

*RFID: READ MY CHIPS!*

A P R I L 2 0 0 4

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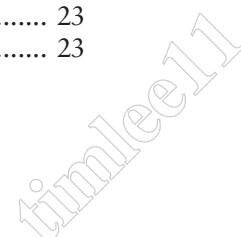
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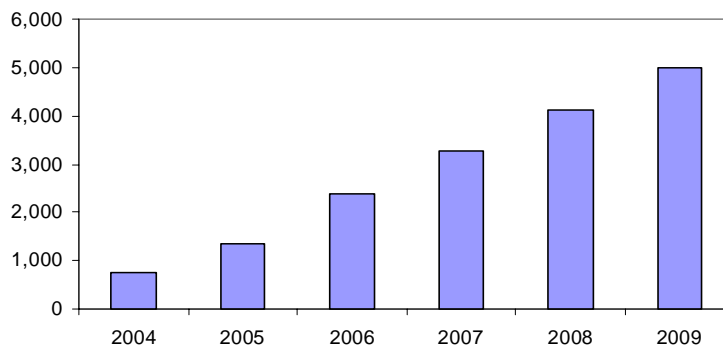
**Executive Summary**

- RFID applications are on the eve of a major hypergrowth cycle. We believe RFID will be one of the fastest-growing technology segments over the next five years. We are projecting the market for RFID hardware will reach \$5 billion annually by 2009. This near seven-fold increase in market size implies a CAGR of 41% during our forecast period. RFID promises to bring investment opportunities in the hardware and software arena as well as provide substantial incremental business to large systems integrators as firms begin adopting.

Exhibit 1

**PIPER JAFFRAY RFID MARKET FORECAST**  
(\$ in Millions)

**U.S. Total RFID Hardware Market**



Source: Piper Jaffray & Co.

- We view RFID as a disruptive technology that will form the foundation of a futuristic "Internet of Things." While this new technology will initially disrupt many tracking procedures currently in place, we believe it will ultimately open the door to frictionless security and humanless item tracking. We expect that RFID will quickly take a large share of the \$7 billion barcode market as well as grow into new markets outside of traditional barcode strongholds. Early applications for RFID will likely focus on security and tracking items in a supply chain. Promises of widespread point-of-sale adoption of RFID are at least four years away, in our view.
- The major components of an RFID system include an encoder, a transponder, a reader, and software applications. The general RFID process begins with encoding a tag/transponder with item-specific information. The tag then typically transmits data when it enters the reader's range. For passive tags, the reader emits an electromagnetic signal that evokes the tag/transponder to allow its data to be read generally via ultra-high frequency. Once the information is read by the reader, the information can be transmitted, enterprise applications stored, and mined for a variety of information.
- Epic battles for market share are emerging. We expect to see three major categories of companies vying for market share including start-ups, incumbent supply-chain enablers, and divisions of large companies. Start-ups will be the only pure-play RFID companies. Incumbents will generally have a strong heritage with barcode technology and deep client relationships. Divisions of large companies round out the competitive landscape

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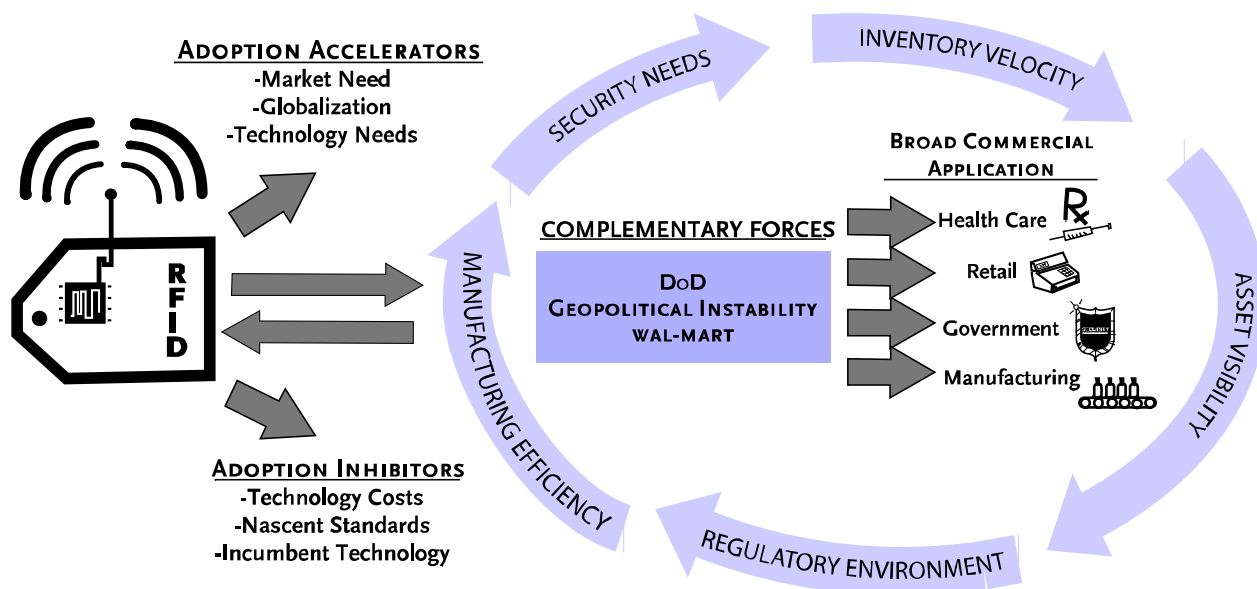
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and will likely attempt to leverage capacity and customer relationships. The transponder and software markets are the likely target markets of these divisions. All companies will bring advantages and disadvantages to the game. We will handicap the likely winners later in this report.

- Timing is everything. Recent announcements that the Department of Defense (DoD) and Wal-Mart are mandating RFID implementation make the "if RFID" question irrelevant, in our eyes. We believe the "when" and "who" questions should be the primary focus of investors. Our view is that RFID will begin to move in earnest from pilot projects to commercialization around the middle part of 2005. Government, CPG retail, manufacturing logistics, and transportation industries will likely be the early adopters. Health care and other diversified manufacturers will likely follow suit. Excluding health care, the majority of RFID applications will occur at the crate and pallet level over the next four years.
- Our market forecast is based on our proprietary methodology that weighs adoption inhibitors and accelerators as well as the influence of complementary forces to either drive or repel the technology. While we will go into more detail in later chapters, the largest factor affecting RFID adoption is unit cost followed by a lack of standards. Progress is being made on both fronts. The complementary forces in our model are buyers with an extraordinary amount of clout, the DoD and Wal-Mart. These two groups should pull RFID technology from individual projects to mass adoption. These two organizations have such buying power that they will ultimately have a disproportionate say in the way that RFID is implemented. Both are committed to RFID. Both will push tag costs lower. Both will mandate a standards-based approach.

Exhibit 2

PIPER JAFFRAY RFID MARKET FRAMEWORK



Source: Piper Jaffray & Co.



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## RFID: Today's Reality

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Radio Frequency Identification (RFID) is an automatic identification technology that utilizes the principles of radio broadcast and radar technology to locate and identify unique attributes of objects passing through an open or closed system. We view RFID as the heir apparent to other automatic identification technologies that utilized barcode, infrared, and/or optical character technology. The technology works by using radio waves to exchange information between tagged objects and readers. The data gathered is linked to a network and passed on to data management application for storage and further processing. Data transfer is effected by means of non-line-of-sight mechanisms using radio waves rather than by more commonly used line-of-sight means such as scanning by lasers. This distinguishing point makes RFID technology superior to many other identification technologies. Chief benefits include:

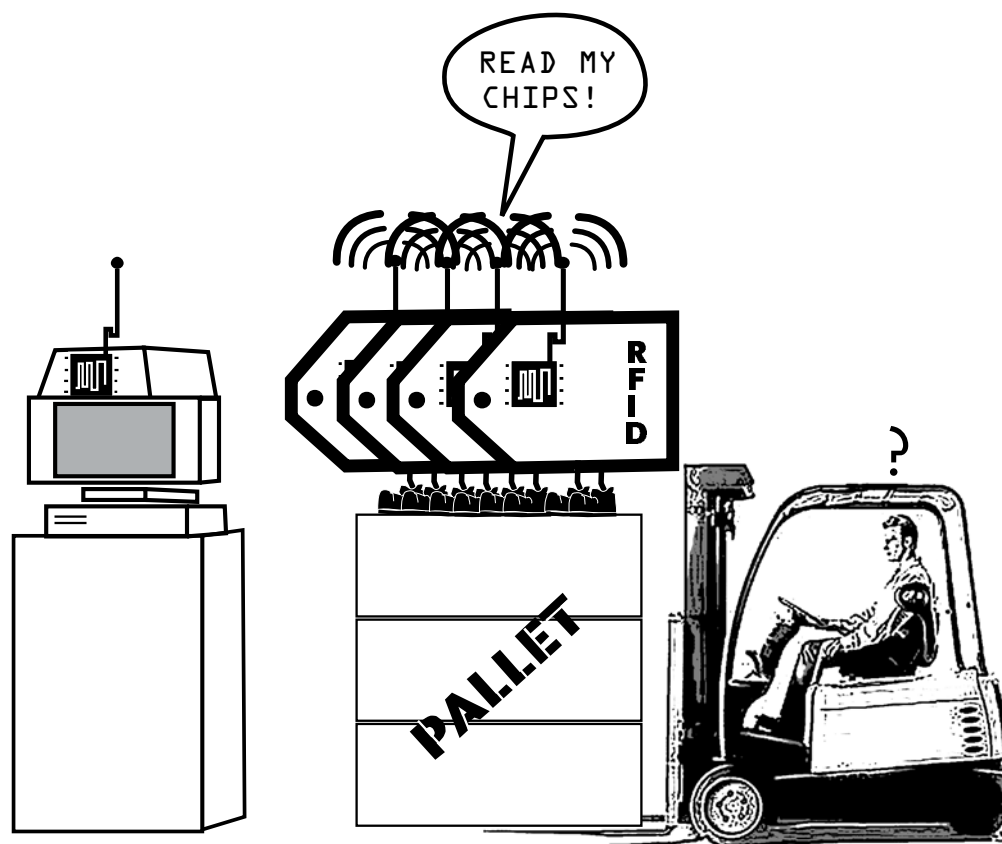
1. **Simultaneous Scanning:** RFID provides the ability to scan multiple items concurrently compared to methods today requiring serial scanning. Increased throughput with less staffing is the obvious benefit.
2. **Humanless Identification:** RFID is intended to be "hands-free" technology. No human intervention is required, and most items/pallets will be identified as they move from point to point in a supply chain.
3. **Instantaneous Updates:** RFID can provide real-time visibility into the supply chain. Packages and unique identifiers can be tracked electronically and routed through business-knowledge applications.

RFID has applications in many fields. The largest early beneficiaries of this technology include security and defense organizations, retailers, health care organizations, the transportation industry, and logistics companies. RFID is expected to result in billions of dollars of savings resulting from increased productivity, reduced fraud, and enhanced security.

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**RFID: Future Promises**

RFID 2015 is much more than an auto ID technology. It will form the gateway to the twenty-first century network of things. The RF tags symbolize the atom forming the lowest common denominator of this network. These “nanocomputers” roam and communicate free of wires and for the first time add a mass sensing capability to computers relatively inexpensively. In other words, a growing legion of silicon chips will move beyond previous walls, wires, or geographic boundaries sensing their environment and transmitting identifying information, location detail, and other information. We believe the ramifications of having hundreds of billions of “nanocomputers” moving freely and sensing the world in an increasingly sophisticated manner are staggering. RFID is much more than a smart refrigerator or a smart shelf. It is a network. Over time, RFID will change the way information is collected, transmitted, analyzed, stored, and acted upon. Tag deployments will be the leading indicators for measuring the reach and sophistication of tomorrow's network. The principle will follow Metcalfe's Law but the scale will be beyond previous contemplation.





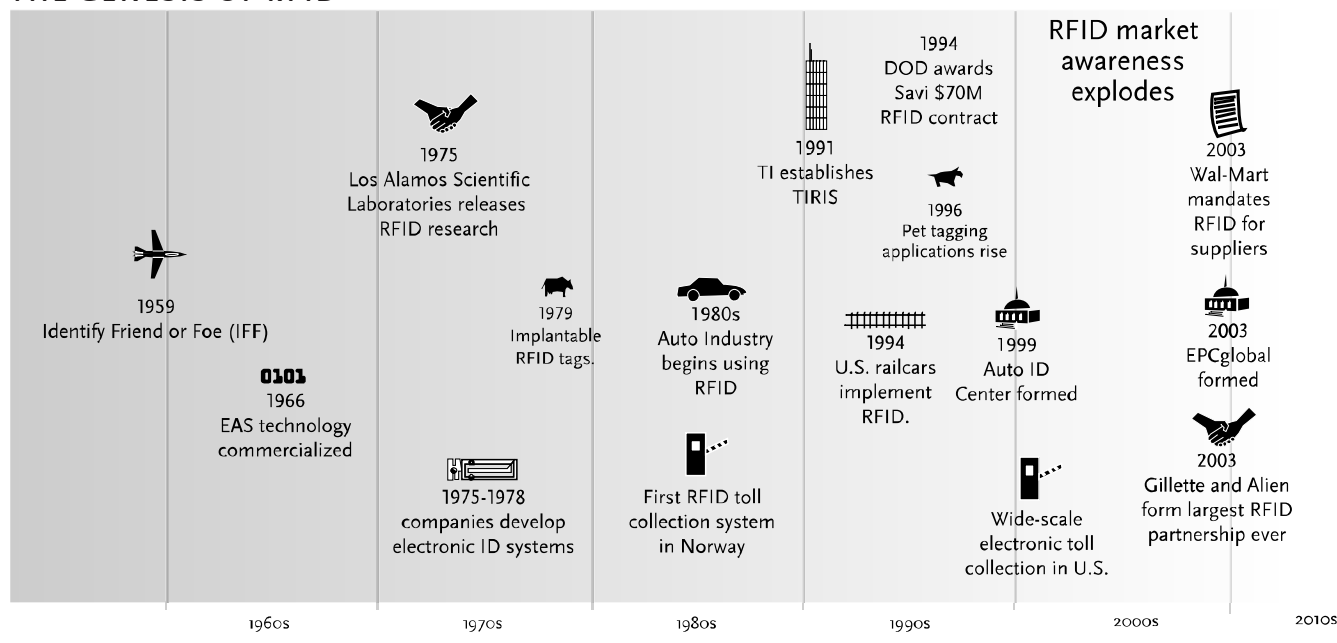
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### Twentieth Century RFID: Tracing RFID Lineage

Given our view that RFID technology owes its technical heritage from the merging of radio broadcast and radar disciplines, we believe the beginning of modern RFID can be traced to these fields. As is often the case, the pioneer or at least the largest early adopter of radio and radar technology was the DoD. Advances in locating objects with radar technologies during the 1920s and applied during WWII were perhaps the strongest foreshadowing of the power that radio waves harness. Military applications quickly broadened to the long-range transponders systems to identify friend or foe aircraft. These systems remain in use today. The military continues to invest in new uses of radio and radar technologies that ultimately could provide the scientific foundation for future RFID enhancements.

