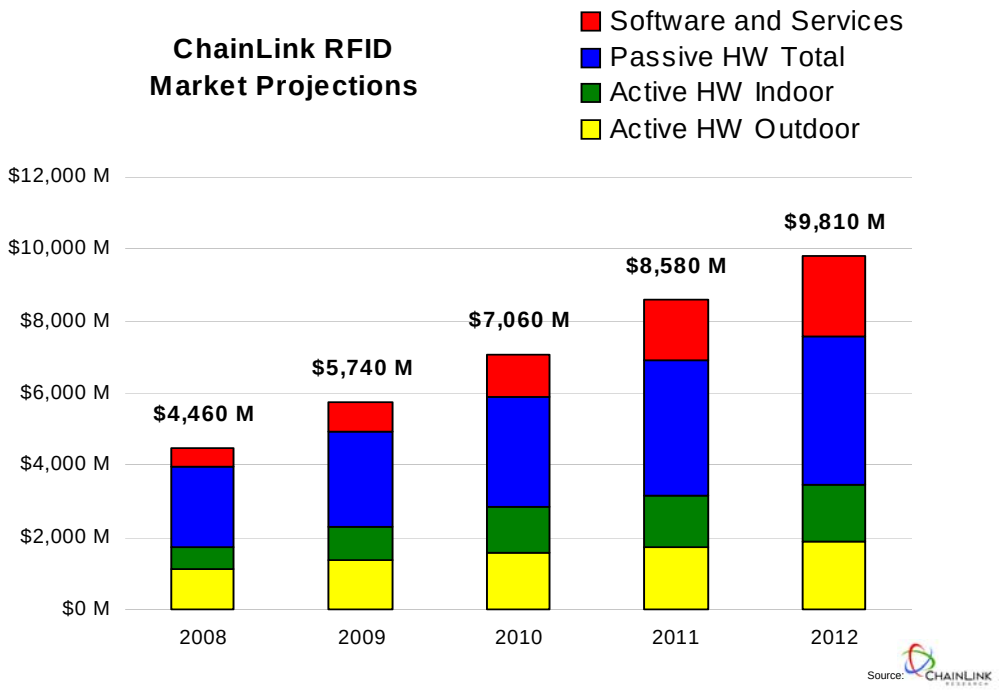

Figure 1: RFID Overall Market

In addition, the versatility of business applications is the real story. Globalization of the production process has created serious issues for consumers who are now demanding traceability (already the law in EU countries), safety, authentication, etc. And our global leverage of wireless continues unabated, creating a plethora of applications from consumer to industrial. Each of these market categories, though slivers in the total RFID market today, will be, in their own right, large markets tomorrow. And the customers are the ones taking those innovative steps forward.

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How far can these numbers actually grow? If one thinks about (and we do, since *we are* a research company) the number of *economically taggable items* in the world, there seems to be no upper limit. For example, there are over 15 trillion bar codes used. At the DoD, estimates are of over 100M high-end trackable, reusable assets worth over $5K. In addition, many more hundreds of millions of consumables that will have auto ID of some kind (passive RFID or barcodes) exist today. The Auto industry has over 5,000 trackable assets per mid-sized plant, tools, machines, etc. There are millions of tools and pieces of equipment in large industrial plants that need to be located, maintained and inventoried. Banks have, on average, seven traceable documents per account holder that they are legally obligated to store and locate. The document you signed to start your 401K needs to be kept for the life of that account—your lifetime. Evidence from trials needs to be kept forever. Mistrials caused by lost evidence are a huge concern. Each industry has both reusable and assetable[2] equipment that needs to be managed, from trucks to hand tools—what to say of end products that might require various unique tags. Automobiles have hundreds of unique repairable units—each a unique asset with a unique ID number, that manufacturers and dealers are required to record by law. Walk around your enterprise and look at all the assets that need to counted, found, re-ordered, tracked, replaced, stored and found again; or managed somehow through manual or electronic remote controls; and you begin to get the picture. And with serious price drops in the market on the hardware—both readers and tags—the feasibility of a larger market becomes easier to fathom.

Another key point to consider now is a re-orientation of the market fascination with tags and tag prices. The theory goes that only a few readers will be in service for the high volume of tags that pass by. But what if—and they are now—the readers were extremely small, unobtrusive, and quite cheap. What doors does that open for new applications or expanded utility of equipment, process management etc.? Quite a lot we predict. Not only do new enterprise applications become possible, but new home applications (and home is the big win in any electronics market—PCs, phones, etc.) and embedded intelligence all emerge.

The proliferation of RFID into mobile devices may create a new market where RFID-enabled mobile devices can act as personal readers of personal tagged items. This could be a market where any person can go to a local retail market and buy personal tagging solutions that enable them to track personal items at home or at work, from your kid's lunch box to your car keys and food items. Think about all the home items that the consumer wants to be assured are fresh, safe and authentic.

Although, over the long term, all these trends point to a serious and important technology market, our goal in this report is to focus on the market today through 2008. Long term market trends can provide assurances of continued support and innovation by vendors as well as of return on investments, not only for end-users, but for services firms that create practices and products, investing capital to create new businesses in new markets.

2. Financially accounted for as property or equipment

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RFID Now: Evolution of RFID Hardware

2007 brought lots of good news for the industry. Global ISO standards were agreed to for the commercial frequencies to supplement and enlarge the EPC Gen2[3] beyond the U.S. Various industry-specific agreements were reached to ensure interoperability, consistency in data mapping and integration. In addition, significant improvements were made in hardware—both the manufacturing techniques[4] and the quality of the products. Durability, versatility, and range are all areas of improvement to ensure successful reading and writing, in a variety of environments. Concerns about the physical aspects—water, metal, etc.—have been addressed with antenna designs to meet specific requirements in most applications[5].

As in other sectors of the electronics industry, form factors and price reductions become the obvious next target. Not only competition, but the inevitable creative application of experienced designers has given us exciting new products, spurred on by customers who are applying the technology in a broader range of applications. Several tag vendors have produced extremely small products, without sacrificing range or durability[6]. In fact, range is one of the big stories in 2007, as smaller tags, cheaper tags, bigger range and new form factors address emerging markets within each item, case and asset level tagging.

What is most exciting, though, are the reader form factors. New readers are emerging which are 50% or more smaller than the past generation, with embedded antenna and enhanced software functionalities, which opens the door to an exciting array of new applications[7].
Just as we have been wowed by the minute RFID chip on the tip of the finger, now it's about the reader.

This new form factor is not only highly versatile, but presented to the market place at a much lower price point. We see this changing how we look at the hardware market. Each category on next page has fairly clear application areas. Since this is a new way of looking at the market, we will define these and then give you industry examples. Later we will give you a model of how users will go about selecting the right categories of hardware to create their solutions, opening up rich choices, more powerful, yet less expensive choices, creating a bigger market opportunity.

3. See Appendix C, pg 38, for ISO RFID standards
4. Such as Alien's Fluid Assembly etc.
5. There are still some really stubborn materials out there
6. Alien and Tagsys, of particular note. Alien Higgs chip has demonstrated ranges up to 100 ft.
7. Most notable vendors here are Alien and Skyetek

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New Views of the Market

So let's look at how these new technologies impact the market. Each of the five categories below is differentiated by a few key factors that focus on the 'job' they perform, serving within a facility/enterprise or outside the enterprise—their physical and technical attributes; their network and software backbone; and price. (See table 1, next page *Hardware Categories)*

- **Enterprise One:** This is the traditional market that we all know. Here we have a rich range of readers for manufacturing, large sites, supply chain, using fixed readers, trucks and dock portals to track large items within warehouses, etc. These readers do their job with 'stability' within an enterprise and are designed for a single location that can be fixed, vehicle mounted (forklift, kiosk, cart, rack,), wall mounted, or are large and expensive handhelds. This is the high-end market. Their communication backbone is through RF and wifi, through enterprise routers and middleware. The readers in this category range from $2,000 to $3,000 for fixed readers, with handhelds as expensive as $3,500.
- **Enterprise Two (Mid Tier):** This categorization is new[8], taking advantage of the smaller form factors and embedded options which are light and can service more front office applications still serving the enterprise, but more focused on asset tracking within office, inter-office, such as from lawyers to courthouses; from storage to office or shelf; and other in-building solutions. Design and function are palm sized. Price points here for readers will be below $1,500 down to $300, and will mirror other electronic sections—as volumes go up, the price points will drop. New form factors open the door for versatility as well as more security, since smaller form factors can be unobtrusive. It also accommodates mid- to small-sized enterprises that have infrequent use of RFID and can now afford to buy. Today there are just a small handful of options available for this market. Most customers in 2007 could only evaluate or buy large fixed readers. In 2008, new form factors will emerge and prices will come down.

Mobile with RFID — With the emergence of Mobile application and RFID used in so many locales (in yards, in sales, field service, etc.) coupling RFID into the mobile device just makes sense. Two scenarios will place this in our emerging market.

- **Mobile One:** Today we have mobile readers in use in many environments. Why we differentiated between an Enterprise[9] Two, for example, and Mobility is the overall platform application. A mobility application is most often inter-enterprise, leveraging public infrastructure (cell, specifically). Today there are programmable Mobile devices for RFID, and their charter expands into areas like home healthcare services, logistics, etc.
- **Mobile Two:** Here we address the Consumer market. Two models will be most prominent. The Cell phone (Near Field Communications[10]) is an ewallet/contactless payment system (HF) for shopping, self-checkout; the other will be a variety of consumer applications (UHF) in which the consumer interfaces with service provider institutions, as well as an array of home applications, from utilities to home entertainment, with embedded or attached options.
- **Embedded:** Here the tags and reader boards are embedded in other products. This area will grow in the future, no doubt, but examples are here today, most notably with car clickers.