Exhibit 3

### THE GENESIS OF RFID



Source: Piper Jaffray & Co.

The commercial market took longer to develop. During the 1960s, electronic article surveillance became the first rudimentary application of RFID that was applied in commercial quantities. Animal tagging projects and vehicle tracking applications began to appear sporadically in the 1970s. Success with these seed endeavors opened the door for more industrial strength applications to sprout during the 1980s. Proximity cards for controlled access became more common. By the 1990s, the transportation market began to realize the benefits of RFID for automatic toll collection.

While some contend that RFID has been in existence since the middle of the twentieth century, others believe the technology is much more modern—perhaps 15 years old. This group believes in the classic definition that RFID is only RFID if there is a silicon IC and an antenna. Whichever view one prefers, it is clear that the foundation for the technology dates back centuries, related applications date back half a century or more, and applications of RFID with a silicon IC and an antenna did not occur in scale until the latter part of the twentieth century. *While RFID has come a long way since the 1950s, we believe the adoption of RFID during the next three years for security and supply-chain applications will dwarf its growth during the previous 50 years combined.*

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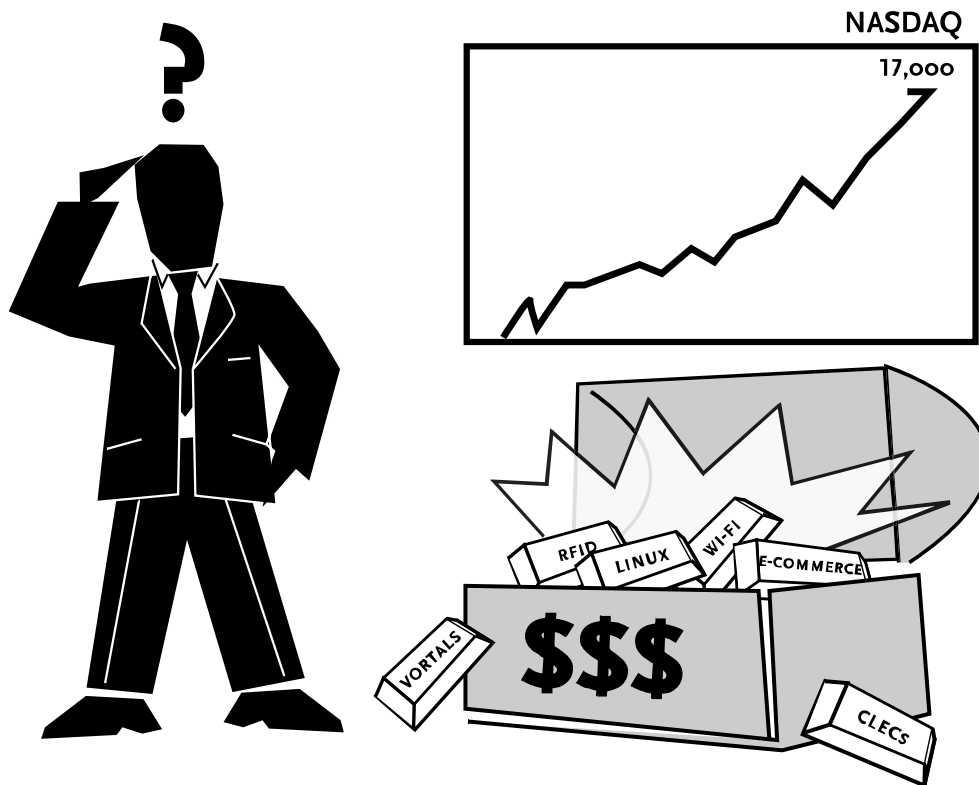
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**Setting The Compass To True North—A Perspective For RFID Investors**

Inevitably, the investor's dilemma when introduced with a new "buzzworthy" technology, such as RFID, is separating the potential of the technology from the hype of the technology. While this is easy to do in hindsight, it tends to be very challenging in the present. Pundits pushing prognostications of greatness or extreme tales of caution seem to promote a binary outcome of success or failure, making analysis in the present even murkier. With all the noise in the marketplace, we believe a framework is necessary to inject order, pragmatism, and consistency when evaluating adoption rates of emerging technologies.

Exhibit 4

**ALL THAT GLITTERS IS NOT GOLD**



Source: Piper Jaffray & Co.

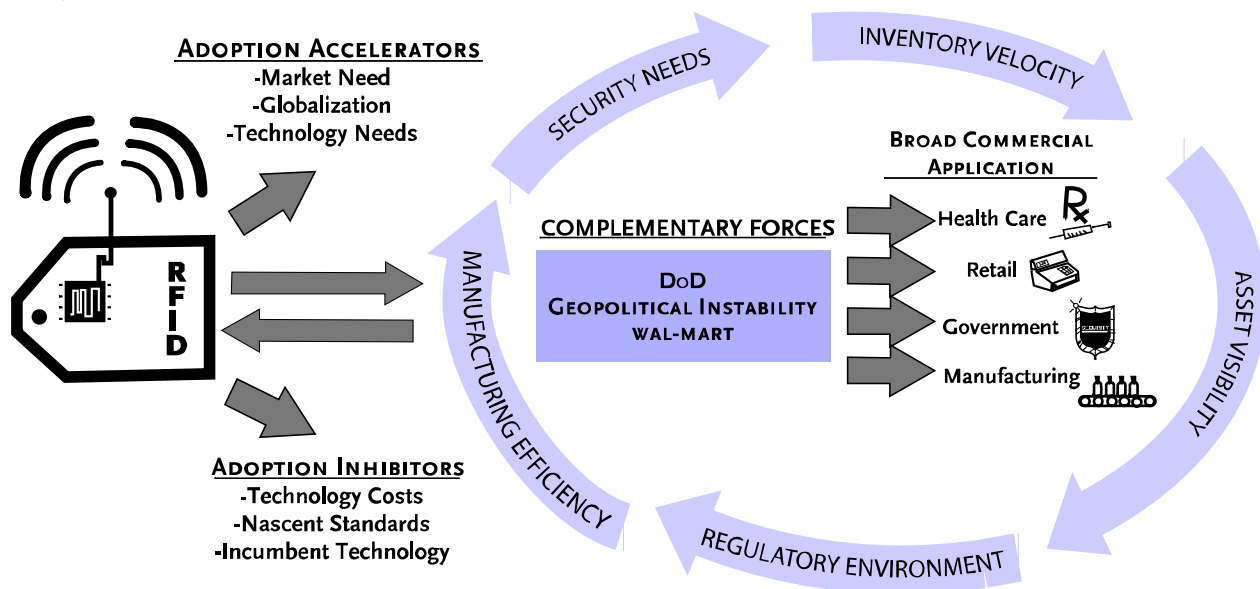
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Piper Jaffray RFID Adoption Model

While we acknowledge that a framework for evaluating RFID may not make for the most exciting conversation at the water cooler, we believe it is the only way to distinguish between RFID fact and fiction. Our goal in creating a framework was to keep it simple, functional, and broad enough to adjust with a rapidly shifting set of adoption variables. The diagram below summarizes our methodology for framing the RFID adoption rate. It provides a frame of reference when asking questions such as the following: What is the market need? Is the system open or proprietary? Are the standards evolved or embryonic? Is anyone pushing adoption?

Exhibit 5

PIPER JAFFRAY RFID MARKET FRAMEWORK



Source: Piper Jaffray & Co.

The four pillars of our Piper Jaffray RFID adoption model are: the underlying technology, a group of adoption accelerators, a set of adoption inhibitors, and a collection of complementary forces driving broader commercial adoption. Accelerating inventory velocity, the quest for real-time asset visibility, and increased manufacturing efficiency as well as heightened security concerns and an increasingly complex regulatory environment are creating a true market need for the technology. Thus, the question of whether RFID will occur has already been answered affirmatively, in our opinion. However, the question of when adoption will occur is central to investing in the space. We believe a deeper look within our adoption model should provide some answers and offer context to piecing together the RFID puzzle.

**State Of The Technology:** We believe three central questions need to be answered to gauge the "readiness" of broad-based use of RFID technology. *How disruptive is RFID to implement and apply? How reliable is the technology today? Can supply capacity accommodate hyperbolic growth in the near term?* Once these questions are understood, the foundation is set to look at adoption accelerators and inhibitors.

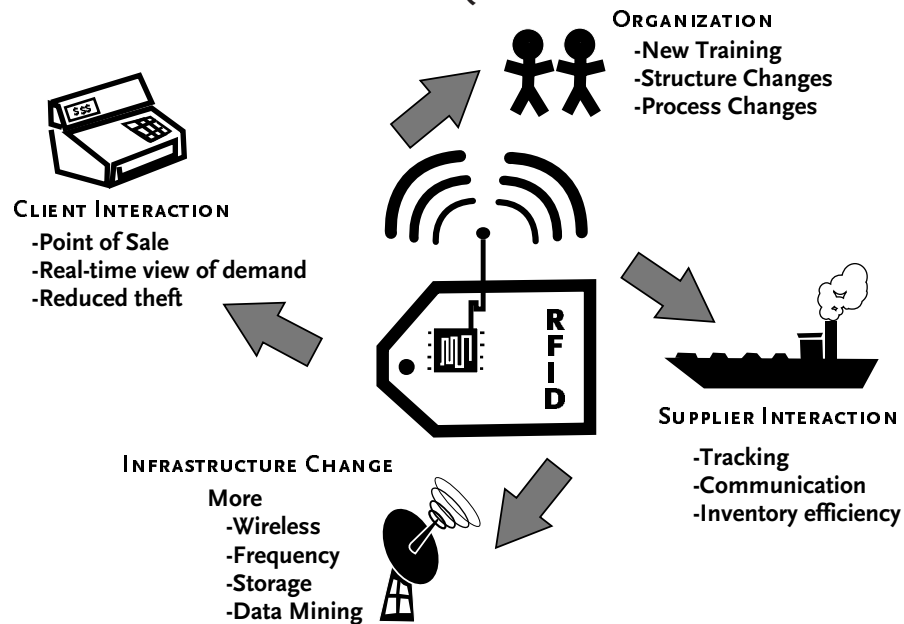
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RFID is sure to be a disruptive technology across the business value chain. We believe implementing companies will need to reconstruct interactions between suppliers and customers, evolve internal processes, make changes to organizational structure, and add significantly to IT infrastructure in order to harness the power of RFID. Tracking, ordering, and securing goods along the supply chain will move to a true real-time environment and redefine the meaning of *just in time*(JIT). Structural changes to internal organizations will be needed to accommodate RFID optimization. Comprehensive training will occur, work force composition changes will be made, and internal processes will be overhauled in order to reap the benefits promised by RFID implementation. IT will never be the same. Companies will need to build out wireless infrastructure, optimize the use of radio frequencies, bolster storage capacity, and overhaul data-mining applications. The beginning and intermediate steps will likely be painful but the longer-term benefits to all stakeholders will merit the pain, in our opinion.

Exhibit 6

### RFID-DISRUPTING THE STATUS QUO



Source: Piper Jaffray & Co.

The reliability and maturity of the technology are other factors influencing adoption. We believe a labyrinth of troubleshooting will occur during the early years of implementation. A lack of a reserved global RFID frequency, evolving standards, suboptimal system orientation, and a host of other unforeseen issues will arise as systems are fielded. Early optimization activities will likely focus around accuracy and speed. Because this merits a much deeper discussion, we devote an entire section to these points later in the report.

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**Near-Term Supply And Demand Equilibrium?**

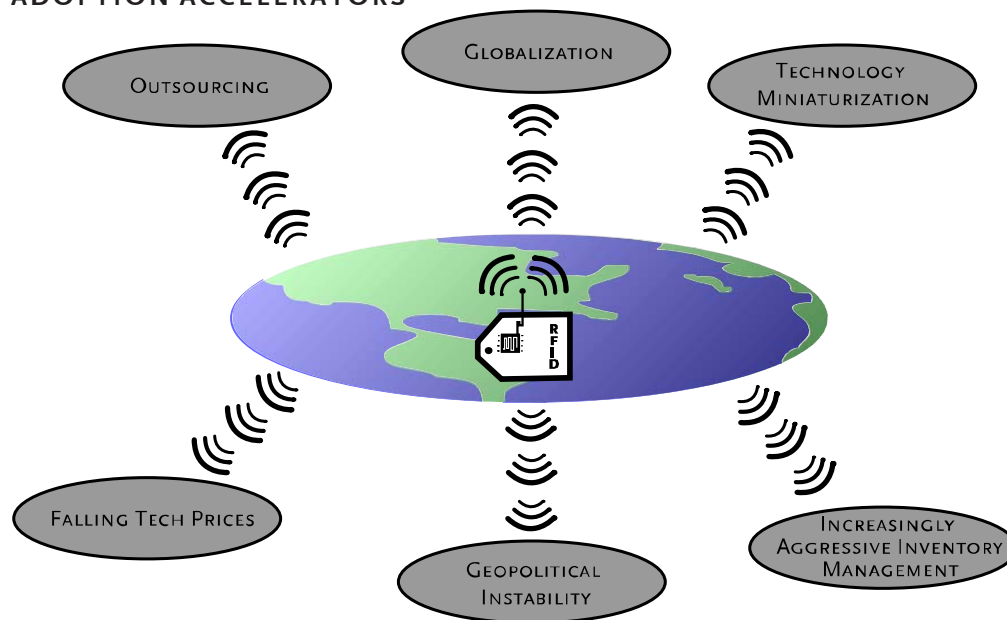
Another essential question remains as to how quickly low-cost, high-quality supply can ramp. We have seen many forecasts illustrating demand with a corresponding tag cost. While we agree that tag costs will be key to determining demand for RFID, we wonder if a short-term supply chasm could occur if tag prices drop quickly. With only a handful of suppliers, we believe some suppliers may have the ability and desire to be the low-cost provider up to a certain quantity with modestly higher-priced providers augmenting the demand. This ultimately could create a tiered pricing model that up to a certain chip volume price per tag is a nickel, then steps up to a dime, and so on. Over time, it is logical to assume the supply curve shifts and a higher quantity of low-price tags become available, resulting in a more efficient pricing environment.

**Six Trends Pushing the Adoption Accelerators**

We believe RFID adoption is being catalyzed by six major global trends. The forces of globalization, propensity to outsource, miniaturization of technology, heightened global instability, falling technology prices, and increasingly aggressive inventory management trump all the other trends driving RFID adoption. While a detailed explanation of these secular trends goes beyond the scope of this report, we believe their impact cannot be underestimated. The impact that globalization and outsourcing are having on the industry is too profound not to focus on, in our view. Without the frictionless flow of people and goods and the increased levels of outsourcing to create these goods, commercial RFID would remain a niche technology. Take these trends, add the continued ability to shrink technology, make it more powerful yet cheaper and widespread RFID use seems plausible. The final major adoption accelerator is business competition driving inventory efficiency. These factors give us confidence that mass RFID adoption will begin to happen within the next 18 months.

Exhibit 7

**ADOPTION ACCELERATORS**



Source: Piper Jaffray & Co.

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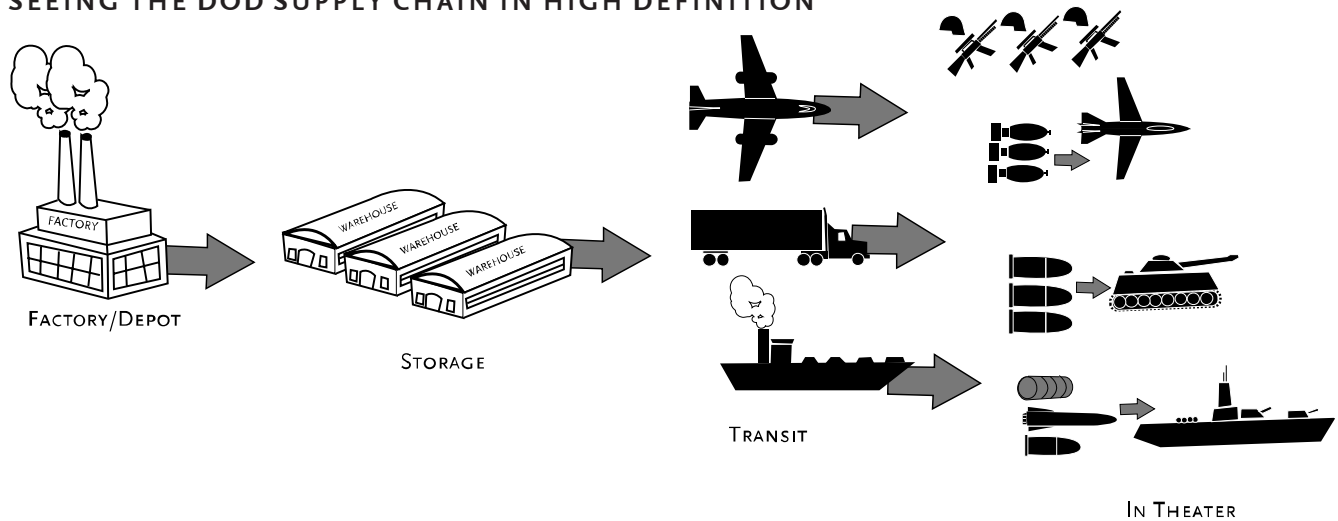
**The Seeds Of Adoption**

**DoD Gets Tagged**

Events have played a role in adoption. September 11 and its impact on driving transformation of the military have clearly accelerated the support for widespread RFID use by the DoD. The result has been the drive to a smaller, faster, and more lethal DoD. This cannot occur without sophisticated logistics processes. Pre-RFID, the DoD would spend thousands of hours determining where pallets were and opening pallets once they arrived to see what was inside. Savi, through a comprehensive network of active RFID tags, has helped the deployed armed forces to lever logistics as a strategic weapon.

Exhibit 8

**SEEING THE DOD SUPPLY CHAIN IN HIGH DEFINITION**



Source: Piper Jaffray & Co.

**The Wal-Mart Effect**

The quest to lever inventory as a strategic weapon is another trend driving RFID that was punctuated with an exclamation point when Wal-Mart announced its RFID mandate to its top 100 suppliers. A push to reduced cash conversion cycles, more efficient inventory management, theft reduction, stockout diminution, and a better real-time look at consumer behaviors are the quantifiable benefits to the mandate. The "me too" phenomenon is kicking in with other retailers aggressively making RFID plans. Security applications are emerging. Regulated industries, such as health care, are beginning to automate and more will follow.

The last mile of commercializing the technology is inevitably a long road. Questions about cost arise. Production capabilities are stressed. The fog of "real" use of the technology versus scripted test environments predictably creates more challenges. We view RFID as a system of hardware, software, and services. Advances are being made on all fronts. More reliable hardware is becoming available, higher-scale production facilities are being erected, increased storage capacity is accessible, enhanced software applications are emerging, and other technology advances are occurring. All are critical to converting the RFID holdouts into RFID adopters.

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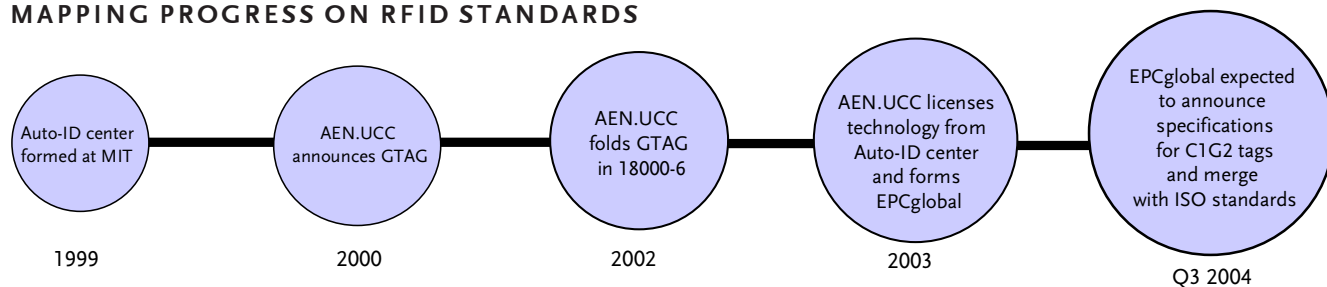
**Adoption Inhibitors**

The major adoption inhibitors are tag costs, evolving standards, and an incumbent technology that is "good enough" in many instances. Nothing receives more attention than the cost of the tags. This is the single largest determinant to adoption of RFID, in our opinion. Costs are declining quickly. This is a bit like the cliché: which came first—the chicken or the egg? Tags are a business of scale; so without scale, pricing cannot come down. Conversely, without price reductions, demand cannot ramp. We expect that tag prices will continue declining. In the near future, nickel tags will be available. We explore the relationship of price and demand in more detail later in the report.

Standards also play an integral part of the adoption equation and have been viscous to date. MIT, in collaboration with industry, was instrumental in bringing vendors and end users together to test next-generation auto ID technologies. The next step was made in late 2003 when the MIT Auto-ID center transferred power to EPCglobal, a joint venture between EAN and UCC. Both EAN and UCC have proven track records in managing standards globally. Progress is being made on next-generation standards. We will explore the key milestones to make the technology broadly usable in a later section.

Exhibit 9

**MAPPING PROGRESS ON RFID STANDARDS**



Source: Piper Jaffray & Co.

Resistance to change will be another impediment that RFID will overcome during the next few years. Companies are familiar with using barcode technology. Systems have been built around the use of barcodes. Some argue that barcodes are essentially free. Others say the human cost of barcodes exceeds a nickel per label. That makes sense, but we believe the larger cost is the opportunity cost of not using RFID. RFID clearly has advantages over barcode systems. Superior storage capability, read-write functionality, durability, and non-line-of-sight reading capabilities are among the key advantages of RFID. As tag prices approach the cost of barcodes, justifying the use of barcodes will become increasingly difficult. This is another area we will expand in a later section.

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Exhibit 10

**COMPARING ALTERNATIVE TECHNOLOGIES**

<b>Attribute</b>	<b>RFID</b>	<b>Barcode</b>	<b>OCR</b>	<b>SmartCard</b>
Cost	High	Low	High	High
Data Storage	High	Low	Medium	High
Form Factor	Small	Small	Medium	Large
Multiple Simultaneous Reads	Yes	No	No	No
Dynamic Data Update	Yes	No	No	Yes
Security and Authentication	High	Low	Low	High
Access Mechanism	NLOS	LOS(optical)	LOS(optical)	NLOS

Source: Piper Jaffray & Co.

Complementary Forces

Sometimes higher forces align to drive technology adoption. This is one of those cases, in our eyes. DoD and Wal-Mart have mandated that companies desiring to do business with them will need to be RFID-enabled. This is a huge endorsement given the size and buying power of these two organizations. Wal-Mart generates more than \$250 billion in annual sales with 22% gross margin. The DoD has 80,000 suppliers and its budget exceeds \$400 billion annually. Companies will rush to support these initiatives, in our opinion. This, in turn, will be an accelerator for broader adoption.





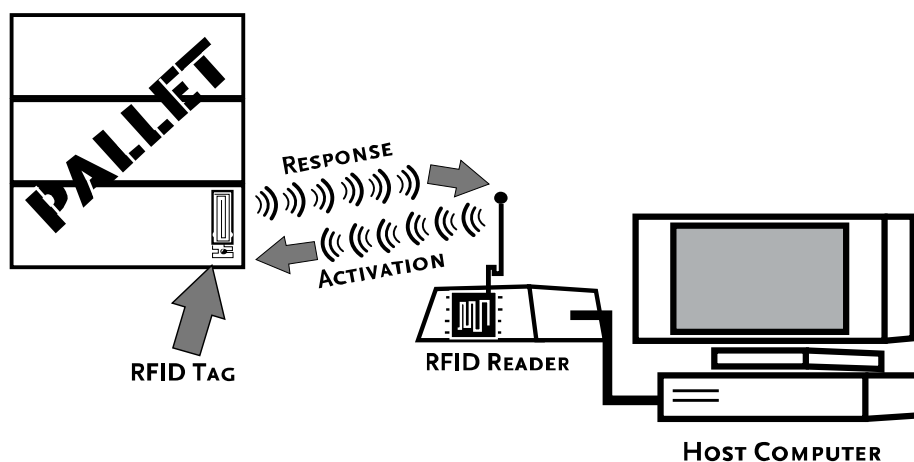
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### RFID Anatomy

A basic RFID system has three basic components: RFID tags, a reader, and a host computer system that runs software to manage information generated by the movement of tagged objects. Tags are attached to the items to be tracked or identified. An RFID tag has a silicon integrated circuit (IC) and an antenna attached to a substrate. The chip is coded with identification or any other information related to the item. When a tag comes across a reader, it is activated by the radio frequency waves from the reader and transmits the identification information stored on the chip. The reader captures this information and passes it to a host computer for further processing.

Exhibit 11

#### GENERIC RFID SYSTEM EXAMPLE



Source: Piper Jaffray & Co.

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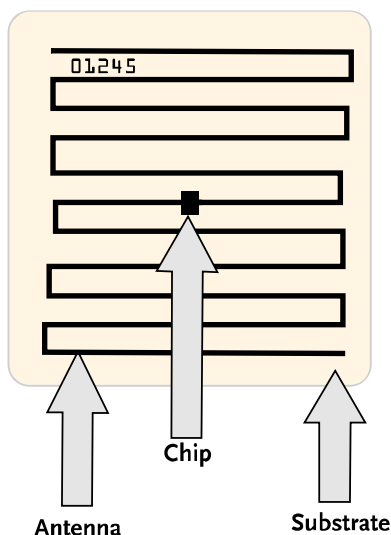
Tags—Nanocomputers  
Of RFID

RFID tags store information about the item they are attached to. Information generally pertains to identification information; supply-chain information such as attributes, source, destination, and route; and possibly other special parameters. Recall that major advantages of RFID tags versus previous automated ID technology are its memory size, programability, and ability to access it through non-line-of-sight means. Matrics, for example, released a 288-bit read-write tag in March 2004.

RFID tags are composed of three components: chip, antenna, and the substrate. The chip and the antenna reside on the substrate, which can either be a rigid or a flexible material. The antenna is usually a metallic or metal-based material deposited on the substrate by etching, printing, or other means. The chip is a silicon-integrated circuit (IC) electrically attached to the antenna. Together these three components form an inlay. The inlay is generally attached to paper forming a multipurpose tag.

Exhibit 12

**RF TAG ILLUSTRATION**



Source: Piper Jaffray & Co.

Tags are either *passive* or *active* depending on their power supply. Passive tags do not have self-sustained power but receive power from a signal sent by a scanner. Consequently, passive tags transmit data solely when "awakened" by a scanner/reader. Conversely, active tags receive power to transmit their RF signal from a self-contained battery. Active tags periodically transmit data similar to a beacon and are generally used in applications requiring a strong RF signal due to absorption or other concerns. Passive tags tend to be less expensive than their active counterparts.

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Exhibit 13

**ACTIVE VERSUS PASSIVE TAGS**

	<b>Active Tags</b>	<b>Passive Tags</b>
Power	Battery Powered	Powered by the scanner
Range	Longer Read Range (25-100 ft)	Shorter Read range (few inches to few feet)
Cost	Expensive (\$10-\$70)	Cheaper (roughly \$0.50)
Durability	Life limited by battery life	More durable
Data Rate	High	Low
Data Transmission	Periodically transmit data	Transmit data only when activated
Data Storage	Larger	Smaller
Application Example	Continuous area monitoring	Pallet/Case tagging

Source: Piper Jaffray & Co.

Between the two types lies an intermediate type of tag called Battery Assisted Passive tag or BAP. As the name indicates, these are passive tags with batteries. The battery on the tag can be used for powering extra memory or for auxiliary devices such as temperature sensors and biochemical detectors attached to the tag. A BAP does not have a transmitter as an active tag does.

Tags can be classified further based on capabilities such as the ability to write to and the ability to communicate with other tags. EPCglobal has defined a classification based on tag capabilities. This classification is discussed later in the report.

The ability to write to a tag offers great flexibility and offers greater value to the users. Here are a few examples.