8. We have seen smaller palm devices in the market for several years, but have not segmented these from the heavyweight brethren up until now.
9. New models from Alien, Motorola, etc.
10. High Frequency

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Honestly, we debated the positioning of traditional handhelds[11] being put in Enterprise One vs. Enterprise Two. But handhelds designed for the warehouse, for example, are very rugged, heavy, large, and quite expensive, as well as designed to serve a single enterprise. Certain models created by industry leaders with the so-called mobile name on them are 3 to 4 or more pounds! Not really mobile or light, and really designed for warehouse, or to be mounted in some way[12]. Typically, a 'back office' application, such as a warehouse or yard, has to physically perform in challenging environments, whereas front-office applications might sit on a counter or desk in air-conditioning. The work that is done is quite different from a human factors perspective. These all point to a different device. Here are examples of how these solutions play out from an application perspective.

	Enterprise 1	Enterprise 2	Mobile 1	Mobile 2	Embedded
Reader Character-istics	Rugged, site-specific, enterprise-focused, industrial aesthetics, higher price point, highest volume	Light weight, office aesthetics, lower price point, high volume	Mobile platform, business applications, public or private infrastructure, less volume	Mobile-consumer public infrastructure, less volume	Integrated into product. Enables and enhances functions of the product it's embedded in.
Examples Readers & Applica-tions	Conveyors/tunnels, large rugged handheld readers, kiosks, forklifts, toll gates, dock doors, MES, carts, equip-ment racks, RFID appliances, high volume supply chain	Handhelds for small DC or individual item picking, inspecting, front office documents, entertainment, sports and games, mid-size to small supply chain	Service & repair, multi-site/ customer site mobile workers, yard inspections providers	E-wallets, games, home management	Intelligence and automation of the equipment it's embedded in—e.g. medical devices, home appliances, toys, vehicles, etc.
Technical Character-istics	Multi-antenna, standard wall power or battery, multi-port	Singe antenna, battery or POE (Power-Over-Ethernet)	Single antenna, battery, many custom apps already developed for these platforms	Single antenna, battery, many standard apps, screen real estate shared between multiple applications	Highly customiz-ed to solution. Powered by the device it's embedded in. Can be tiny & inexpensive
Network & Software Backbone	Enterprise: WiFi or Wired	Enterprise: WiFi or Wired	Cellular Network	Cellular Network	No network con-nectivity. Or based on solution
Market	Business	Business	Business	Consumer	Based on solution

Source: ChainLink Research

Table 1: Hardware Categories for Readers

Later we will discuss how these apply in business and industry applications.

Over the next few years, the unit sales of Enterprise Two and Mobile solutions will grow. Dollars (see figure 2, next page) vs. Units are different, since the extra features and ruggedization needed for Enterprise One come at a cost. But these smaller priced 'fit' solutions will put pressure on companies in this category to reduce their prices, too.

11. Such as Alien's ALR-9800, Intermec's IP4, or Symbol/Motorola's MC9090-G RFID
12. Such as Motorola's RD5000 and is about 7 inches, but weights almost 4 pounds!

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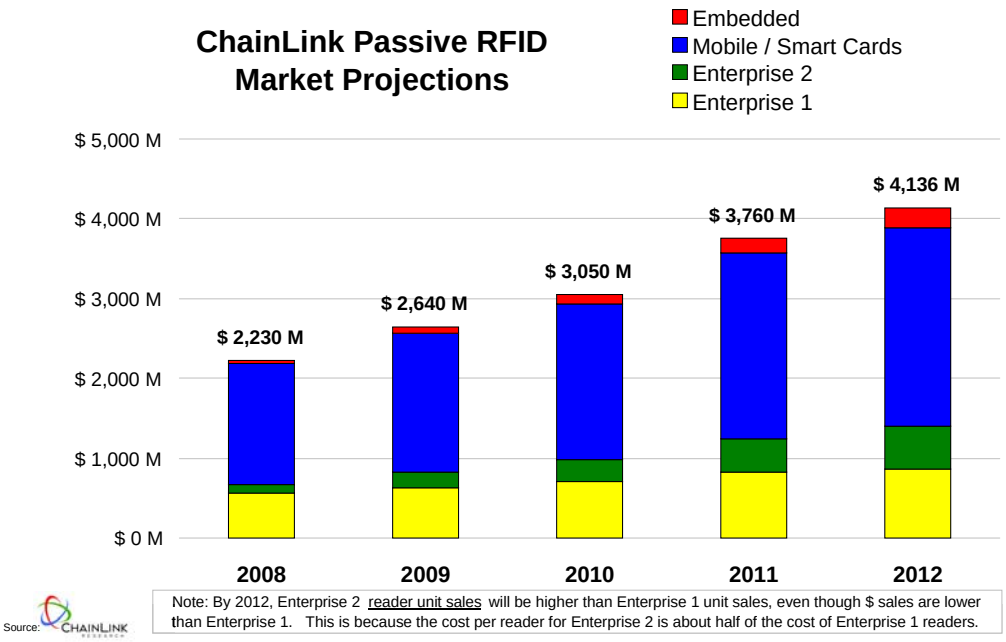

Figure 2: RFID Passive Market

However, in talking to the people in the implementation community who are close to the major large accounts, they state that their customers are not as sensitive to the hardware cost, but rather the overall value of the solutions. But hardware cost reductions are just inevitable as markets evolve.

Users are going to buy based on several fundamental issues: the process, the environment, the item to be tagged, etc. Therefore, we will continue with our discussion and move into these realms.

What About the Tags?

The tag market is going through some changes, as well. Although it might not seem as visual, the same logic applies. Rugged comes at a price—but also provides that value. Here issues are more around sensitivity, durability, and price. In global shipping the issue is around wider band (not just US based UHF), as well as range, since there are a variety of locations which always place challenges upon readability.

The diversity of labels today is such that a whole market of Converters play the major role in crafting RFID chips into the myriad of finished products. Unique antenna designs help with range, reading in physically challenging environments (like water, metal, etc.[13]) As we fulfill the object of RF for ID, the labels can get smaller and unobtrusive, to ensure that they stay with the item for its lifetime.

13. Space does not permit a detailed analysis of these. Read the report: *RFID Hardware - What You Must Know:* www.chainlinkresearch.com/research/detail.cfm?guid=B03A8206-CA4F-0362-4645-7DF02068244F for a tutorial of tags and antennas, ranges, physical properties, etc., as well as over 100 RFID vendors review.

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Labels	These are paper-thin flexible labels (generally paper or plastic) with a very thin and flexible RFID device embedded within or on the back of the label. Creating the Tag/Label from the RFID Inlay can be a very creative process, with thousands of unique designs. Labels can be tickets, hang tags, adhesive labels printed with barcodes, wrist bands, etc. In many cases unique antennas are designed for these labels.
Smart Cards	Credit-card sized proximity RFID devices, designed for use in applications such as ID cards and payment cards. Mostly used for financial applications such as prepaid (train or bus passes) or credit cards. Smart cards have more intelligence than magnetic stripe type cards and the ability to store data (e.g. stored value cards). This is also quite useful for security and access control.
Packaged	These are tags that are enclosed in some sort of rigid package. The choices in packaging shapes, designs, and materials are extremely diverse. Unique package designs can add: ruggedness, protection for harsh or dangerous environments (e.g. laundry applications, near acids and chemicals, etc.), ability to work on metal objects or other materials, and secure mounting capabilities. Unique packaging can help improve signal strength, as well as encapsulating, such as tags in bottle caps, etc.
E-Seals	These are tags used in locking and securing items. E-seals provide that extra barrier of resistance for hazardous shipments, keeping out unauthorized personnel from dangerous situations. Electronic controls are often attached to the tag.
Sensor + Tag	Sensors (e.g. temperature, shock & vibration, humidity, radiation detector, etc.) are now combined with RFID to provide intelligence. These can not only detect the physical condition (the sensor), but record it on the tag, or in some cases can actually take some immediate action (such as issuing an alarm) based on the change of status. The sensor is a device, such as a photoelectric cell, biological/chemical sensor, or other sensor that detects physical condition or chemical state.
Embedded	RFID tags may be embedded within other devices in order to add intelligence. For example a tag can be embedded in a cell phone, creating e-wallet and other applications. Smart toys that have tags embedded in them so they can recognize each other are another example.

Table 2: Types of Tags

Source: CHAINLINK RESEARCH

That leads to the issues around packaging. Lifetime use may require special packaging. Sizes, form factors, etc. are all part of making the tag versatile. Emerging in materials (water, even cement) can work with RFID, but packaging needs to address the protection of the electronics.

Security, tamper proofing, and anti-counterfeiting can be served by e-seals, or by chemically treated tags that leave traces on the package so that the user knows that the product might have integrity problems. Success here requires either embedded TAG ID or software—pre-notifications, like ASN (advanced shipment notice) or other messaging to match data on tags to receivers' expectations.

Bundling elements onto the tag, such as e-seals, sensors, etc., are all designed around reading and recording, either on the tag or the backbone systems for the identity, location, condition, etc. of the item. We found in any non-commodity markets—Pharmaceutical, Consumer Electronics, luxury goods, etc.—that over 48% of our survey respondents planned to

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include **sensor +** and/or **e-seals**[14] in their solutions. So, standards as well as the backbone data bases are critical in these more open environments.

There are interrelationships between tags and reader sales in certain environments (we will discuss this more in the next section) that drive the creation and value of a total solution and therefore create a total cost of ownership model.

In markets that service consumers such as retail, public transportation etc., there is a relationship or perception to value that drives up investment in read points—how much traffic will go through this lane, how many customers will use self-checkout, how many employees enter through this door, and therefore can we add value (sales, reduce sales force, improve productivity, improve data collection speed and accuracy, and so forth). So, it is time to add more read points. You see this phenomenon with Toll Collection where time by time more lanes are allocated to Fast Lanes. But the tag to reader ratio in these markets is not as tightly coupled, as in fixed location environments like yards, ports, etc. where the reader network is designed around a specific asset count and the ability to locate in a fixed size, closed or open space. This logic will also apply in embedded applications where the relationship between the reader and tag is important (car clickers).

In chokepoint applications such as drive-thru, turnstile, vending, self-checkout, etc., the range between item or person to reader becomes the important factor in the designing of environments. But millions of tags will probably go through one reader over time[15]. We will return to this topic in the next section.