- Different customers may require different information programmed into the tags. A distributor can easily meet this requirement with a read-write tag rather than with a read-only tag. With a read-only tag, distributors would have to maintain inventory of tags for individual customers.
- Companies could supplement identification information on tags with more information that could help in recall management. Supplement information such as ship date and time, lot number of individual components, etc., could help in making the recalls more targeted.
- The chain of custody for controlled and hazardous substances could be maintained on the RFID tags. As the material travels, the received and shipped time can be recorded on the RFID tag. This could be used to satisfy requirements of agencies like the DOT, OSHA and the FDA.

Depending on the application, tags can be used either in a disposable manner or as a means for permanent identification. Permanent tags are used for applications in which codes or smart labels cannot be used due to extreme environmental conditions. These tags are encased in protective material to shield them from the environment.

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## Readers—Gatekeepers Of The Network

Readers are used to read information from the RFID tags. RFID scanners activate a tag by sending an RF signal. Common methods of data transfer rely on the principles of inductive coupling or backscatter modulation. Once activated, the chip transmits the information stored on it. The scanner reads this information, decodes it, and passes it on to the host computer. Since RF signals do not require line of sight to travel, there are many more placement options available for the scanners. Readers may be fixed, handheld, or PCMCIA cards.

**Fixed Readers:** The RFID market may be the only market where small, handheld units will not be the most popular reading devices. *We expect fixed readers will be more popular in security and supply-chain applications during our forecast period. Only through fixed readers can the objective of humanless commerce and frictionless security be met.* Fixed readers can be mounted on doors, forklifts, conveyor belts, or any other place through which there is a high traffic of goods. This type of fixed configuration enables automatic identification of packages as they pass through the vicinity of the scanner. Fixed readers are similar to a gatekeeper that records the movement of all tagged items in its vicinity. Fixed readers may have different configurations depending on the application. A fixed reader mounted on a massive door may have multiple antennas so that it can capture data for all directions while a reader mounted on a conveyor belt may have just one antenna pointing toward the conveyor.

Exhibit 14

### READER EXAMPLE



Source: Alien Technology Corporation

**Handheld:** Handheld scanners are used in a fashion akin to the portable barcode scanners—to read individual tagged items. Handheld readers typically have shorter read and write range as they can be brought in close proximity to the tag. Another issue with the hand-held reader is that since RF does not require line of sight, a reader can potentially scan the tag it does not intend to scan.

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Exhibit 15

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### HANDHELD READER



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Source: Intermec, Inc.

**PCMCIA:** PCMCIA cards are used to augment the capability of existing platforms to read RFID data. There is a significant installed base of handheld computers that are used for barcode applications. To protect the investment in the current installed base, the legacy handheld computers can be upgraded by adding a PCMCIA RFID card. We believe that the PCMCIA cards will be used as stopgap measures to protect the current investment.

Exhibit 16

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### PCMCIA READER



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Source: Intermec, Inc.

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What's In A Smart Label

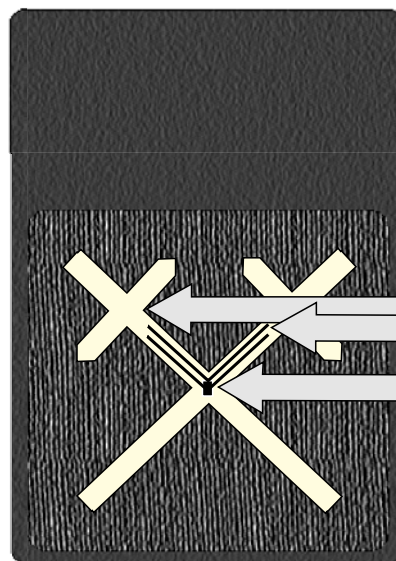
The use of RF tags ushers in an era of smart labels. Smart labels are paper-thin labels with an RFID tag embedded in them. Typically these labels are embedded with an RFID chip to complement the barcode and human readable information printed on them. These labels are called smart because of the additional functionality and flexibility provided by the RFID tags. In many cases, these labels can be updated in the field multiple times and can be reused for multiple needs and applications. Smart labels provide dynamic capabilities as opposed to a barcode or text labels, which provide more static capabilities.

Exhibit 17

SMART LABEL WITH MATRICS TAG



LABEL FRONT



LABEL BACK

Source: Matrics, Inc.

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Printers—Making Labels Smart

Smart-label printers print barcodes and other information on the label and at the same time program information on the RFID tag. RFID printers are often called encoders because of their ability to write to the chip. These printers use label stocks that have RFID tags sandwiched between the face stock and the adhesive layer. Zebra is the domestic leader in the barcode print market. The company spends nearly 6% of sales on R&D and not surprisingly has introduced a couple of RFID printers with substantial potential, in our view. Zebra RFID printers contain the functionality to determine whether a label needs an RFID tag, or just a straight barcode label. If a tag is needed, the printer selects the label stock with the tags and encodes it. If not, Zebra printers print a cheaper barcode label. *This type of functionality will be essential during the early rollout phase of RFID given our belief that many client companies will continue shipping products that contain both smart labels as well as traditional barcode labels.*

Exhibit 18

SMART-LABEL PRINTER



Source: Zebra Technologies Corporation

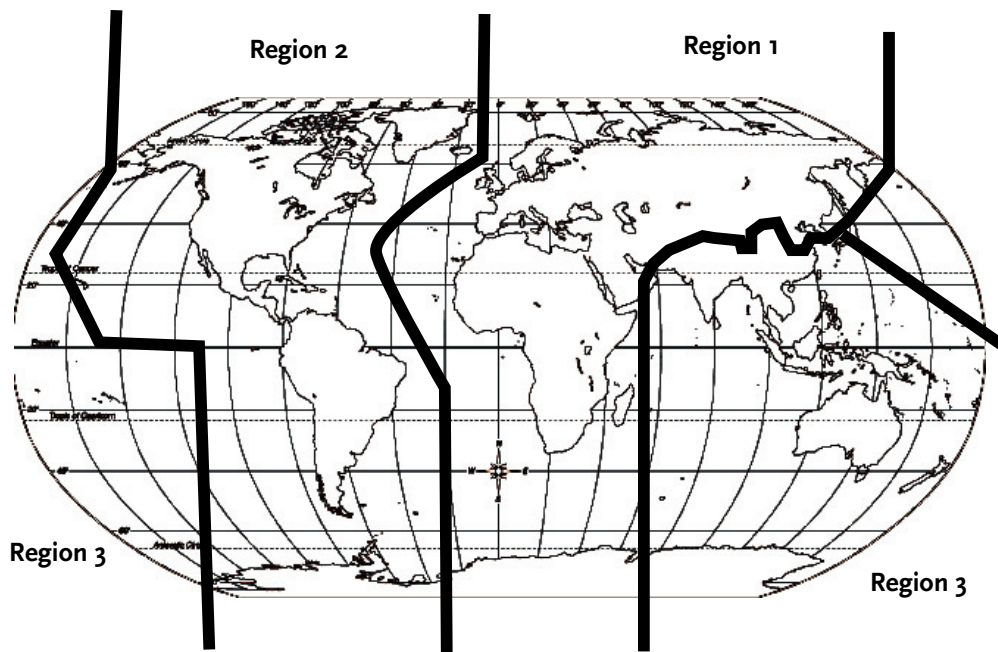
Frequency Spectrum—Being On The Same Wavelength

**Frequency Regions:** Communication between the tag and the reader must occur at common frequency. Unfortunately, there is no uniformity in the use of radio spectrum across the world and every country manages its own spectrum largely driven by the requirements of local users and industries. In addition to creating a barrier for seamless global trade, this lack of uniformity results in non-interoperable communication systems across the world and higher implementation and operating costs. In order to inject some consistency, the world has been divided into three regions, and countries within each region are expected to implement plans for that region by 2010.

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Exhibit 19

**GLOBAL FREQUENCY REGIONS**



- Region 1 Europe and Africa
- Region 2 North and South America
- Region 3 Asia-Pacific and Australia

Source: Piper Jaffray & Co.

In general, the radio spectrum can be divided into three ranges. Each frequency range has its own advantages and disadvantages and the selection of a frequency range depends mostly on the application. Lower frequencies have a lower data rate and a smaller range as compared to higher frequencies. Power consumption is also generally lower at lower frequencies than at higher frequencies. Another differentiating feature among higher and lower frequencies is the signal attenuation—as the frequency of an RF system rises, the ability of RF waves to penetrate different material decreases.

Exhibit 20

**RFID SYSTEM ATTRIBUTES AT VARYING FREQUENCIES**

	100-500 KHz	10 -15 MHz	850-950 MHz,2.4-5.8GHz
Transmission Range	Short to Medium	Short to medium	Medium to Long
Data Rate	Low	Medium	High
Penetration	High thru non-metals	Medium	Low penetration
Power Requirement	Low	Medium	High
Cost	Low	Potentially low	High
Noise Immunity	Low	Low	High

Source: Piper Jaffray & Co.





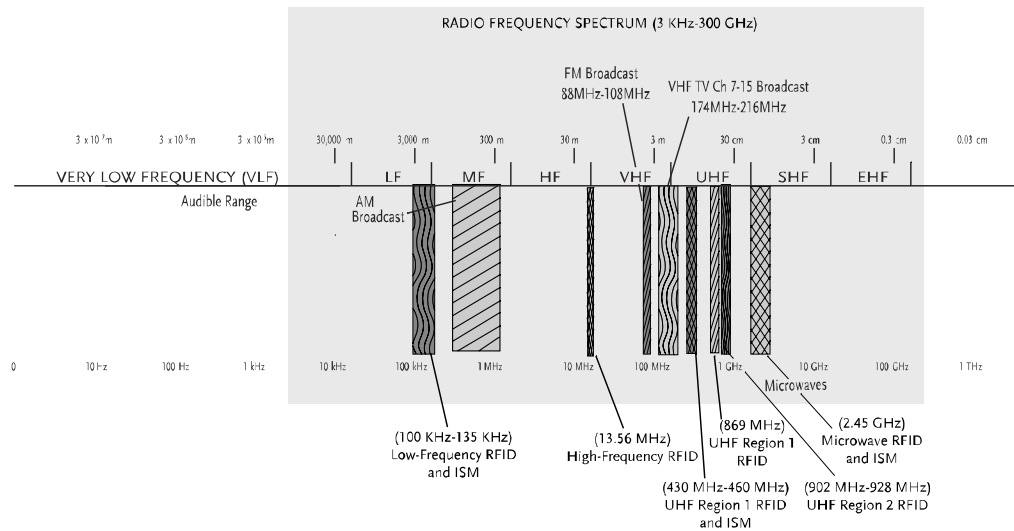
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Fine-Tuning The RFID Frequency Selection

RFID tags generally operate in unlicensed frequency range due to cost advantages. Though there are many carrier frequencies around the world for RFID applications, the most talked about are: low frequency (LF) - 125KHz to 134.5 KHz, high frequency (HF) - 13.56 MHz, ultra-high frequency (UHF) - 869 to 915 MHz, and microwave - 2.45GHz. These frequency designations are different from the frequency bands discussed in the earlier section.

Exhibit 21

RFID BAND ALLOCATIONS



Source: Piper Jaffray & Co.

**Low Frequency (LF):** These tags operate at 125KHz and typically have a range between three and four feet. Low frequency tags are best suited for applications that need RF waves to penetrate through different material. Such applications include animal identification, access control, and vehicle immobilization. In most countries, transponders operating in this band are not required to be licensed.

**High Frequency (HF):** These tags operate at 13.56 MHz and have range between three and six feet. This frequency band is available globally as an unlicensed ISM (industrial, scientific, and medical) band. Since the operating frequency of these tags is higher, they have a higher data rate of approximately 106K bits. Higher clock speed also enables the integration of a microprocessor and security features such as cryptology. Typical applications include Electronic Article Surveillance (EAS) in the retail industry, smart cards, and item tracking.

**Ultra-High Frequency (UHF):** These tags operate in the range of 400MHz and 1GHz, depending on the geographical location. In region 1, the frequency range is between 430 and 460 MHz and at 869 MHz. In region 2, principally North America and South America, the frequency range is between 902 and 928 MHz. Lack of a common frequency range across region 1 and region 2 complicates communication between the two regions. Due to the high frequency, tags in this frequency band have a higher data rate and a range of nearly seven feet. Therefore the tags are most suited for supply-chain applications. On the flip side, the tags in this frequency band consume more power and often require design innovations when dealing with non-RF-friendly materials such as liquids and metals.



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**Microwave Frequency:** The tags in this band operate in the range of 2.35GHz and 2.45 GHz. Microwave ovens also operate in this range. Microwave ovens use magnetrons and high-power radiators, and the radiating frequency of these devices varies with the temperature. This randomly varying frequency interferes with common communication devices and renders the band useless for regular communications. However, many short-range applications that can withstand interference from microwave ovens have been assigned this band, the most notable being 802.11b WLAN (Wi-Fi). RFID can also work in this band. Due to high power requirements, active tags are often used in this frequency band.

Exhibit 22

**RFID FREQUENCY BANDS**

Description	Frequency Range	Read Range	Applications
Low Frequency(LF)	125-134 KHz	Up to 18 in	Animal tagging, Access Control
High Frequency(HF)	13.553 - 13.567 MHz	3-10 ft	EAS, Smart Cards
Ultra-High Frequency(UHF)	400MHz - 1GHz	10-30 ft	Supply Chain
Microwave	2.45 GHz	10 ft-plus	Specialize Applications

Source: Piper Jaffray & Co.

**Critical RFID Performance Metrics**

Our research indicates that the most important RFID system performance variables to implementing companies are accuracy, throughput, and range. Clearly, there are other factors that affect purchase decisions including tag durability, memory size, and more, but we believe accuracy, throughput, and range represent the outer layers of the onion when firms implement RFID systems.

**Accuracy:** The benchmark for read accuracy exceeds 99% given the high volume and rapid velocity of items flowing in RFID systems. Environmental factors, orientation sensitivity, and the RFID system design are the major aspects affecting accuracy. *An added bonus of RFID is that human error can often be removed from the process, whereas human intervention is necessary with barcode systems.*

**Throughput:** Speed requirements will vary depending on the application. For example, an assembly line RFID implementation would likely require much faster read-rates than a high-end retail application at the point of sale. To give an order of magnitude of speed, Matrics' tags are designed to be read in a typical environment at rates of 200 tags per second. Read rates are governed in large part by the frequency used and the communication protocols between the tags and readers.

**Range:** Customer range requirements also vary substantially depending on application. Again, the notional conveyor system in a warehouse may have a requirement for 5 to 10 foot read ranges. Conversely, an RFID system used to track animals may require read ranges of 1-2 feet with substantial durability. Frequency is the largest contributor to a passive RFID systems range. The general rule of thumb is that as frequency rises, the read range will rise. Range is much less of a constraining factor with active RFID systems given their self-contained power sources.



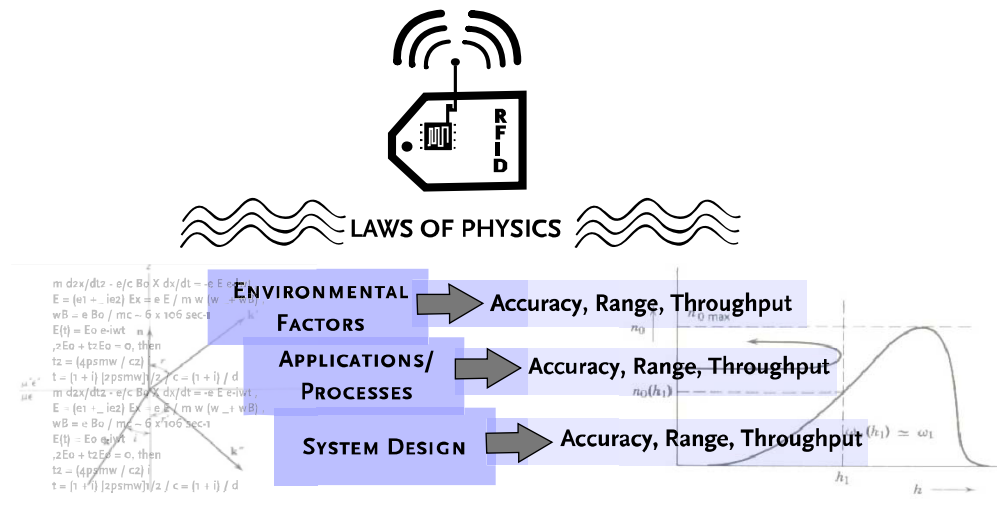
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The ART Of Performance Zen

Several factors impact the performance of an RFID system. While there are many factors affecting performance—most notably the laws of physics—we believe the two major variables affecting performance include environmental elements and system design factors. When a careful system design is matched with an appropriate RFID application, we believe Accuracy, Range, and Throughput will be maximized.

Exhibit 23

ACHIEVING RFID PERFORMANCE ZEN



Source: Piper Jaffray & Co.

**Environmental Elements:** Interference from metals and RF noise can degrade the performance of an RFID signal. Metals and liquids tend to absorb RF waves. This is often mitigated through antenna design and/or by applying a buffer between the tag and the hostile material. Noise from other systems communicating within the designated frequency range is another environmental consideration that can affect range, speed, and accuracy. Most problems with both types of interference issues can be addressed through a thoughtful systems design. Optimizing the selection of tags, readers, and frequency of use is the chief factor affecting interference.

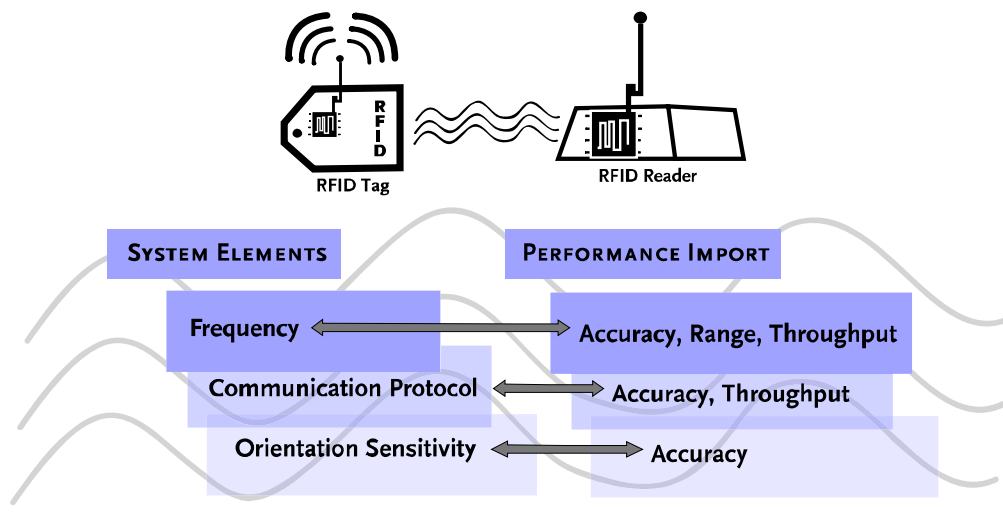
**Systems Design:** Not surprisingly, RFID systems design plays the crucial role in determining overall performance. While the complexity of systems design (and a discussion of the laws of physics) far exceeds the scope of this piece, we thought it would be relevant to mention a few central design considerations focused on the interaction between the tag and reader. As we have discussed in some detail, frequency is a large determinant of range and speed. It also plays a major role in the ability of RF waves to penetrate RF hostile materials such as water and metal. Communications protocol between tag and reader affects throughput and accuracy. Orientation sensitivity is largely a factor between antenna design of tags and antenna deployment of readers. This will determine in large part the read accuracy of tags passing through the interrogation zone in a different manner (vertically, horizontally, etc). When the system is designed well for orientation sensitivity, speed and accuracy will be optimized for a given application. This provides greater flexibility to the package and product designers in tag placement options and eliminates the need of human intervention for aligning the packages or scanning the tags.

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Exhibit 24

**TAG TO READER DESIGN CONSIDERATIONS—A 30,000 FOOT VIEW**



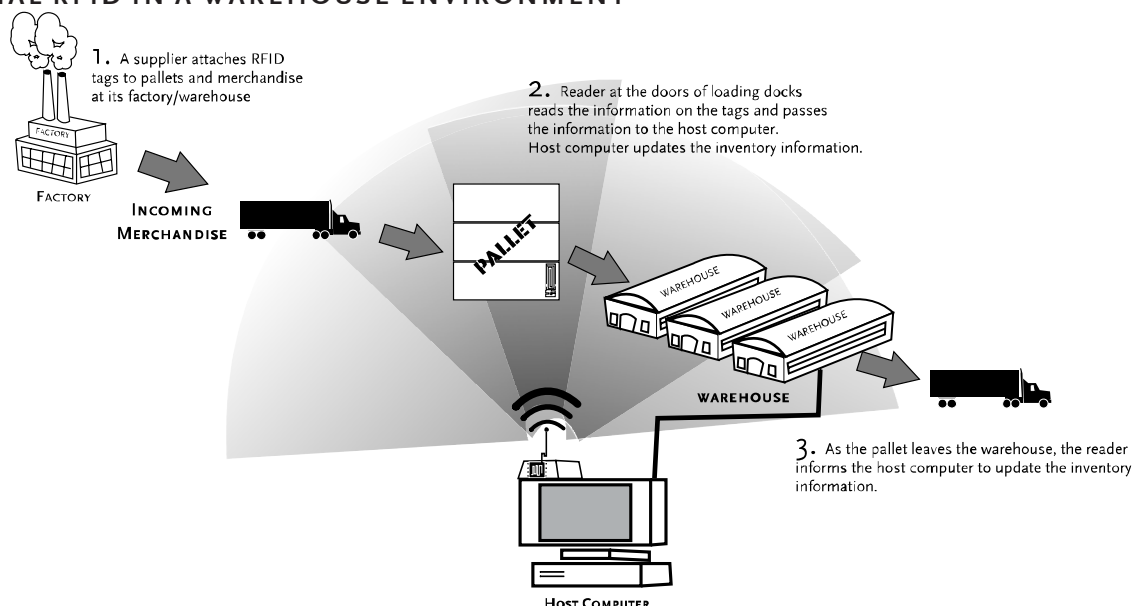
Source: Piper Jaffray & Co.

**Notional RFID Example**

An example of such a system is a warehouse. RFID readers are installed at various points in the warehouse. As the goods enter the warehouse, the readers capture the information on RFID tags attached to the pallets without contact and line of sight. This information is passed to a database that updates the quantity and location of the pallets. Similarly, as the pallets leave the warehouse, the information is updated. The automatic update improves efficiency by removing the need to manually update the inventory information and provides better visibility into the supply chain by providing complete and real-time information.

Exhibit 25

**NOTIONAL RFID IN A WAREHOUSE ENVIRONMENT**



Source: Piper Jaffray & Co.



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### The RFID Market

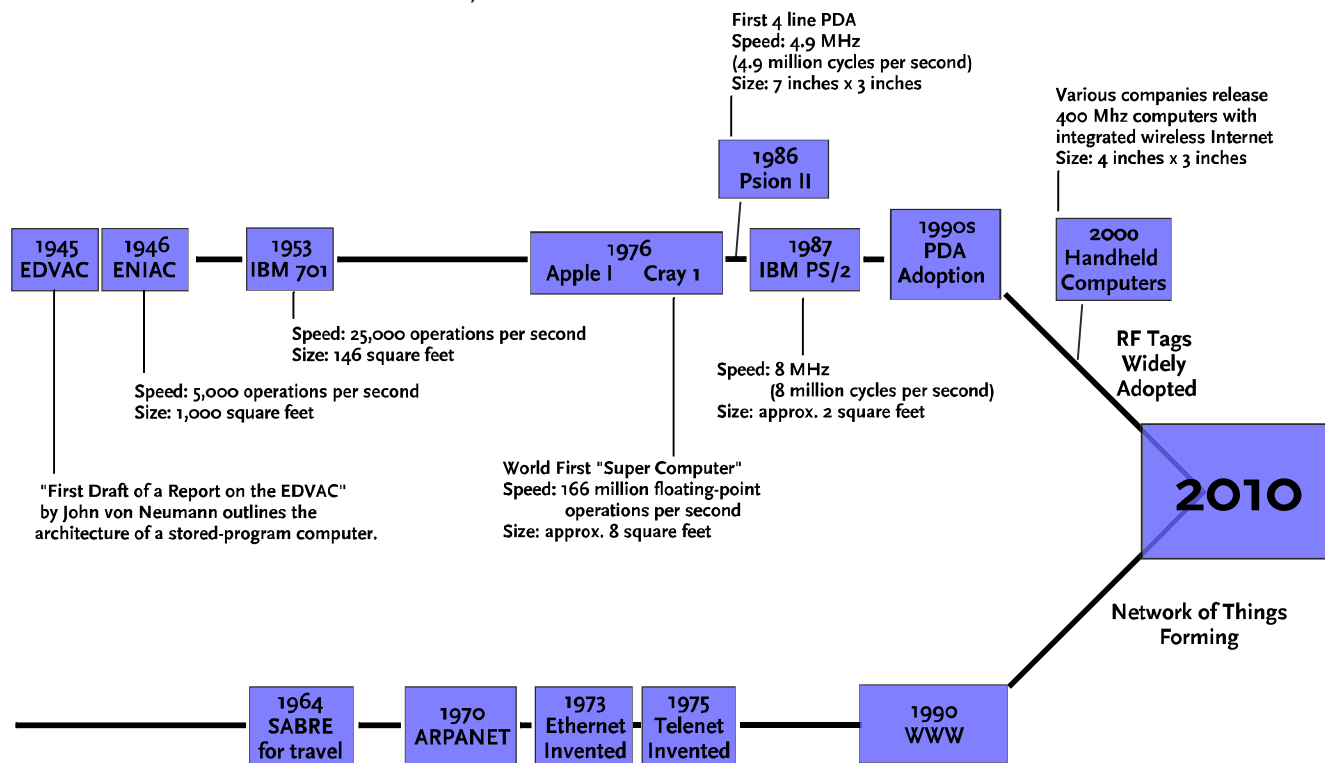
#### Powerful Global Trends Pulling RFID To The Market

We believe that globalization/outsourcing, a propensity toward just-in-time inventory management, advances in miniaturization and other technologies, and a growing ability to effectively mine scores of data are making the "old way" of managing inventory obsolete. In addition to these broad global trends, a handful of heavy spenders are pulling RFID technology into their IT infrastructure as quickly as possible while others are being dragged to adopt in order to keep up with the technology leaders. Either way, we believe both the "by choice" or "no choice" adopters of RFID will rapidly see the benefits of employing the next-generation automatic ID technology and extending their network reach. Current technologies are more than 30 years old, labor-intensive, and fairly limited in communication abilities.

Not only does it seem that the world is getting smaller, but technology footprints seem to be shrinking equally fast. The notion that technology miniaturization is making technology better, cheaper and, most importantly, smaller has provided a backdrop for the RFID industry to take off. From the machine credited with being the first computer in the 1940s to the rise of supercomputers in the 1970s followed by PCs and PDAs, computer footprints are shrinking while computer use is increasing. We believe the RF tags are the next step in the progression. Whether or not people subscribe to Metcalfe's Law, most agree that the value of the network increases as its user base increases. Thus, while the number of people carrying devices limited previous networks, the so-called "Internet of Things" removes that limitation. *In other words, the "Internet of Things" extends the reach of the network from people to include objects carrying silicon, and we believe we will begin to see this form within the next decade.*

Exhibit 26

### THE SMALLER COMPUTERS GET, THE BIGGER THEY BECOME



Source: Piper Jaffray & Co.

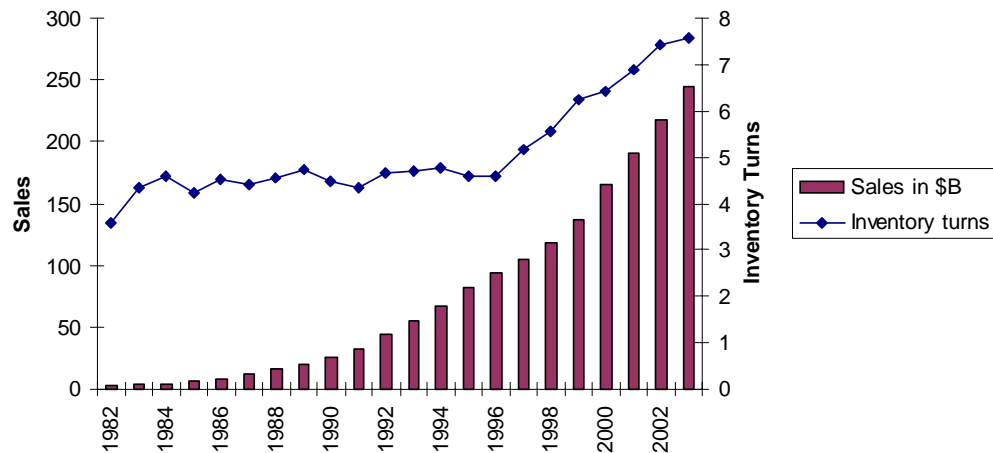
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The military was compelled to adopt RFID because previous logistics processes were too inefficient and often limited its abilities. Successful retailers have also been on the bleeding edge of adoption. To accelerate cash-conversion cycles, just-in-time inventory has moved from just a topic at leading business schools to a practice implemented widely by many leading manufacturers globally. No one company highlights this point better than Wal-Mart, in our opinion. Wal-Mart has doubled inventory turns since the early 1980s. During the same period, its supply chain increased in complexity and size. Not surprisingly, Wal-Mart is leading the charge to RFID adoption, mandating its suppliers to begin arming cases and pallets with RF tags. While nobody knows the answer, one could surmise that Wal-Mart needs to deploy "next-generation" technology like RFID to keep inventory turns on the increase.