So the buyer in the early stages of this market made purchases based on ratios of tags and readers. This will continue in closed loop and locating applications, but in choke points and traceability (open environments) this logic probably won't apply, leading the market researcher to really look at these two phenomena as somewhat distinct. Just as in the Telco market—the number of base stations is somewhat related to the number of cell phones, but not strictly. Usage traffic becomes more of the key[16].

RFID Business Solutions

What can we do with these more powerful, reliable, more mobile and less expensive technologies? Range and power with a small package—we did not have that before. Range was the domain of Active, so this provides some new opportunities[17]. Also, with small inexpensive readers, we can embed solutions, be more mobile, and be unobtrusive.

14. Read *E-Seals: Uses, Standards and Providers* Parallax View August 2007: www.chainlinkresearch.com/research/detail.cfm?guid=1F026746-3048-785E-312A-9A834BE01B30
15. For a detailed discussion on locating and chokepoint systems consult the *Active RFID* report, August 2007: www.chainlinkresearch.com/research/detail.cfm?guid=1A6F1E1B-3048-785E-31DE-8547E5D8C93A
16. Example: Cities have millions of visitors per day who do not buy their cellular units in that market, but drive up usage.
17. High range passive opens the door to a lower cost RTLS over time.

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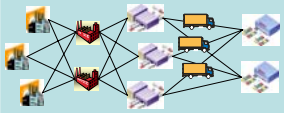
RFID Solutions – The Process

RFID solutions today are both about enterprise operations as well as multi-enterprise activities—from supply chain to financial services to entertainment. Unlike software, like an accounting package, the physical as well as the informational processes need to be understood. A concept that is used in the RFID market is 'closed loop' vs. 'open loop' processes (see figure 3). Closed loop provides significantly more control[18] by the buyer on crafting the process and its boundaries, as well as the technology chosen to serve the objective[19]. They can instrument the process more easily to ensure that read points are at appropriate locations to fulfill the process goals.

We think that it is a misnomer to call something open loop, since there is no loop. So we just refer to it as an open environment, or open process. It is important for you to understand what the RFID process will be in order to select a solution.

RFID Process Definitions	Compliance	Closed Loop	Closed Loop-Multi-Tier	Open Solution
				
Solution	Stand-alone solution within the four walls of a facility	Routing back to you or within facility	Within your eco-system- partner, Customer etc.	Across the Chain
Benefits	Keeping Customers	ROI within the enterprise	Shared Processes, shared customers, etc.	Shared values-Global Thinking
Examples	Slap and Ship	Yard, Milk Runs	Item-level tagging of product would continue to be read and written to, such as servicing item, trace and track. Item may or may not return	Item-level tagging of goods through the supply chain

Source: ChainLink Research

Figure 3: RFID Process Definitions One

So closed loop would have examples like returnable totes or a closed loop-multi-tier—an example would be service management. A higher data storage tag could be put on a computer, for example, that would stay for the life of the product. This would be updated from time to time by based-on-services performance, then used for warranty, changes, and upgrades, as the product is built, moved, sold and bought through the life of the product. We define this example as closed loop—although the product may or may not return (loop) to the manufacturer—but the *people* do. In the eco-system there is control, so issues around selecting the technology, agreeing on data sharing selecting capability equipment etc. can be decided. Staying with our service example, a large firm that has a repair network of partners can declare the use of a technology choice for readers—and guide their partners to select the choice of standards-based hardware so that they can interact.

18. This clearly points to why closed loop implementations are claiming good return on investment.
19. For definition see Appendix A: glossary of Terms (pg 33) at the back .

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	Closed Environment	Open Environment
Multi-use	• Tags re-used within one process such as Tags on materials or totes within a manufacturing plant. Or Kanban between suppliers. • Delivery (milk runs) trucks. • Permanent tags of serviceable units such as computers, utilities equipment (power, cell towers, etc.) • Durability, more data on the tag are key features. Low cost per use and can be made highly reliable because of degree of control over all aspects of the implementation.	• Tags reused across multiple trading partners. e.g., Trace and Tracking pallets or other reusable assets that pass through many hands/ companies. • Container license plates, toll tags, etc. • Smart Cards, Metro passes, etc. • Durability, range for locating, read/write. May require increased encryption. • Need to face challenges of making it work across many trading partners with less predictable environments and instrumentation investments in place.
1-time use	• 1-time use, within one organization. e.g., Tesco's applying tags on game DVDs as they come into the back of the store. (The infamous EAS tag.)	• 1-time use, across multiple trading partners. i.e., follows the process and is then disposed of or killed such as Wal-Mart, DoD – tag cost must be very low or payoff high, because of 1-time use.

Source: ChainLink Research

Table 3: Process Driven RFID Definitions Two

The open approach needs many conditions to be met in order to provide value to all the players in the process—such as standards, instrumenting the end-to-end process, accounting for many variables in environments, etc. This has not had the highest population of proponents claiming hard quantifiable value. And it is no surprise that it has been harder to convince the body of suppliers out there that this is a great solution for them. Over time, yes; but in the short run, less so.

In addition to this characterization, the multi-use vs. single or disposable use (see table 3) also needs to be considered. Closed loop generally are multi-use tags, which require durability—they might be around for a long time. Many tags have a short life—used once, then disposed of. Unless there is some urgent need for special packaging, finding the lowest cost solution is desirable.

Track and trace[20] is its own kind of multi-use technology—whether active or passive. End-to-end value can be derived. That is why applications for product integrity, authenticity, etc. are in so many pilots.

Tag and reader sales naturally have a tight relationship in this phase of market development. However, that will not be true forever. In closed loop there a ratio/rule of thumb rela-

20. Read *Track and Trace: Indispensable Enabler for Global Trade* Parallax View August 2007: www.chainlinkresearch.com/research/detail.cfm?guid=1DD32C85-3048-785E-317F-377CC0BBB0D1

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tionship between these—a yard will have a certain size and number of assets, and you will need so many readers at such a range to locate/read your items. Open environments, on the other hand, will gauge reader sales by range from read points to items—items flashing by on high speed conveyors, or cataloguing or identifying a document or vile of drugs. Once read points (gates, self-checkout, or desk for reading documents) are in place, thousands or millions of reads can take place from one read point.

Business Solutions View

So what kind of solution for business applications will be hot in 2008? Table 4 on next page provides these solutions, by industry. There are so many we have surely excluded some. We are differentiating between already in production vs. pilot vs. being introduced. There are organizations that might have gone from intro to full production, but it might not be large enough to hit the threshold to make a market report such as this.

The industry view shows 'who's buying'. Not too many industries are left out. Beyond industry, company size is a more important element, since for every Fortune 500 company there are hundreds of mid-sized companies. One myth worth debunking right here is that RFID is a solution for only the rich. Cost is always in relation to value, we feel. But even ChainLink was surprised at the number of mid-sized firms that are implementing or plan to implement RFID.

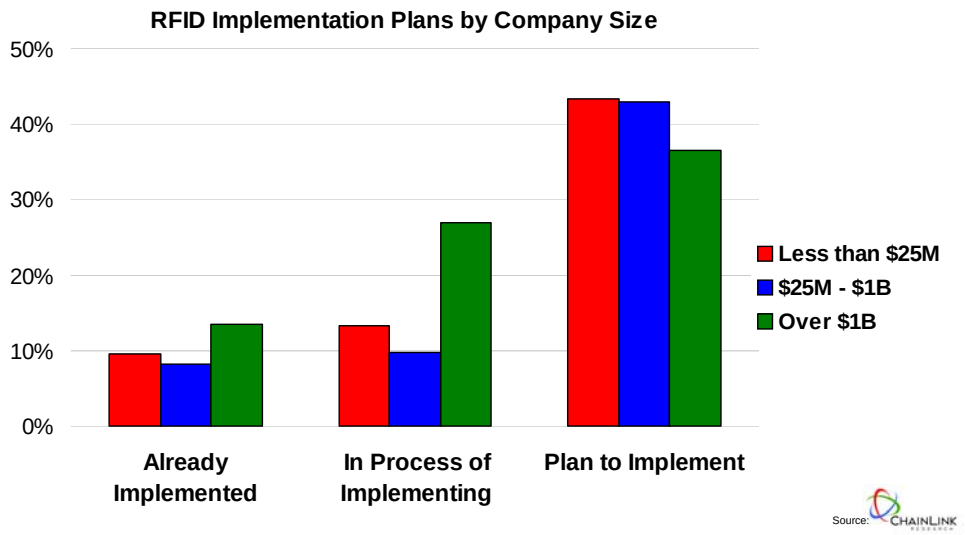

Figure 4: Company Size

This mid-sized view, which tends to be a price sensitive market, bodes well for the Enterprise Two market growth. Smaller solutions footprints, at a more attractive price point, will obviously be well received by all sizes of companies, but many just can't get in until those price drops become available to the masses—not just for the large volume buyers. 2008 will see this change.

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	Enterprise 1	Enterprise 2	Mobile 1	Mobile 2	Embedded
Reader Character-istics	Rugged, site-specific, enterprise-focused, industrial aesthetics, higher price point, highest volume	Light weight, office aesthetics, lower price point, high volume	Mobile platform, business applications, public or private infrastructure, less volume	Mobile-consumer public infrastructure, less volume	Integrated into product. Enables and enhances functions of the product it's embedded in.
Auto-motive	Toll Collection, Mfg Process, Asset tracking	Dealer Locating, Service and Repair	Dealer Locating, Security, Law Enforcement		Car Clickers, Value Add
Consumer Services	Outdoor services, drive thru, Car Wash, etc	Vending Machines		Local Services Repair, Hardware, etc.	Integrated into product. Enables enhances functions of product
Consumer Products	Mfg/Lot/Batch Data Management, Supply Chain. Compliance	Front Office, Inventory, Mid-Size Enterprise Supply Chain, Compliance	Authentication	Authentication	
Construc-tion	Supply Chain	Inventory Management, Equipment Tracking, Rentals, etc.	Inventory Management, Supply Chain Mgt, Order Management		Motion Detection
Document Manage-ment	Storage, Tracking	Writing, Logging, tracking			
Financial Services	Kiosk	Document Mgmt, Validation	POS/payment systems	Smart Cards, Near Field Communication Mobile Banking	
Entertain-ment/ Sports	Entry Gates/access Control	Access Gates-single entry point, Inventory Mngmt, Retails, Attendee Tracking	Maintenance, Locating	Games	
Food Chain	Distribution/ Warehouse, Fleet Management, Container Tracking	Farm equipment Mgmt, Animal Medical care, Food Tracing, Pedigree/ Provenance	Authentication	Authentication, Home Inventory, Membership	Animal Tracking
Healthcare	Medical Storage-smart shelves	Administration, Patient Care	Administration, Patient Care		Medical alert
Home-Land Security	Customs, Cargo Tracking, Passport Control,	Customs, Passport Control, Small Airports, Baggage handling	Customs Inspecting		Passports
Insurance		Asset Validation	Security		

Source: CHAINLINK RESEARCH

Table 4: RFID Applications by Industry and Type of Reader

IN USE NOW

2008 Roll-Outs

In Pilot 2008 roll-outs

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	Enterprise 1	Enterprise 2	Mobile 1	Mobile 2	Embedded
Life Sciences: Pharma	Mfg/Lot/Batch Data Management, Supply Chain	Pharmacy, Anti-Counterfeiting, Dispensing			
Life Sci: Medical Devices	Mfg, Supply Chain	Maintenance, Inventory Mgmt	Maintenance	Home Health equipment operation	Dispensing, Diagnostics
Logistics/ Maritime	Yard/Port Management Security, Access Control, Container, Realtime Locating	Real-time Locating, Container Mgmt, Track and Trace	Container Management		
Logistics/ Ware-house Mgmt.	Yard/Gate Access, Bulk Picking, Cross Docking and Ship	Item picking, Inventory Mgmt, Data Mgmt	Inspection		
Mining	Asset Tracking, People Tracking	Front Office, Inventory, Compliance			
Mainte-nance & Repair		Auto ID, Repair	Warranty, Repair, Inventory Management		On board diagnostics
Commer-cial Transport-ation	Baggage handler, conveyors, etc	baggage locating		Metro/bus train passes	
Transport-ation/ Carriers	Tracking, Access Control, Container Management		Tracking, Order Verification		
Product Integrity	Data Management, sealing, tracking	Product Validations, sealing, tracking	Product Inspection/ Validation	Ownerships, Validation, etc	
Home-Personal Asset Mgmt.				Entertainment systems, games, Inventory asset management (for insurance, etc)	
Home Healthcare			Home and Mobile health care workers	Medical dispensing, care management	
Retail	Store Ops, Supply Chain	Store Ops	Store Ops	Mobile Shopping, self check-out etc.	Security systems,
Security	Access Control, Trace and Track, eSeals	Access Control, eSeals	Access Control, eSeals	Alerting, Sensing	eSeals

IN USE NOW

2008 Roll-Outs

In Pilot 2008 roll-outs

Source: CHAINLINK RESEARCH

Table 4 (continued): RFID Applications by Industry and Type of Reader

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Therefore, in summary, solutions and purchases will be driven by these cross sections of needs:

- Industry: Retail, Mining, Financial Services, etc. These industries have cross sections of needs. An example is Pharmaceutical, with its many pressing issues like epedigree, counterfeiting, efficacy, logistics, accurate dispensing and more. Not one element, though, will be the whole driver—but the bundle of these needs will make up the value.
- Include in-house asset tracking for legal and valuable assets (laptops, line cards, routers).
- Tagging for brand authentication (anti-counterfeiting) + tracking food items (when recalls occur), i.e. tracking batches of food items vs. massive recall.
- RFID Process (Closed vs. Open), how and when we share processes and manage intelligence across the value chain, or within our own controlled process. Multi-use vs. single-use tags within these Open or Closed processes, and what kind of read points will be needed to instrument the process?
- What is being tagged? How do the tag Characteristics (such as data storage, size of tag, packaging, sensors or seals) map to the requirement of the item (quality, authenticity, freshness) in order to support the process needs.
- Where the Business Processes are conducted—warehouse (forklifts, high racks), office (document management,), lab, Entrance or Gate (access control), etc. These locations all have their unique characteristics, and what hardware fits best into these environs will be different.
- Company Size/Budget may drive to seeking deeper value, lower price solutions etc. before they buy. Many firms told us, for example, that they only have less than 30 shipments a year to the DoD. So infrequent use cases can benefit from 'lighter' price points.

In the next section we will pull all the above elements together and create some guidance on how, based on all these properties, solutions will be derived and purchased.

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RFID 2008 Checklist

Understanding your solution requirements and selecting the right technology does not have to be that complex. Issues around function/fit and price become key in all discussions, as we have discussed earlier.

Here we would like to offer an approach to selecting the right fit in terms of tags and readers. There are so many applications that one can't name them all in these roadmap diagrams. But we are providing an approach to ensure that you are thinking in a logical way to get that right fit, the right solution.

On figure 5 (following page spread) we have created a path to **2008 decision making**[21]. Simply stated, you really only have a few hard questions to ask. (Refer to the chart as we walk through this).

Selecting the Hardware Solution:

- Where will the reading be done? If I am not in range of wireless access, then clearly I need a mobile solution. Once that has been established, you can follow the roadmap into the RFID reader choices. RFID readers are really designed for very active RFID usage, where your mobile phone (certainly today) is not designed to be the high volume RFID reader. Which also addresses the need for antennas.

- Who will be doing the reading? Simple examples are a warehouse worker or an office worker. As we stated before, Enterprise One is a rugged design that can sport multiple antennas, etc. Enterprise Two is focused more at low volume design and office type applications. And the price reflects this. We have heard of cases already where users, attracted by the 'light price', were quickly disappointed by the lack of ruggedness. After dropping these a few times, the reason for the price differential can become apparent.

- What will be tagged? Here there is, at times, a relationship to the reader, such as in frequencies, of course[22]. But the *item* is the key. What is the purpose of tagging—tickets and hang tags for retail, or sensor+ for temperature, light, etc.? Will the item traveling international routes, (requiring world tags) be wide band? Like readers, as we have said earlier—there is a price for everything—but if you don't need the features, why pay more?

21. As the mobile RFID market grows this approach may change.
22. For a discussion on frequencies, please read *RFID Hardware - What You Must Know:* www.chainlinkresearch.com/research/detail.cfm?guid=B03A8206-CA4F-0362-4645-7DF02068244F

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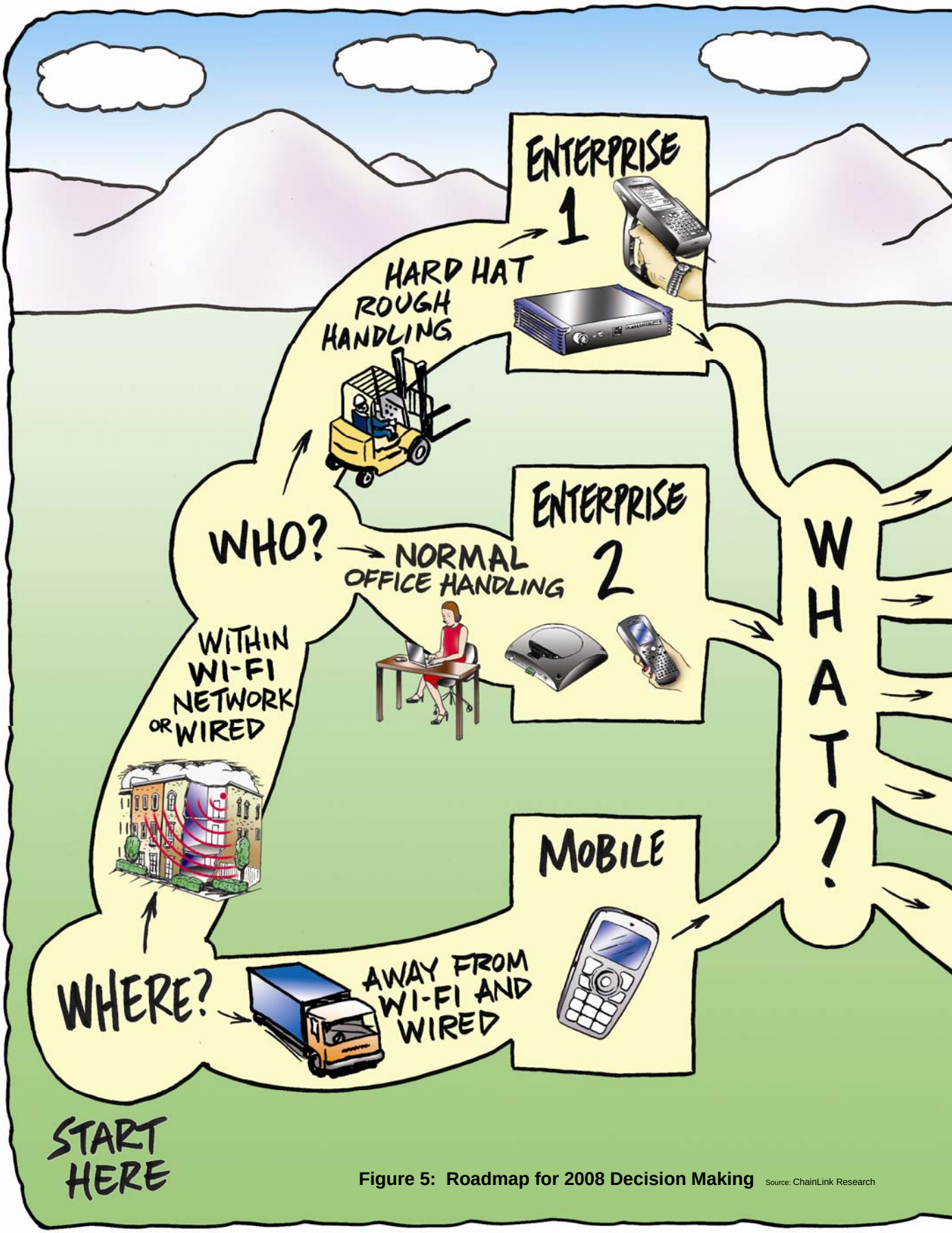