Exhibit 27

### WAL-MART TURNS



Piper Jaffray & Co. and Company reports

**Security:** Security agencies need an economical, practical, and secure means to track and identify a vast number of instruments and constituents of terrorism. The number of objects that need to be tracked require the use of a completely automated solution. For example, U.S. airlines handles 1.2 million luggage pieces daily and 14 million containers arrive at U.S. seaports annually. In addition, more than 450 million people enter the United States each year. Government programs using smart cards are beginning to be deployed to track foreign visitors. This use of smart cards will grow substantially over the next decade.

**Supply Chain And Material Handling:** Companies are looking at ways to squeeze costs out of their supply chain and increase visibility into their supply chain. This is driven by hypercompetition in certain industries, especially in logistics and retail. Another contributing factor is the globalization and rapid expansion of distribution networks. As distribution networks expand and the volume of items in supply chains increases, companies have realized that an optimized supply chain can tremendously boost both the top and bottom lines. Current technologies have been fully exploited and additional gains can only be realized by using next-generation technologies.



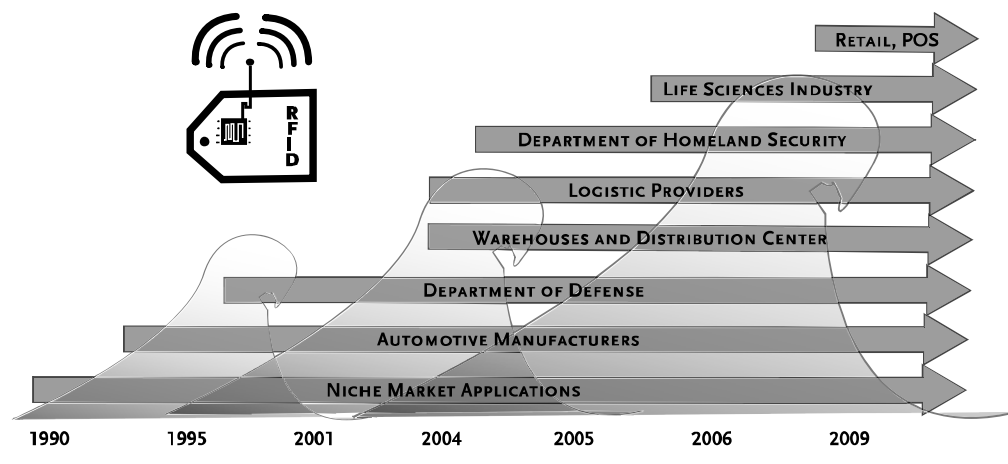
April 2004

RFID Goes Deep Into Many Vertical Markets

The largest market adopters over the next four years will be the DoD and various links in the retail supply chain. At the same time, despite the fact that so many RFID discussions are polarized to these two vertical markets, we believe the technology will have much broader applications. The Wal-Mart initiative and DoD's mandate to its suppliers have certainly grabbed headlines, but we believe many other industries will adopt RFID aggressively during our forecast period. Other verticals also playing a substantial role in our RFID forecast include the life-sciences market and diversified manufacturers. We expect the majority of RFID implementations will concentrate on security, tracking items (parts and people) in the supply chain, tracking items (spare parts or parcels) for customer service, and controlling access. Each of the major markets we are forecasting is discussed in more detail below.

Exhibit 28

WAVES OF RFID ADOPTION



Source: Piper Jaffray & Co.

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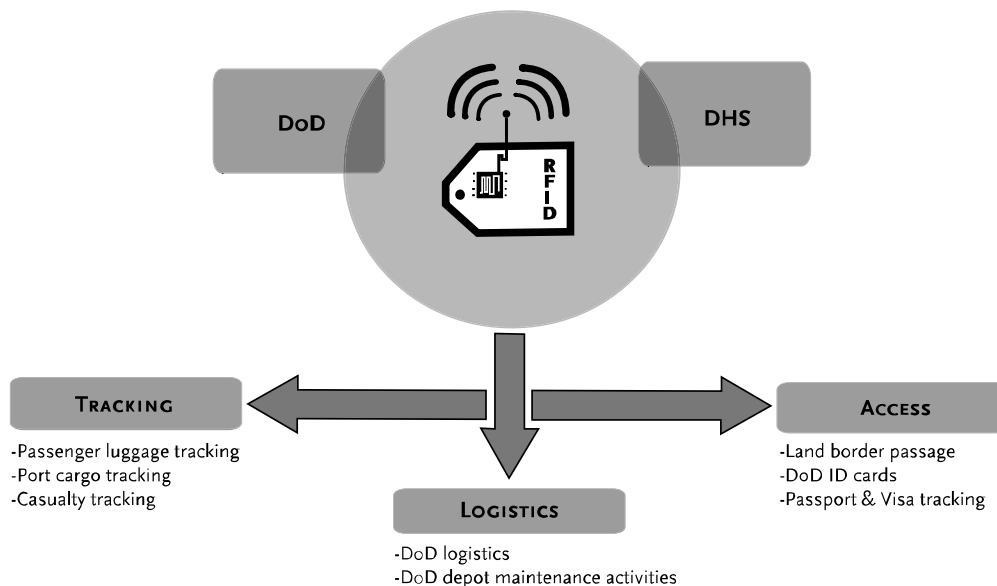
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The Government Wave Of RFID Is Here

The most aggressive adopters of RFID technology in the government will be the DoD and the Department of Homeland Security. These two agencies have collective budget authority approximating \$450 billion annually and have many problems that can be partially solved via RFID technology. Over time we expect to see more government agencies adopt RFID; but given tight budgets across most civil agencies, we believe DoD and DHS are the primary adopters during our forecast period.

Exhibit 29

UNPLUGGING THE GOVERNMENT RFID OPPORTUNITY



Source: Piper Jaffray & Co.

timlee11

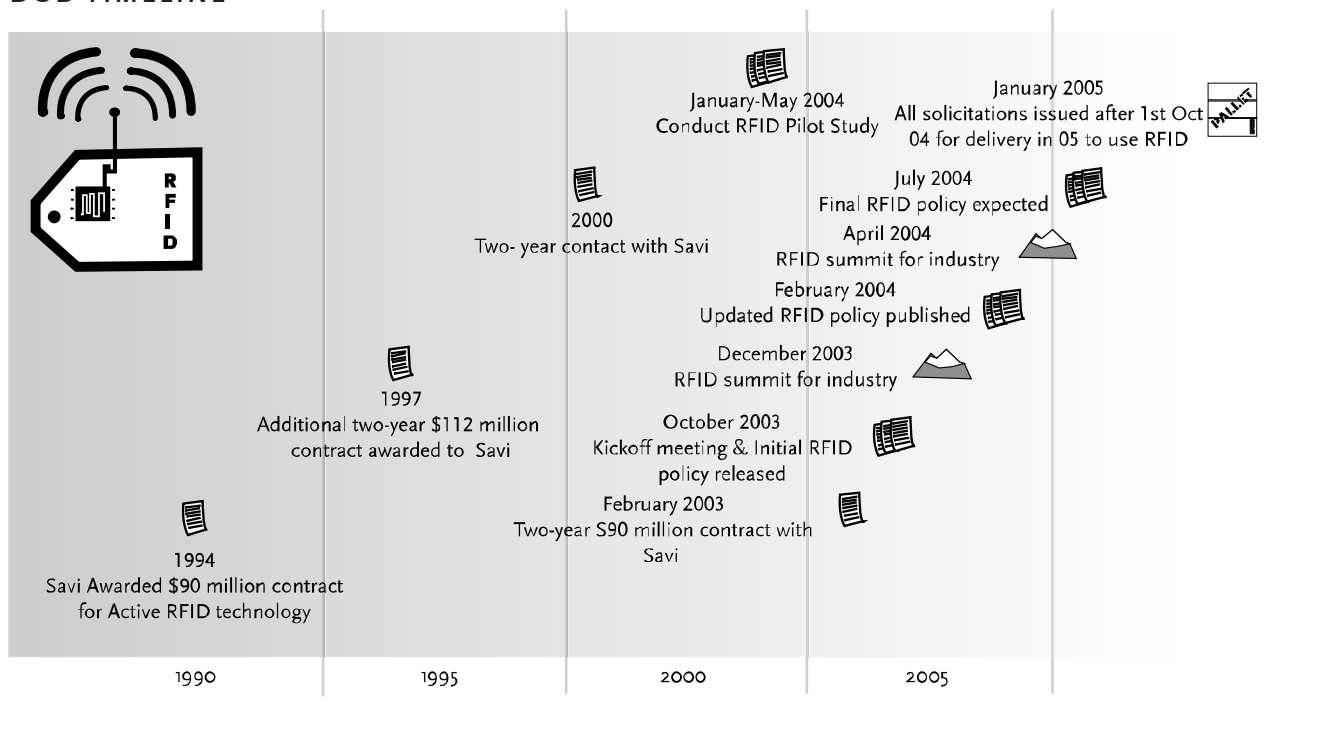


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Early DoD applications will focus on improving efficiency in its logistics process or its supply chain. There is no other organization in the world that has a more complicated supply chain than the DoD. Success and failure of this chain can mean the difference between life and death. The DoD has been experimenting with the technology for more than a decade and by many accounts has invested well over \$100 million during this time period battle testing it in Iraq, Afghanistan, Bosnia, and other places around the world. In 2003, the DoD announced a mandate that its 80,000 suppliers would need to begin utilizing RFID technology during the years 2005-2010. *The DoD spends close to \$100 billion annually on a broad set of logistics tasks. This will be one of the largest opportunities for RFID vendors through the end of the decade.*

Exhibit 30

DOD TIMELINE



Source: Piper Jaffray & Co.

DoD applications will blend active and passive RFID along with other identification technologies in its solutions set implementations. *Savi has been a leading provider enabling the DoD to see its logistic channels in high definition.* One key program, Total Asset Visibility, was hatched out of logistics problems encountered during Operation Desert Storm. This program uses Savi active RFID tags and infrastructure along with other technology to track food, bullets, and other equipment in more than 45 countries. Many other applications have been piloted by the DoD as well. This could be a pivotal technology to speed critical maintenance on field equipment such as HUMVEES, tanks, aircraft, and so on, although some discretion would be needed for items in the field to ensure that covert status is maintained. The Navy, for example, tested RFID technology to track casualties during conflicts. Some believe this pilot could lead to a "smart dog tag" for soldiers that could transmit items such as name, serial number, blood type, allergies, unit, and other information critical during wartime.

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The Department of Homeland Security will also employ RFID technology over the near and intermediate term to improve security. DHS has a budget of roughly \$40 billion annually and will likely begin to accelerate the use of RFID technology at key border points. State and local government, airlines, and logistics providers often augment DHS funds to get systems fielded. Airport security, port security, and land-border crossings will be the most significant areas that will deploy RFID technology.

At airports, there are several programs at various stages to begin tagging passenger luggage. *Matrics is leading a passive tag program at the nation's seventh busiest airport, McCarran International, Las Vegas.* McCarran will deploy Matrics' tags and readers to track luggage from passenger check-in, through security screening, and onto the plane. Delta Airlines is pursuing a pilot to improve security and reduce lost baggage as well. We believe these will be the two seed projects that stimulate others to follow on the checked luggage side. Over time and if privacy concerns can be overcome, smart boarding passes could emerge. RFID is promising in other airport venues as well, including airport employees, runway security, and other perimeter initiatives. RFID is being deployed at land-border crossings to speed commerce at the U.S./Mexican border. Seaport security is being pursued aggressively. DHS and shippers are testing RFID technology as a way to track the more than 38,000 containers that enter U.S. ports each day.

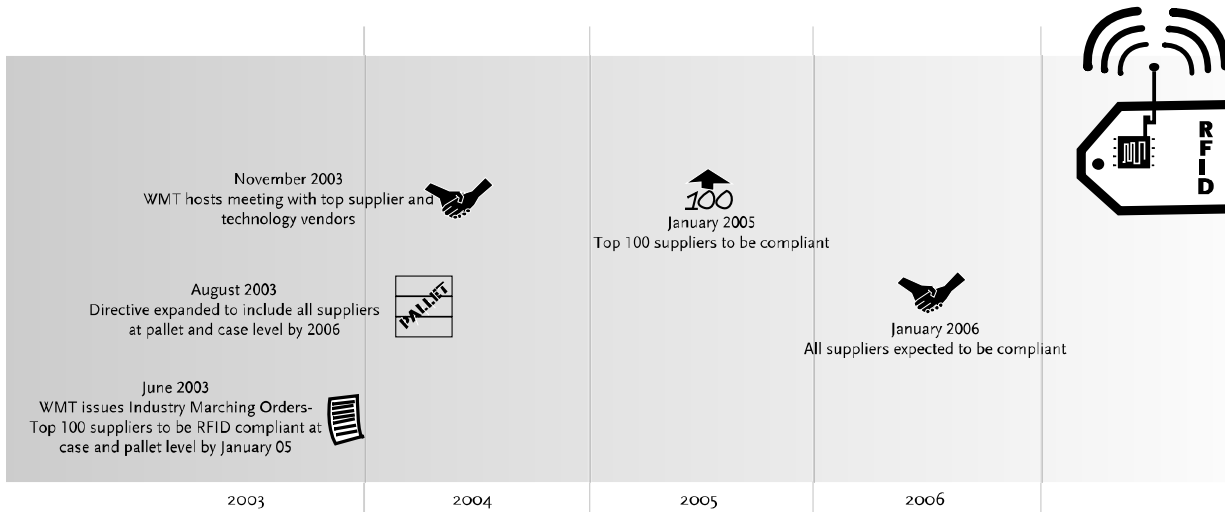
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Retail—A Look At The Shot Heard Around The World

As we have discussed, Wal-Mart is driving its suppliers to use RFID technology in 2005. Those directly involved are the 100 or so top suppliers that pedal substantial product volume through Wal-Mart outlets. But the aftershock is hitting competitors of Wal-Mart that do not want to concede any more competitive advantages to the Arkansas retailer, such as Best Buy, Target, their suppliers, and more.