Figure 5: Roadmap for 2008 Decision Making Source: ChainLink Research

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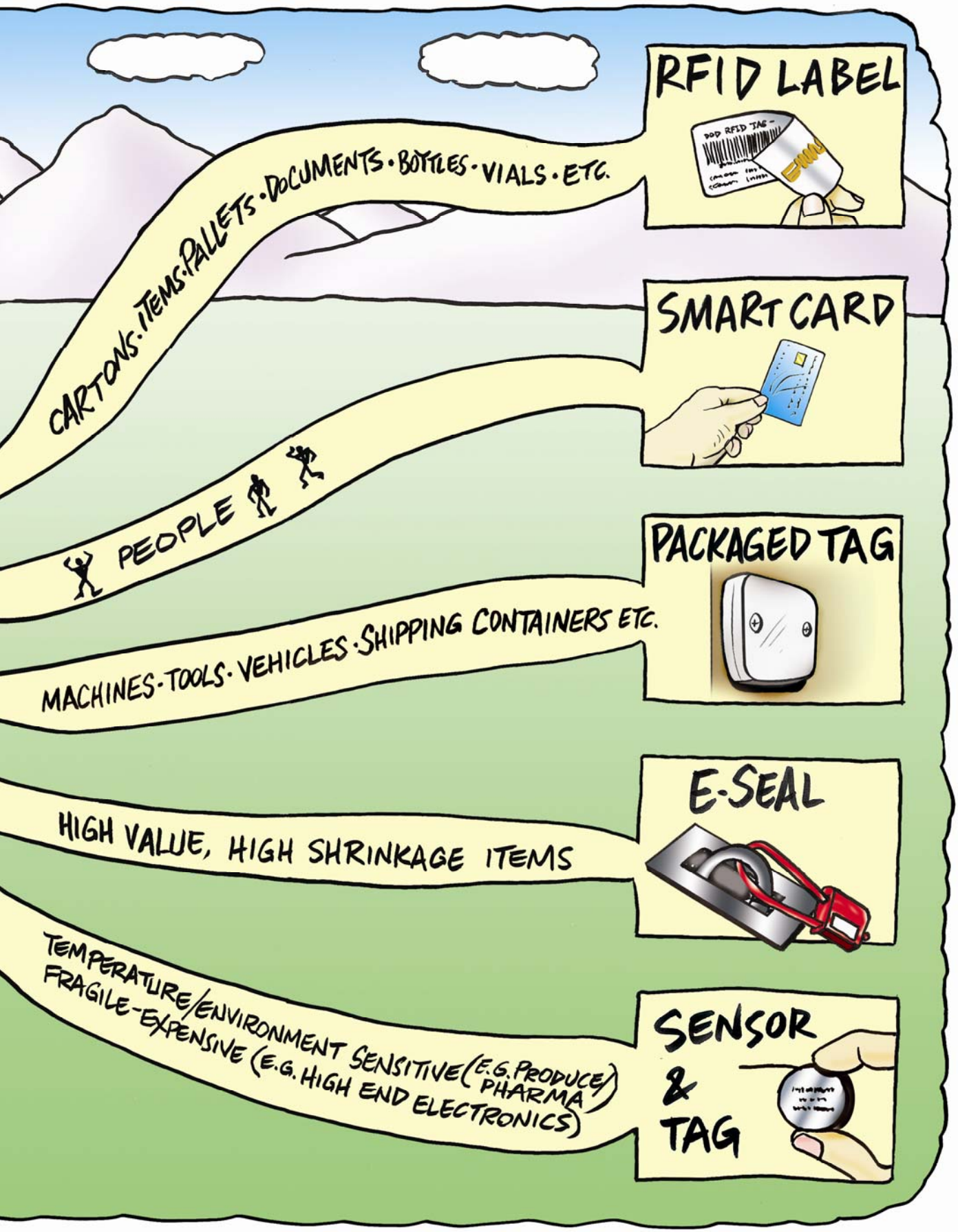

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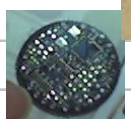
Market Leaders There are many important players of value in this market. Here are the market leaders and examples of their solutions[23].

Market Leaders Passive RFID Hardware Players by Sector	Finished Tags	Sensors	Enterprise One Readers	Enterprise Two Readers	Mobile Readers	Printers	Comments
Acsis, Inc.							Tag/Reader partnership, Creates unique Appliance for RF and Middleware
Alien Technology							Unique Antenas Worldwide Band Small Forms
Avery Dennison Printer Systems							Unique Antenna Design for Consumer Products
Checkpoint Systems, Inc.							Variety of Tags, EAS, Readers and Sensors
Escort Memory Systems							Tag, Reader, Sensor and Controller use in Mfg Systems
Intermec Technologies, Inc.							Rugged Wide Band
Impinj							Chips for tags and reader, now sell direct
Lowry Computer Products							Converter/Tunnel Systems
Nokia							Near Field HF
Palm							UHF and HF solutions
Printronix, Inc.							Partners with major RFID tag providers
PEAK Technologies							Converter/Tags, Readers and consulting/implementation
Savi Technology							Integrates to all RFID types, Partners on Mobile/Cellular
SkyeTek, Inc.							Very Small Readers 
SOKYMAT							Low Cost Readers
Motorola/Symbol							Enterprise 2 product should be released in 2008
TAGSYS							HF tags and readers
TransCore							Passive and Active Technologies
Texas Instruments							HF Electronics for many partners to package
Tyco/ADT/Sensormatic							
Zebra Technologies							Active and Passive Multifrequencies

Source: ChainLink Research

Table 5: Market Leaders of Passive RFID Hardware Players by Sector

23. For a more complete list and analysis of suppliers consult the report: *RFID Hardware - What You Must Know:* www.chainlinkresearch.com/research/detail.cfm?guid=B03A8206-CA4F-0362-4645-7DF02068244F

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Getting Started

We would be remiss if we did not address what the successful users have stated as their lessons learned and best advice. RFID, like any project, has many elements that plain good advice still applies to. But there are unique aspects to this that should be thought about. The above roadmap provides guidance on the kind of technology, but there is more to do. Here is the advice culled from interviews and case studies:

RFID Implementation Approach: Who What Where When and Why

Successful RFID integration projects incorporate **3Pe**—looking at **Policy**, **Process**, **Performance** and **Enablers** (technology and services) as elements to successful project management. Build your plan with:

1. **Eco-System-wide Team**
   - ☑ **Process** view for RFID—whether closed loop or open—Get your trading partners involved.
   - ☑ Business and IT are part of the program—RFID is not like barcodes. It touches the communications backbone of the enterprise and has security considerations than are much broader than barcode scanners.
   - ☑ Senior Management Sponsorship—make sure you have funding before you start—don't waste suppliers', consultants' or your teammates' time by conducting lots of meetings and then not have the back-up from management to pursue. When you present your Benefits and project package, you can obtain revised budget.
2. **Business Assessment:** ***Why***
   - ☑ Analysis of existing processes—How can RFID help?
   - ☑ Identification of opportunities for business performance improvement
   - ☑ **Policy**: What are the rules of the business and how will they change?
   - ☑ **Performance**: Plan for ROI
3. **Enablers/Technology Assessment:** ***Who What Where and When***
   - ☑ **Who** will be the users and their ergonomic requirements?
   - ☑ **What** are the item tagging requirements?
   - ☑ **Where** will RFID be used?
     - ☑ Eco-system survey—what is the process to be instrumented—what kind of challenges will we meet in terms of wifi availability, regulations, physical and section obstacles; what is the data required and derived from the read points?
     - ☑ Specific site analysis—site surveys, tag to reader ratios, site RF analysis
     - ☑ Technologies—active vs. passive, Enterprise 1 or Enterprise 2; Mobility is a useful alternative in environs without wifi.
     - ☑ What are the software and integration requirements?
     - ☑ What kind of service providers and expertise will be required for process and technology?
   - ☑ **When**: What are the data collection/*timing* requirements?
4. **Proof-of-Concept Pilot**
   - ☑ Create Pilot that is truly representative of the business—physically and from an information perspective
   - ☑ Create Pilot Goals: will these goals achieve the ***Performance Threshold*** to demonstrate the value and feasibility of a large roll-out?
   - ☑ Don't try to use the pilot as the implementation. Pilots are for learning.
   - ☑ Measure results against projections to "prove the concept"
   - ☑ Use lessons learned from pilot to develop a phased implementation plan and detailed system design
   - ☑ Build Consensus on success before proceeding to roll-out.
5. **Create Roadmap for Phased Implementation**
   - ☑ Plan should include risk assessments
   - ☑ Allow for proper training of employees
   - ☑ Build in change management elements
   - ☑ Keep management involved—you will need support—every project does.
   - ☑ Education, education, education—there is never a big enough budget for this. And poor results reflect this.

Source: ChainLink Research

Figure 6: RFID Implementation Approach

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Value Now: ROI for RFID

The above solutions are quite varied. RFID is a very versatile solution. But discussion about compliance and mandates still persists in the press, although research has shown that the main drivers for RFID use is based on the organization's own value proposition[24]. In our research, over 66% of respondents (see figure 7) stated that they were process/improvement driven vs. mandate driven. And there was a strong corollary between those respondents and the ones who declared an ROI. What is also interesting is the year by year increase in spending for RFID, as well as the percent planned for RFID projects in the coming year.

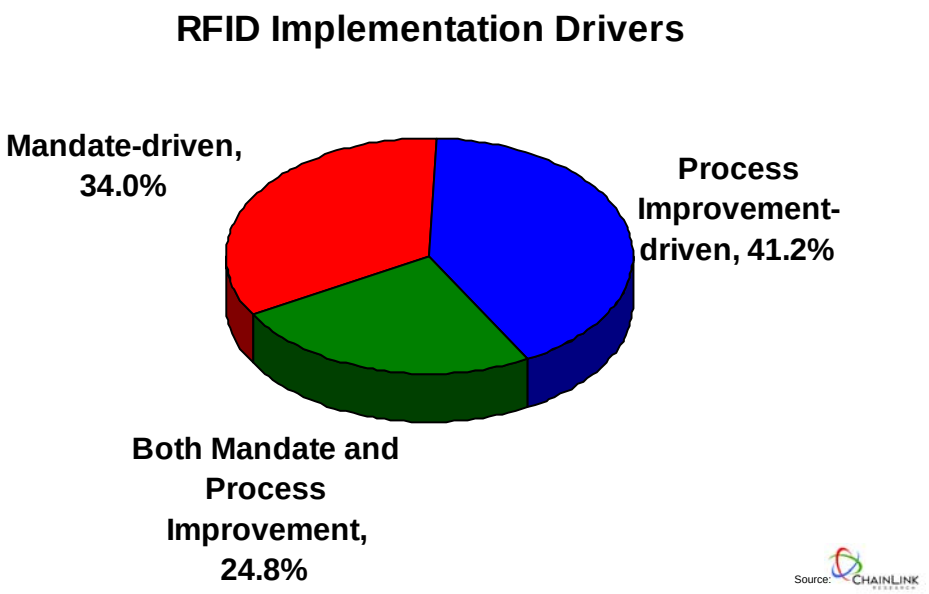

Figure 7: RFID Implementation Drivers

In our discussion here on value, we are going to describe what is actually happening now, and what is driving the enterprises' interest, therefore creating the momentum for the next few years.

Based on organizational drivers, firms quantify strategic as well as tangible value for RFID. These strategic areas represent risk factors for firms, which do manifest in huge costs and losses such as recalls, but again are harder to quantify, vs. reduction in costs or improvement in in-store inventory, time savings, etc. Long term, the strategic goals do net the value, but project sponsors need hard numbers to sell their programs.

24. For example, Griva SpA ,Vicaima, P&G, Navy, Astra Zeneca, Toyota, etc. all using RFID to help drive time to market and reduce cost of manufacturing/asset tracking in their business today.

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Focus on the Process

The other factors in value are very much centered on the type of projects that were undertaken. So-called closed loop and track and trace have had the highest value from the myriad of users we talked to, as we mentioned before. Closed loop projects have several key elements of importance:

- Control of the process. Here the touch points, read points and the environs are understood, so that a proper design, with instrumenting of the process can be done. This helps to ensure that the backbone data bases are refreshed with real-time data for track and trace, matching and validating, as well as analytics for response management and longer term process improvements.

- Re-use of hardware. Closed loop defacto means re-use. Manufacturing process, real-time locating systems and ID tags (license plates, etc.) on containers, vehicles, documents and folders, read/write tags that stay with products over their lifetime—they all have these properties.

Track and Trace requires instrumentation of the process. If this can be achieved—in Active markets we are seeing this, with NATO, US DoD, etc.—then the goals can be achieved. In the passive market, customers of Wal-Mart who *use their data* from Retail-Link and collect their RFID data now have these insights into issues such as instore inventory positions, promotion management, etc.

Sometimes you have to change your process to make better use of RFID (especially when barcodes are replaced by RFID.)

As eco-system partners work together in process work, evaluating read point locations and integration, we will see more successes come on-line.

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Value Assessments and Stages of Value

Most firms have a much more cautious approach to technology these days. Pilots have become—and rightly so—key parts of an overall corporate roll-out of technology, which can take several years. Keeping pace as technology moves from pilot to portfolio application can be a challenge. If the technology truly represents increasing value—better performance and better cost—then this can be an upside for value assessments that firms make. The more knowledgeable firms put these into their calculations.

As firms leverage their investments, not just by extracting data from technology, but by increasing their learnings from projects, they go through stages of value. Most firms, though, do not create their ROI models to reflect this. They look for one big number, rather than *growth in learning* over time. But looking at what firms actually do, especially through these early years with passive RFID, these stages of value are being assessed and then aligned with a project roll-out. As you go from your first project or pilot to a larger rollout, your value model should equate to higher gains and increasing value realization.

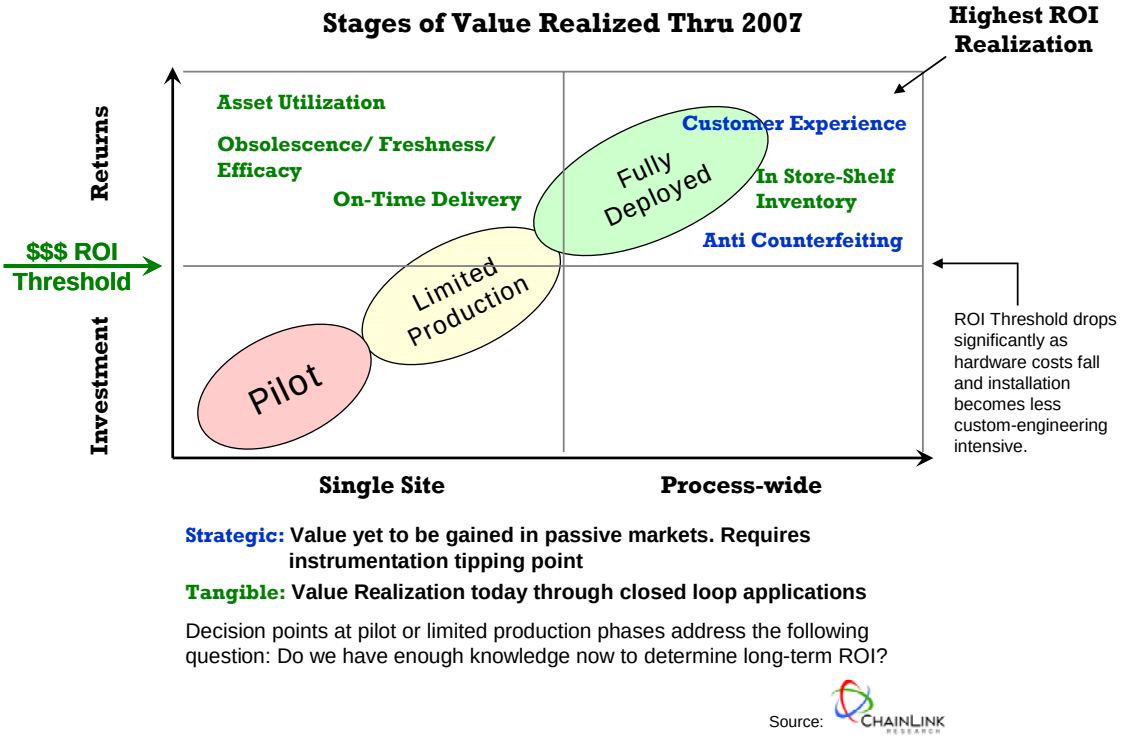

Figure 8: Stages of Value Realized thru 2007

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What we see is that firms are making deliberate careful assessments of pilot results and weighing the benefits of moving on to larger initiatives. We like to use the term 'investment threshold'—what constitutes an actual validatable experience or number to assume the same or higher achievement as they roll-out. These discussions need to look, then, at the overall process, the costs of instrumenting vs. the strategic and tangible value at each stage. As the process gets more instrumented, the value goes up, creating a network tipping point. For example, the more readers that are out there, the more intelligent the process is.

Interesting segments of the market that are getting through these ROI thresholds and driving up value and the network effect:

- Manufacturing—both inbound, such as receiving, Kanban, etc., but more importantly managing the processes within the plant such as manufacturing sequencing, maintenance of equipment, etc.
- Asset Management and Tracking—many industries have these issues with inventory management and accounting: rental returns in everything from consumer level items to heavy equipment, tracking assets through facilities, and establishing ownership/ returning assets from pallets, the tools, to library books. Asset tracking in hospitals may sound mundane, but is a real life saver!
- Maintenance Depots—the challenges of rapid locating, as well as the data management challenges in many industries of not only using certified parts, but recording the events in the life of that part. Industries like Aerospace, Automotive, Medical Devices, etc., all fit here.
- Vehicle tracking from municipal buses, to Delivery services, milk runs, etc.
- Cold Chain and ingestibles tracking and traceability—as we mentioned before, Europe has a food traceability law, the FDA has pedigree reporting (although these require shared processes across multi-tiers). They become cost justifiable as investments in the reader networks increase.
- Access Control—from employee security, to yard entrance etc.
- Document management in so many industries (legal folder, evidence tracking, etc.) may seem mundane to many, but they make the case!

We could go on. Refer to table 4 (pgs 14-15) on Business Solutions for another angle on these lists. But the point here is that this theme of enterprise or partnership integration enables increasing returns as more assets get tagged and more read points come onto the network. However, today they are, in reality, closed loop winners. *For those who sell these solutions, that should be your cue to go after these types of projects.*

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Conclusions:

RFID technology is clearly evolving, and the applicability in so many categories is growing. From a market perspective, the market size of active and passive, industry use cases will continue to appear, as well as more versatility and range will grow, while prices will come down. Expertise for system integrators should focus on industries, since buyers want knowledge—as always—in their industries. However, you should also know that the technology choices are much richer, if you want to lead a successful project (i.e., ROI).

Not all readers and tags are created equal. Some are better used for target applications based on form factor, price and performance. No longer can we lump all readers and tags in the same category or bucket.

Expectations for continued spend are good, with more pilots as well as roll-out (see figure 9).