Exhibit 31

WAL-MART RFID ADOPTION TIMELINE



Source: Piper Jaffray & Co.

Retailers will likely be one of the most significant beneficiaries of the RFID technology. We believe the major spending on RFID technology during our forecast period will be the suppliers to these superstores, but over time the big retailers will spend at increasing levels to mine the data and bring the technology into the store front. The efficiency gains along the supply chain should reduce headcount requirements, reduce stock outs, reduce human errors, increase supply-chain velocity, and improve inventory efficiency across the board. *One of the larger-than-life examples of a consumer package goods utilizing RFID is Gillette's partnership with Alien to purchase up to 500 million RFID tags.*

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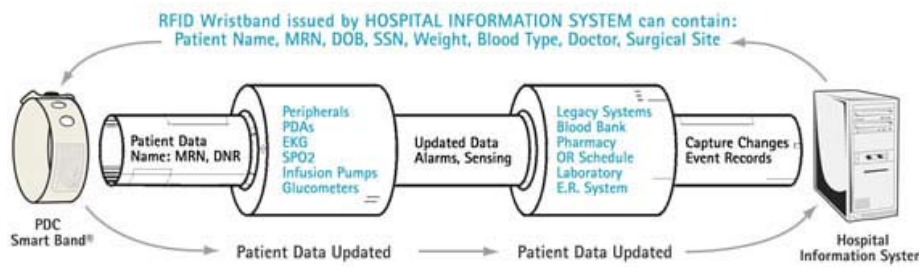
Life Sciences—A Patient RFID Wave Is Coming

Hospitals and medical organizations will be major adopters of RFID over the next few years. RFID can provide nontransferable positive patient identification in order to reduce major medical errors that are common today. Experts estimate that between 44,000 and 98,000 deaths occur annually due to medical errors. Patient and specimen misidentification are the leading contributors to the deaths due to medical errors. Besides tragic loss of life, it is estimated that these errors cost the industry more than a billion dollars per year.

Other applications likely to find their way into hospitals are RFID-enabled smart cards, patient wristbands, and RFID tracking systems for medication and medical devices. Smart cards would grant area privileges and access to employees based on job role and tenure. Patient wristbands will enable hospitals to track patient data during a hospital stay. The current mechanism of cross-checking patient data using a paper trail or barcode technology is error-prone and too people-intensive. RFID systems could also be employed to ensure that restricted medications are treated appropriately. Another use could be to track the location of critical operating equipment. While we are optimistic that the potential uses of RFID in the health care setting are extremely large, we believe the market will take longer to develop than many of the other markets in our forecast.

Exhibit 32

HOSPITAL DEVICES



Source: Precision Dynamics Corporation

SIDEBAR - FDA MANDATES

In February of this year, the FDA issued guidelines for the pharmaceutical industry to protect against counterfeit drugs using RFID. The FDA wants drug makers, distributors, and pharmacists to adopt the new technology by 2007. Though these guidelines are not mandatory, the pharmaceutical industry has indicated its willingness to adopt the technology by 2007.

RFID tags will be attached to the drug packages at point of origin with manufacturer information and other related data as date of manufacture. As the package moves down the supply chain, additional information will be added to the tag. This information can be used at every point in the supply chain to authenticate the legitimacy of the drug.

Though U.S. drug supply is generally secure, concern about drug safety is on the rise, triggered mainly by two high-profile cases in 2003 involving Pfizer's blockbuster cholesterol drug Lipitor and Amgen's anemia drug Procrit, used often by cancer and AIDS patients. According to the FDA, open investigations related to drug counterfeit cases in the United States have increased fourfold from around five in the late '90s to little more than 20 in 2003.



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Transportation And Logistics—Riding The RFID Wave

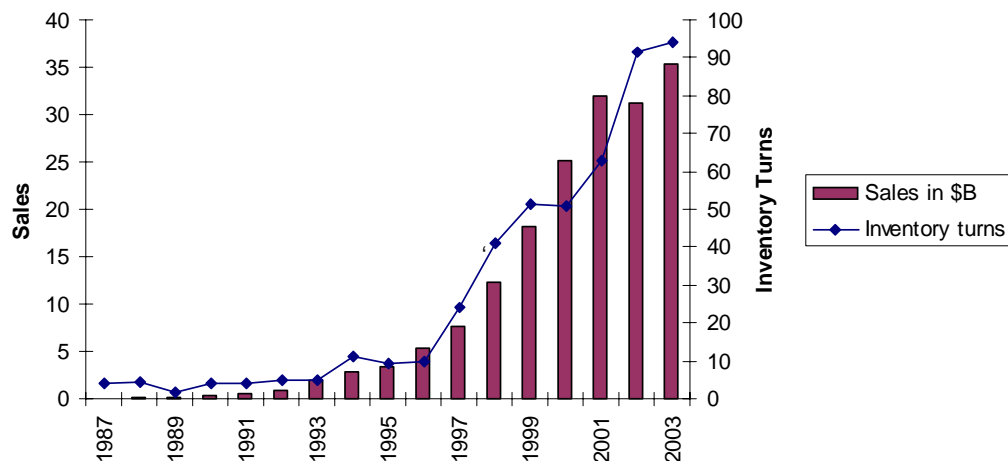
Logistics companies are looking for means to improve the throughput of the goods sorting process. It is during the sorting process that packages are placed in different conveyors and bins based on the destination. If the throughput of the sorting process can be increased, the logistic companies will be able to ship more packages and also delay the pickup time. The additional revenue will tremendously boost the bottom line, as very little variable costs will be incurred for the additional packages.

Manufacturing

Manufacturers are faced with intense pressure to cut costs and improve quality along with the increasing need to offer customized products to a larger and global, but increasingly fragmented, base of customers. Customers are increasingly demanding more customized products, and this is causing manufacturers to incorporate many options in the products or produce products in various configurations. Cars and personal computers are the most common examples of these customized products. The ability to manage inventory with increasing sales and product variety is a critical success factor as illustrated by computer maker Dell.

Exhibit 33

DELL SALES AND INVENTORY



Source: Piper Jaffray & Co. and company reports

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*April 2004*

Manufacturers have been one of the early adopters of technology, although not at a very large scale. RFID has been a panacea for manufacturers. The technology has helped manufacturers to implement just-in-time (JIT) inventory management systems by providing greater visibility in the supply chain. Accurate data related to inventory stock, in-process inventory, shipping status and date, exact location of inventory, etc., can be gathered in seconds, literally by a mouse click.

RFID has helped manufacturers to improve quality and implement increasingly complex manufacturing runs resulting from the trend toward mass customization. For example, RFID tags can be used to record all of the steps performed and parts added on an item as it passes through the assembly line. As an item passes through the assembly line, a reader attached at every assembly station reads the RFID information and based on that information automatically instructs the assembly-line worker about the parts to be added or operations to be performed. This not only cuts down errors but saves time as the operator does not have to spend time in determining which parts should be added and which operations have to be performed on the item.

#### **SIDEBAR - FORD AND ESCORT MEMORY SYSTEMS**

Ford used RFID at its Cuautitlan, Mexico facility to cut down on errors and costs in its truck production operations. Escort Memory Systems (EMS) of Scotts Valley, CA was selected to help Ford with the technology implementation.

Ford had a manual coding system involving paper identification sheets for tracking truck and auto frames as they made their way through the final assembly, paint, and body shop areas of the production line. These paper tracking sheets were being lost, misplaced, destroyed, and even worse, getting switched in the manufacturing process. This made the quality control difficult and costly. For example, a switch in tracking sheets can result in a car or truck being painted the wrong color.

The RFID solution provided by EMS proved to be very effective for tracking and routing auto bodies through the production line. An RFID tag was attached to the vehicle skid and programmed with a coded number that indicated the operations needed to be performed on the vehicle. Information such as vehicle color and interior trim could be gathered from the coded number. As each operation is completed, the coded number is updated in the RFID tag and this ensures that operations are not performed twice. At the end of the production line, the RFID tag can be checked to make sure all steps have been performed and nothing is missing.

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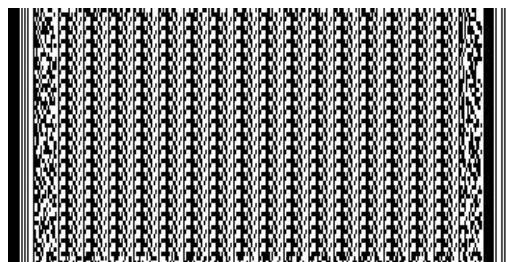
**RFID Versus The Incumbent Auto-ID Solutions**

Barcodes are the most prevalent current automatic identification solution. Other solutions include smart cards and optical character recognition. Barcode technology is simple and fairly inexpensive if the human costs are not included in the cost calculation. A major advantage barcodes have is that many supply-chain infrastructures are built to optimize barcodes. Major drawbacks include limited memory space, a predisposition to human error, and a lack of security features.

**Barcode:** Barcode consists of a field of bars and white gaps of varying widths arranged in a parallel fashion and can be found on most packaged goods bought in supermarkets. This pattern of black and white spaces, coupled with their width, represents numerical or alphanumeric data. Barcode patterns can be printed easily on plain paper, thermal paper, or any other kind of surface such as metal or plastic. The codes are read using laser scanners, which use the reflection of a laser beam from the black and white barcode to encode the data.

Exhibit 34

**BARCODE ILLUSTRATION**



2-dimensional barcode



1-dimensional barcode

Source: Piper Jaffray & Co.

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**Optical Character Recognition:** Optical character recognition (OCR) technologies can read data printed in human readable form. The data is optically scanned into a computer and special software translates the image into data that can be used for further processing. This technology was invented in the 1960s and is still widely used, especially in document management and banking applications. Almost all bank checks are processed using OCR.

OCR has a few significant advantages over other auto-ID technologies. Data can be read visually in emergencies or at the time of system failure. In addition, data density is higher than barcode although less than RFID. Disadvantages include high price and complex technology implementation.

Exhibit 35

**OPTICAL CHARACTER RECOGNITION EXAMPLE**

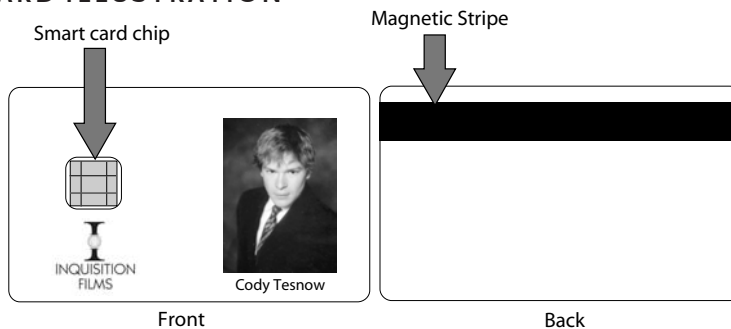
PART NUMBER	DEHC 7890-30-1
VENDOR	Knowall Tech. Inc.
DATE OF MFG	01-23-2004
DESCRIPTION	Handheld computer Grey ver. 1

Source: Piper Jaffray & Co.

**Smart Cards:** While smart cards have been in circulation for some time, use of smart cards is accelerating post-9/11. Smart cards are plastic cards, similar to credit cards, with memory for data storage and an optional microprocessor for computing capabilities. The gadgetry on the card makes the cards extremely secure against unauthorized access and manipulation. Due to their security features, smart cards are chiefly used for secure applications such as financial transactions and access control. Prior to September 11, and even today, Europe remains ahead of the United States in terms of smart card use. Smart cards have been widely adopted in secure applications although the form factor and relatively high cost have limited the use of the cards in other applications. These barriers are falling, opening the door for broader use.

Exhibit 36

**SMART CARD ILLUSTRATION**



Source: Piper Jaffray & Co.

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**RFID Value Proposition  
(Cost And Benefits)**

RFID is the most pressing hands-free automatic identification solution that has the potential to deliver read rates consistently near the 100% level to varied vertical markets, in our opinion. The technology offers the ability to scan multiple items simultaneously using a non-line-of-sight mechanism. This capability will create tremendous value by reducing operating costs and increasing revenue opportunities in addition to improving quality and reducing shrinkage. In addition, the technology provides economical solutions to critical problems such as container security and authentication of documents and articles.

**Benefits Over Existing Solutions:** The current solution suffers from many drawbacks, most notable is the inability to store large amounts of data, dynamically update data in fields, and scan multiple items simultaneously without human intervention. Barcodes are economical but cannot store large amounts of data. Optical character recognition can store a slightly larger amount of data as compared to barcodes but the technology is expensive and complicated. Both barcode and OCR require line of sight to function and are highly susceptible to environmental conditions. Neither of these solutions offer any significant level of security against tempering and forgery. Another limitation of the current solution is the lack of ability to dynamically and automatically update the stored data.

Exhibit 37

**RFID VERSUS OTHER TECHNOLOGIES**

<b>Attribute</b>	<b>RFID</b>	<b>Barcode</b>	<b>OCR</b>	<b>Smart Card</b>
Cost	High	Low	High	High
Data Storage	High	Low	Medium	High
Form Factor	Small	Small	Medium	Large
Multiple Simultaneous Reads	Yes	No	No	No
Dynamic Data Update	Yes	No	No	Yes
Security and Authentication	High	Low	Low	High
Access Mechanism	NLOS	LOS(optical)	LOS(optical)	NLOS

Source: Piper Jaffray & Co.

RFID combines the advantages of all the existing automatic identification technologies while eliminating the disadvantages. RFID enables simultaneous reading of multiple tags through non-line-of-sight mechanisms. RFID tags can store a large amount of data, which can be updated automatically and dynamically. RFID offers a higher level of security features for data protection.

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**RFID: The Next Big Wave Of Technology Spending**

We believe that RFID will be one of the fastest-growing major technology markets for much of the rest of the decade. The market needs the technology. Big spenders are committed to buying RFID solutions. New companies and incumbent companies are rapidly innovating to meet the demand. Costs are falling. Supply is ramping. Quality is improving. And word is spreading.