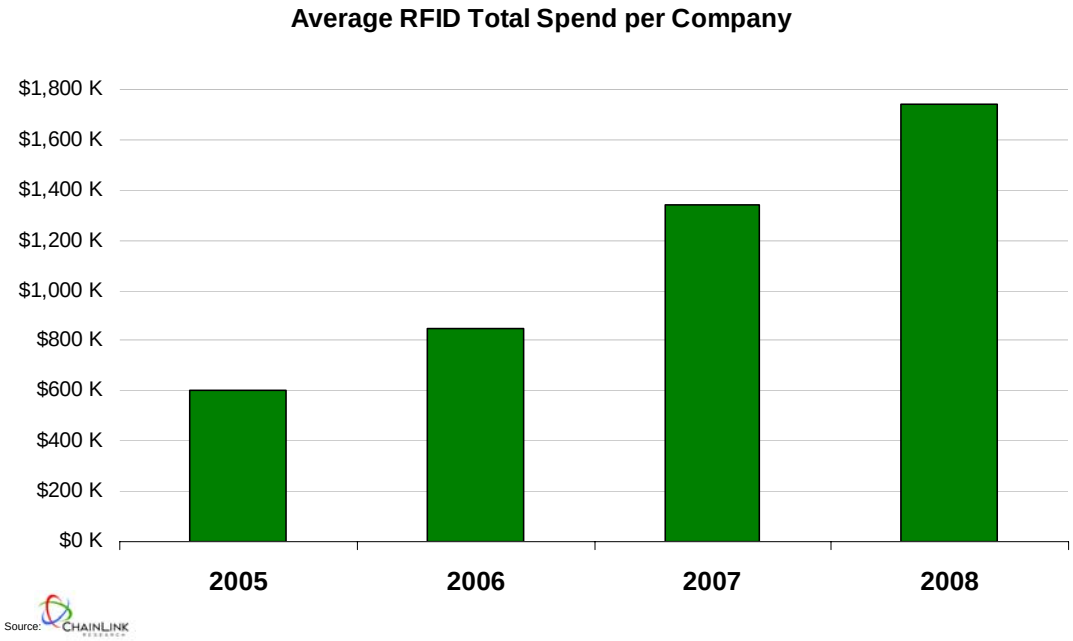

Figure 9: Average RFID Total Spend per Company

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Getting Started — Final Thoughts

It is always interesting to hear about the lessons learned from the people who have been implementing. Here are some of the best advices:

For End User Firms:

- Begin with education. There is a lot to learn before jumping into the deep end. Go to a facility[25] with labs that simulate real world environments.
- Pilot and experiment to develop understanding of technology's capabilities and challenges.
- Plan and implement with a Roadmap approach. Use what works today and plan your portfolio for several years out, so that you can take advantage of the new things that come along. At some point things will stabilize, and the new products won't have as many leaps forward. But that won't happen for awhile, so plan for the long run.
- Plan for the data that you will need *for* the systems and will need to derive *from* the systems.
- Evaluate legacy systems for handling higher data flow and new types of information.
- Revise business processes to properly enable new technology capabilities that produce significant value. You won't get the value unless you change your process.
- Build a change management program to effectively cope with shift to new technology, procedures, policies, etc.
- Start with a positive attitude—if you think it won't work and you won't get value—you won't.
- Don't try to do projects on the cheap—if you think it is worth doing—do it right. It is not about money, it's about investing the time and people who should be involved.
- Try Quick Start RFID solutions to get started. Many solution providers have these. It's a low/no risk way to start learning.
- Manage and Learn from your implementations partners—they don't know it all.

25. RFID Solution Center is just such a place in Dayton, Ohio: www.rfidsolutionscenter.com

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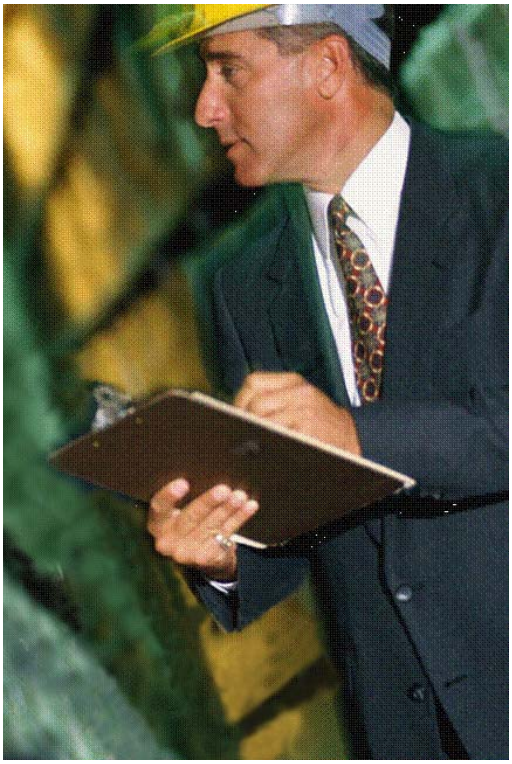
For Service Providers and System Integrators:

- Third-party service providers are in an excellent position to be the provider of choice for RFID services for their customers. No doubt there is some learning curve, but those who package, handle, distribute, move, or service products for your customer can not only make *your job easier*, but can provide this new service *and increase your revenue per customer.* We have seen this model already working with third-parties like 3PLs, packaging, and paper companies that are in various pilot stages in various programs of this type.

- System Integrators that implement solutions in manufacturing, warehouse, yards and stores, for example, are also in a position to see the emerging client's needs. Hybrid models are pervasive in the consulting market with Prime Contractors bringing in partners with Auto-ID expertise. The RFID market to date has great expertise within the 'boutique' consulting firms, small firms that are deeply knowledgeable about Auto-ID. But with some prodding there is more business to be had in a variety of business settings, and therefore revenue sharing models can work, expanding market penetration. In the long term, this also will increase the knowledge base in the consulting market, thus expanding the market growth.



This year—*2007*—brand and product integrity are under fire. Heightened concerns about tampering, counterfeiting, and traceability are hot topics. Working groups from the Chamber of Commerce, with several working groups on Anti-Counterfeiting, trade management, industry working groups and government action groups (President Bush's Import Safety working group to advise on legislations, to name some) are all focused on these issues. And where there is smoke, there is fire. No one can precisely predict when legislation will dictate traceability, or the tipping point of consumer pressure will drive to it, but wise firms are seeking the value now. In the EU, if you want to do business, you must comply with these types of regulations.

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Supply chain effectiveness is still the economic driving force for much of the RFID market, and this work will continue at GS1[26] and other industry groups.

Smart Cards continue to roll-out with more organizations that are using ID cards. Contactless payment systems, drive-thru systems, etc.[27] will have their day.

RFID has demonstrated that value can be gained when the reader network is in place—the closed loop—and the processes and data are the focus by contributing organizations. The projects that dangle with lack of definitive results are those that are not well prepared. Shortcuts generally don't yield results. RFID should be thought of as both strategic as well as tactical enablers. Plan for both. Great things don't come in a day, but one step at a time.

26. See Appendix A, pg 33, EPCGlobal Network
27. McDonalds, 7-eleven, etc. are leaders in this area

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Appendix A: Glossary of Terms

802.11: IEEE 802.11, also known as Wi-Fi, denotes a set of Wireless LAN/WLAN standards developed by working group 11 of the IEEE Lan/Man Standards Committee (IEEE 802). The term 802.11x is also used to denote this set of standards and is not to be mistaken for any one of its elements. There are several 802.11x standards. The 802.11 family currently includes six over-the-air modulation techniques that all use the same protocol. The most popular techniques are those defined by the **b**, **a**, and **g** amendments to the original standard; security was originally included and was later enhanced via the 802.11i amendment. The 802.11b and 802.11g standards use the 2.40 GHz (gigahertz) band, operating (in the United States) under Part 15 of the FCC Rules and Regulations. Because of this choice of frequency band, 802.11b and 802.11g equipment can incur interference from microwave ovens, cordless telephones, Bluetooth devices, and other appliances using this same band. The 802.11a standard uses the 5 GHz band, and is therefore not affected by products operating on the 2.4 GHz band.

The segment of the radio frequency spectrum used varies between countries, with the strictest limitations in the United States. While it is true that in the U.S. 802.11a and g devices may be legally operated without a license, it is not true that 802.11a and g operate in an unlicensed portion of the radio frequency spectrum. Unlicensed (legal) operation of 802.11a and g is covered under Part 15 of the FCC Rules and Regulations. Frequencies used by channels one (1) through six (6) (802.11b) fall within the range of the 2.4 gigahertz amateur radio band. Licensed amateur radio operators may operate 802.11b/g devices under Part 97 of the FCC Rules and Regulations, allowing increased power output but not allowing any commercial content or encryption.

Access Point: 1. A standalone device that connects to a wireless LAN, and can be RFID or Wi-Fi. 2. The radio device that receives the signal from the base station 3. A physical area (Hot Spot) where you can pick up Wi-Fi signals.

Active RFID: A business solution for tracking and tracing items or people that uses Active Tags rather than Passive Tags. See Active Tag, Passive Tag.

Active tag: An RFID tag that contains its own power source. This power source is used to power the microchip, and receive and transmit data. The use of a battery substantially increases the range of the signal, compared with a passive tag.

AIP: See Air Interface Protocol.

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Air Interface Protocol (AIP): The rules that govern how tags and readers communicate.

Antenna: The antenna is the conductive element that converts RF into electrical energy and vice versa, thereby enabling the tag or reader to send and receive data wirelessly. Antennas can be wire, etched conductive or conductive inks made from aluminum, copper or silver.

API: See Application Programming Interface (below).

Application Programming Interface (API): A source code interface that a computer application, operating system or library provides to support requests for services to be made of it by a computer program.

Authentication: For a tagged item, the device as well as the item have to be authenticated. Mobile devices/cell phones and readers must also be authenticated to gain access to the network.

Automatic identification and data capture: A broad term that covers methods of identifying objects, capturing information about them, and entering it directly into computer systems without human involvement. Technologies normally considered part of auto-ID include bar codes, biometrics, RFID and voice recognition.

***Backhaul*:** Transmitting from a remote site to a central site.

***Beacon*:** An active or semi-active RFID tag that is programmed to broadcast its signal at a set intervals.

Bluetooth: A short-range radio technology aimed at simplifying communications among Internet devices and between devices and the Internet. It also aims to simplify data synchronization between Internet devices and other computers. Products with Bluetooth technology must be qualified and pass interoperability testing by the Bluetooth Special Interest Group prior to release.

Cellular: Called “cellular” because the system uses many base stations to divide a service area into multiple “cells.” Cellular calls are transferred from base station to base station as a user’s call travels from cell to cell. Cellular devices use low orbiting satellites to send signals from the phone to the base station.

Choke point: Entering a reader field. This usually occurs at handoff points or at physically constricted locations where readers can be installed, such as gates, dock doors, etc.

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Choke point control: As items/devices pass through reader fields, Active RFID allows bi-directional communication to control activities (such as restricting access) on the ground.

Closed loop systems: RFID tracking systems set up within a process where the item and tag return to the source. It may not need technology based on open standards.

EPC: Electronic Product Code

EPCglobal: A non-profit organization set up the Uniform Code Council and EAN International, the two organizations that maintain barcode standards, to commercialize EPC technology, now GS1. EPCglobal is made up of chapters in different countries and regions. It is commercializing the technology originally developed by the Auto-ID Center.

EPCglobal Network: The Internet-based technologies and services that enable companies to retrieve data associated with EPCs. The network infrastructure includes the Object Name Service, distributed middleware (sometimes called Savants), the EPC Information Service (EPCIS) and Physical Markup Language. EPCIS is provided by VeriSign.

E-seals: Electronic seals placed, for example, on intermodal shipping containers to ensure the integrity of the container contents throughout the entire shipping process.

GEO Satellite Systems: A geosynchronous or geostationary satellite that stays in the same overhead position relative to a location on the surface of the earth, at approximately 22,000 miles over the earth. Used for the transmission of high-speed data, television signals and other wideband applications.

Global Positioning System (GPS): A world-wide radio-navigation system that was developed by the U.S. Department of Defense. In addition to military purposes, it is widely used by marine, terrestrial navigation and location-based systems.

GPS: See Global Positioning System (above).

Intrinsically Safe: The danger of accidental actuation of electro-explosive devices or otherwise electrically activated ordinance because of RF electromagnetic fields. This unintended actuation could have safety (premature firing) or reliability (duding) consequences. Also called HERO. (Hazards of Electromagnetic Radiation to Ordnance).

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LEO Satellite Systems: Low Earth Orbit satellite.

MAN 802.16: Commonly referred to as WiMAX or less commonly as WirelessMAN or the Air Interface Standard, IEEE 802.16 is a specification for fixed broadband wireless metropolitan area networks (MANs) that use a point-to-multipoint architecture.

Middleware: In the RFID world, this term is generally used to refer to software that resides on an appliance, reader or server, between RFID readers and enterprise applications. The middleware is used to filter data and pass on only useful information. Some middleware can also be used to manage readers on a reader network.

Passive tag: An RFID tag without its own power source. When radio waves from the reader reach the chip's antenna, the energy is converted by the antenna into electricity that can power up the microchip in the tag. The tag is able to send back information stored on the chip. Today, simple passive tags cost from U.S. 20 cents to several dollars, depending on the amount of memory on the tag, packaging and other features.

Personal Area Network (PAN): A technology that could enable wearable computer devices that communicate with other nearby computers to exchange digital information within the range of an individual person, typically within a range of 10 meters. For example, a person with a laptop, a PDA, and a personal printer could connect them without having to plug anything in, using some form of wireless technology. Typically, this kind of personal area network could also be interconnected without wires to the Internet or other networks.

Protocol: A set of rules that govern communications systems. (See Air-interface protocol.)

Read range: The distance from which a reader can communicate with a tag. Active tags have a longer read range than passive tags because they use their own power source (usually a battery) to transmit signals to the reader. With passive tags, the read range is influenced by frequency, reader output power, antenna design, and method of powering up the tag.

Reader/Interrogator/Encoder: The reader communicates with the RFID tag via radio waves and reads (interrogator) as well as writes information (encoder) to and from the tag. A reader may store the data and/or pass the information in digital form over the network or directly to another device. Readers may also receive data from other sensory devices (e.g. motion detector) and/or they may control other devices (such as indicator lights).

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Reader field: The area of coverage. Tags outside the reader field do not receive radio waves and can't be read. This is also sometimes referred to as the read field.

Reader network: Topology of readers. Can be local installations such as a grid to maintain 'presence,' mobile readers that have wireless communications (cellular or GPS/Satellite), or a series of strategically located choke point readers to track a process, control access, etc.

RFID tag: A microchip attached to an antenna that is packaged in a way that it can be applied to an object. The tag picks up signals from and sends signals to a reader. The tag contains a unique serial number, but may have other information. Tags come in many forms, and can be packaged in many ways. RFID tags can be active, passive or semi-passive.

Sensor: A device that responds to a physical stimulus and produces an electronic signal. Sensors are increasingly being combined with RFID tags to detect the presence of a stimulus at an identifiable location.

Tag: See RFID tag

Track and trace: The process of retrieving information about the movement and location of goods.

Transponder: A radio transmitter-receiver that is activated when it receives a predetermined signal. RFID transponders come in many forms, including smart labels, simple tags, smart cards and keychain fobs. RFID tags are sometimes referred to as transponders.

UHF: See Ultra-High Frequency (below).

Ultra-high frequency (UHF): From 300 MHz to 3 GHz. Typically, within the RFIC community, UHF refers to RFID tags that operate between 866 MHz to 960 MHz.

Wi-Fi: This is another name for IEEE 802.11. It is a term coined by the Wireless Ethernet Compatibility Alliance (WECA). Products certified as Wi-Fi by WECA are interoperable with each other even if they are from different manufacturers. A user with a Wi-Fi product can use any brand of Access Point with any other brand of client hardware that is built to the Wi-Fi standard.

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Appendix B: Sharing RFID Data

VERTICAL INDUSTRY CHARACTERISTICS

We found that different vertical industries had different inter-enterprise sharing needs driven by their unique challenges, processes, supply chain models, and the maturity of the industries in sharing data with trading partners. Some of these are outlined in table 6, below.

Pharmaceutical	• Challenges around diversion, counterfeiting, cold chain, and clinical trials, which all can benefit from sharing RFID-based tracking of individual items across multiple tiers from manufacture through to retail sale.
Retail	• Large retailers tend to be the hubs of their supply chain. • Trend towards private label products drives a more integrated supply chain model—a growing need to manage an extended supply chain versus a single 'procurement' relationship with brokers and agents.
CPG	• Less advanced supply chain models – still working on getting a global IT platform in place internally. • Tend to have Tier 1 supplier level relationships – behind the curve in collaboration with supply partners.
Electronics	• Most collaborative business model – from wafer fabrication to point of sale perspective. • Share bill of material and other key data across an extended supply chain. • However, this is still fragmented and no comprehensive SVoT was in place at this time in the communities interviewed.
Aerospace and Defense	• Complex supply chain with little collaboration in most cases. • However, changing models within DoD and other key communities are creating drivers for adoption of more interactive and responsive supply chain relationships.
Automotive/Heavy Equipment	• Driven by cost-reduction programs—not innovators in the IT arena although many have adopted EDI programs in the past. • Perception of SVoT in this community tended to be narrow in general.

Table 6 - Industry-Specific SVoT Characteristics

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What research said about the new world with RFID and shared processes of data. Change in business and change in attitudes will have to take place.

The Old Model	The New Model	Changes Required
Limited sharing of transactional data only (orders, ASN, etc.)	Rich data sharing (designs, roadmaps, production info, pricing, actual consumption, failure data, etc.)	Developing strategic relationships. Segmentation of information access. Scrubbing data into actionable information. Better security processes and ongoing training.
Direct relationships, only with immediate supplier and customer	Multi-tier digital relationships, via third party platforms	Third party platform provider must have strong technical security/architecture. Even more importantly, excellent training to prevent social-engineering attacks.
Manual processes and manual decision making	Autonomic processes, where "the system" makes some decisions automatically	Confidence in the solution before people will relinquish decision making. This can come through controlled pilots, proving that the system makes good decisions.
Lack of data on cause and liability when problems arise	Remedial capabilities for problem resolution, with accountability	This requires willingness of all the players in the delivery chain to be closely monitored and own up to liability. It usually takes a strong player to mandate participation.
Unreliable delivery performance, resulting in reliance on excessive inventory to maintain service levels	Reliable time definite delivery enables a "virtual warehouse," where in-transit inventory can be counted as future on-hand inventory	This model can only be adopted when there is faith in end-to-end process, based on proven performance. This requires process disciplines and equally important, total visibility and earliest possible warning (and predictions) of deviations from execution plan.

Table 7: Old / New RFID Model

"It would absolutely help the evolution of the healthcare supply chain to have a shared single version of the truth. But we need to resolve issues around roles. Some of the big distributors are also manufacturers. The lines are so blurred, they act like GPOs (Group Purchasing Organizations). When we ask for a bid, the distributor, who also has their own manufactured product, has total visibility into the contracted pricing. They have the advantage of bidding with full knowledge of current price. I get a lot of ethical questions from our owners on this. Should we exclude a distributor from bidding?"

SVP, Major Healthcare Group Purchasing Organization

In our industry the different brands have been at war for over 30 years. We'd love to have POS data, but the retailers are not going to give us that data. The OEM is reluctant, because they are afraid competitors will get that information . There's a lot of talk about collaboration, but nobody trusts anyone – so the information is watered down. In the future, if I have the same POS info Wal-Mart has, then I think the overall supply chain will be better.

Logistics and Business Services Manager, Major Semiconductor Manufacturer

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Appendix C: Where to Go Next

Education: RFID Solution Center www.rfidsolutionscenter.com/. On site training as well as labs for trying out your solutions.

Reading: chainlinkresearch.com/home/index.cfm

Consulting and Converting firms like Acsis, Inc; Lowry; PEAK; The Kennedy Group; Rush Tracking, (too numerous to mention here[28]) can all advise and well as create solutions for clients.

Custom designs for antenna packing of tags, etc. can come from designer and converters like Lowry, RCD, etc.

Understanding Standards: IEEE Society, ISO and GS1, as well as specific industry working groups in Automotive (AIAG) Aerospace, etc. exist.

RFID firms: consult our Market Leaders chart on page 20. But don't limit yourself, there. The market leaders such as Alien, Motorola, Printronix, Zebra, et al, have partners who can provide a more customized and tailored solution. There are many stable long standing enterprises that have been at the game a long time. The report *RFID Hardware—What You Must Know*[28] has a more extensive chart of providers in the market.

28. Consult Vendor charts in *RFID Hardware-What You Must Know:* www.chainlinkresearch.com/research/detail.cfm?guid=B03A8206-CA4F-0362-4645-7DF02068244F

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