Market Size

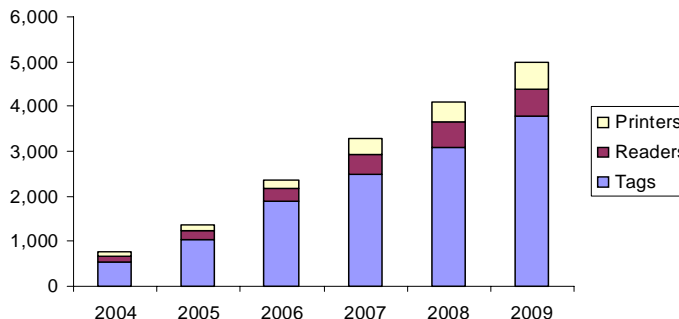
We forecast that the U.S. RFID hardware market, composed of tags, readers, and printers, will grow from \$742 million in 2004 to nearly \$5 billion in 2009 at a CAGR of 41%. We expect tags will form the major chunk of the market with sales rising from \$544 million in 2004 to nearly \$3.8 billion in 2009 at a CAGR of 42%. We estimate printers will grow from a mere \$86 million in 2004 to \$580 million in 2009 at a CAGR of 42%. We project readers will grow from \$113 million in 2004 to \$624 million in 2009 at a CAGR of 36%.

Exhibit 38

**PIPER JAFFRAY U.S. RFID HARDWARE MARKET FORECAST**

	2004	2005	2006	2007	2008	2009
Tags	544	1,055	1,904	2,499	3,102	3,779
Readers	113	164	265	444	555	624
Printers	86	140	209	340	444	580
<b>Total</b>	<b>742</b>	<b>1,359</b>	<b>2,379</b>	<b>3,283</b>	<b>4,102</b>	<b>4,983</b>

**U.S. RFID Hardware Market in \$ Million**



Source: Piper Jaffray & Co.



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Segmenting The RFID Vendor Field

We divide the RFID vendor field into three broad categories including start-up companies, incumbents supply chain technology vendors, and divisions of larger companies that want to leverage existing technology portfolios or channel relationships to break into the new market. Each of the companies in our broad categories brings advantages and disadvantages to the table. When the dust settles, we expect to see a handful of successes emerge from each category and a lengthy list of failures from each category.

Exhibit 39

**RFID VENDOR LANDSCAPE**

CATEGORY	EXAMPLE	COMPETITIVE ADVANTAGES	COMPETITIVE CHALLENGES
<b>START-UPS</b>	<b>ALIEN, MATRICS, SAVI, WHERENET, ESCORT MEMORY</b>	<b>STRONGEST TECHNOLOGY, AND ONLY RFID PURE PLAYS</b>	<b>FUNDING AND SIZE</b>
<b>INCUMBENT TECH PROVIDER</b>	<b>ZBRA, SBL, CKP, PTNX, UNA, PXR, AVY</b>	<b>BRAND AND CUSTOMER/CHANNEL RELATIONSHIPS</b>	<b>EXECUTION AND GENERAL R&amp;D INVESTMENT RATES</b>
<b>DIVISIONS OF LARGE COMPANIES</b>	<b>TEXAS INSTRUMENTS, PHILIPS</b>	<b>SIZE AND SCALE</b>	<b>END MARKET KNOWLEDGE AND POTENTIAL CULTURE CLASH</b>

Source: Piper Jaffray & Co.

**Start-Up Companies:** These are the only current RFID pure plays in existence. Examples in this category include Alien Technology, Matrics, SaviTechnology, Oat Systems, WhereNet, Escort Memory Systems, and others. And while today most are privately funded, we believe a small group of these names will make the transition to the public markets. These companies' chief competitive advantage is their technical acumen. Many are perceived as the pioneers of the modern RFID business.

We believe this group's pure focus on RFID and generally much higher ratio of engineers to marketers often give this group the edge on the innovation side. Not coincidentally, we have seen a group of start-ups win big deals with blue chip clients including Matrics with International Paper, Alien with Gillette, Savi with the DoD, and more. We believe the innovation and focus compel these large players to ink multiyear deals with a relatively young group of companies. The primary disadvantages these names face are funding, and to a lesser extent, perception. Being privately funded, these companies have to constantly focus on getting additional funding to ramp up production and staff capabilities; admittedly, the appetite for a good RFID business plan appears to be very robust. The other disadvantage is perception. We use this term loosely but we generally believe that big



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companies want to have infrastructure solutions provided by other big players. The good news is that both of these disadvantages just seem to be minor speed bumps in the progression of the RFID upstarts' growth cycle.

**Incumbent Solutions Providers:** These are not pure-plays and generally have RFID-related sales below the 10% of total sales mark. This category includes players who are entrenched in the incumbent auto-identification technology markets such as barcode and OCR. The most notable examples include Zebra Technologies, Symbol Technologies, Checkpoint Systems, Paxar, and UNOVA/Intermec. These companies tend to generate the majority of sales via printers, readers, and labels that rely on barcode or other legacy auto-ID technologies.

Exhibit 4o

**RFID HARDWARE COMPANY COMPS**

Ticker	Price (4/22/04)	Market Cap. (\$ mil.)	CY03 Sales (\$ mil.)	CY04 Sales(E) (\$ mil.)	EV/CY05 sales(E)	P/E 05(E)
ZBRA	75.88	3,605	536	611	4.6	29.3
UNA	19.13	1,157	1,145	1,192	0.8	21.7
CKP	16.73	628	723	746	0.8	14.7
SBL	13.46	3,112	1,507	1,726	1.5	19.5
PXR	15.67	613	712	763	0.6	12.8
PTNX	14.14	82	128	134	0.4	11.4

Source: Company reports, Piper Jaffray and First Call estimates

This group's chief competitive advantage stems from three general sources: its brand, customer relationships/industry knowledge, and established sales channels. Chief concerns making the transition for this group pertain to execution and an often slower rate of innovation than the start-ups. Execution will be key because these companies will be faced with defending their core business while investing in the disruptive technology, RFID, that is cannibalizing their existing business. There will be a level of self-cannibalization, which we believe is necessary for this group to grow its businesses. Slower rates of innovation are natural with larger companies, but some companies are investing heavily to keep innovation high. Most notably, is Zebra. Zebra invests roughly 6% of total sales in R&D and has \$400 million in cash that we believe the company will deploy to acquire RFID-related technology.

**Divisions Of Large Companies:** Again, this group will generally have an even smaller component of sales (well below 5% of total sales) generated by RFID products. These are companies that have competencies in RFID-related technologies and have spawned divisions to attack the market. The most notable examples include Texas Instruments and Philips Semiconductors. Both of these companies have significant experience in RF and semiconductor technologies and are leveraging these competencies to break into a lucrative market. In addition to this group's technological expertise, these companies are flush with capital and can outspend most of their competitors. Disadvantages include less familiarization with the end markets served and potentially some difficulty maintaining intellectual capital within the non-core divisions.

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Tags—The Silicon  
Razor Blades Of RFID

Tags are the consumables in the RFID market and form the largest chunk of the market. They are often disposable, creating a recurring revenue stream. Ironically, even tags that are not disposable are often misplaced, creating a predictable base of recurring sales as well. Tags are a critical product because we believe tags orders are the leading indicator for additional spending on RFID in other software, hardware, and service areas. Tags also form the foundation for the overall RFID solution. Alien Technology, Matrics and Texas Instruments are the leading passive tag vendors. Savi is the leading active tag manufacturer. The long pole in the tent of tag production has been attaching antennas to chips. Innovations to increase speed and accuracy while reducing costs are happening rapidly. *Matrics' PICA method and Alien's Fluidic Self Assembly technology are two such potential manufacturing alternatives that hold promise versus more common flip-chip assembly processes.*

**Growth Drivers:** The primary growth driver for the tag is the price. During most of 2003, tags were priced north of \$0.50. At the time of this publication, tags are generally pricing between \$0.20 and \$0.50 depending on volume. The industry march to nickel tags seems to be the magic number that turns the lights on to full unit-level RFID adoption. We believe nickel tags will be reality toward the end of our forecast period.

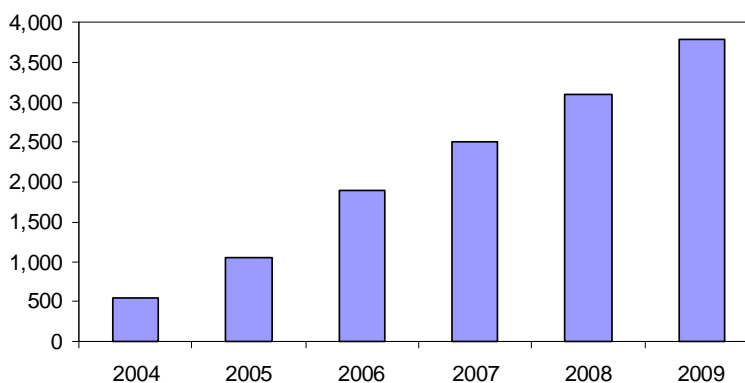
**Market Forecast:** We estimate that the tags market will grow from \$544 million in 2004 to \$3.8 billion in 2009 at a CAGR of 42%. Exhibit 41 depicts the market growth.

Exhibit 41

PIPER JAFFRAY U.S. RFID TAGS FORECAST

	2004	2005	2006	2007	2008	2009
Market Size(\$mil)	544	1,055	1,904	2,499	3,102	3,779
YoY Growth		94%	80%	31%	24%	22%

U.S. RFID Tags Market in \$ Million



Source: Piper Jaffray & Co.

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Readers

Readers form a significant chunk of the RFID market. Currently, readers are priced around \$1,000-\$3,000. We expect the prices of readers will decline dramatically during our forecast period as well. Reader costs can be slightly misleading given the propensity to have small handheld units blended with larger fixed and mobile readers. We are projecting that the average price of readers will fall by more than 50% by 2008. Symbol, Matrics, Alien Technology, SAMSys, and Intermec are the leading providers.

**Growth Drivers:** RFID adoption is the major driver and tag orders are the primary leading indicator. As the adoption increases, more readers will be needed to cover the increasing number of transit or nodal points. Another driver is needed for additional visibility in the supply chain as users begin to fully appreciate the benefits of the RFID. After the initial deployment, we expect users to install additional readers in warehouses and distribution centers to track pallets as they move through the supply chain.

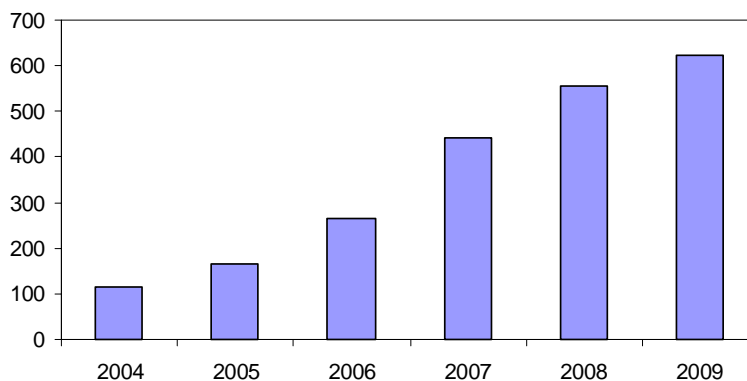
**Market Forecast:** We estimate that the reader market will grow from \$113 million in 2004 to \$624 million in 2009 at a CAGR of 36%. Exhibit 42 depicts the market growth.

Exhibit 42

**PIPER JAFFRAY U.S. RFID READER FORECAST**

	2004	2005	2006	2007	2008	2009
Market Size(\$mil)	113	164	265	444	555	624
Y/Y Growth		46%	62%	67%	25%	12%

**U.S. RFID Reader Market in \$ Million**



Source: Piper Jaffray & Co.

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Printers

Printers form the last major leg of the RFID hardware market in our forecast. Traditional barcode printers, in our view, will be modified and become the major technology used to encode RFID tags in the field. Printers with this functionality are currently priced at \$3,500. The recurring theme is that we expect this market will see fairly rapid price declines as well. We expect the prices will decline more than 50% to sub-\$2,000 by 2008. Zebra Technologies, Intermec, and Printronix are the leading printer vendors.

**Growth Drivers:** Again, the primary growth driver for the printer market is the increased adoption of RFID foreshadowed by tag orders. As RFID adoption grows, we are likely to see more high-end barcode printers with integrated RFID encoders. During the RFID adoption cycle, we expect to see integrated encoders with midrange and perhaps low-end printers as well.

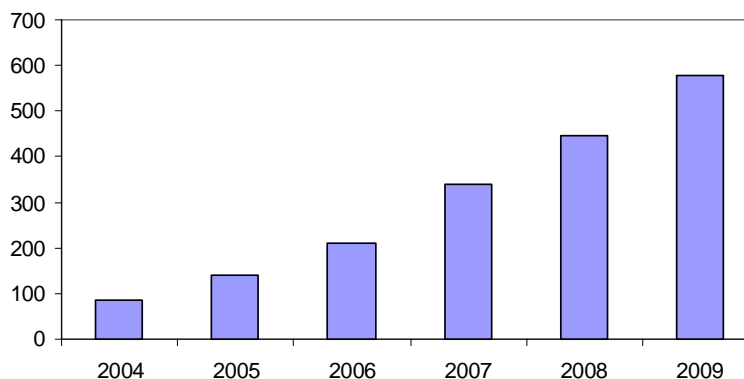
**Market Forecast:** We estimate that the printer market will grow from \$86 million in 2004 to \$580 million in 2009 at a CAGR of 42%. Exhibit 43 depicts the market growth.

Exhibit 43

**PIPER JAFFRAY U.S. RFID PRINTER FORECAST**

	2004	2005	2006	2007	2008	2009
Market Size(\$mil)	86	140	209	340	444	580
YoY Growth		63%	49%	62%	31%	30%

**U.S. RFID Printer Market in \$ Million**



Source: Piper Jaffray & Co.

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**Vertical Markets Analysis**

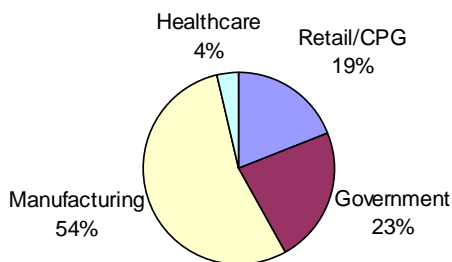
Within our consolidated RFID hardware market, we have forecast the size and growth rates by major industry category. The major market segments in our forecast include the U.S. Government, Retail/CPG, Transportation & Logistics companies, Manufacturing, and the Life Sciences industry. While other niche applications will surely emerge, we believe these industries will comprise more than 96% of the overall end-market opportunity.

Manufacturing is the largest end-market of RFID in 2004. However, we believe the U.S. Government and Retail/CPG markets will become the largest vertical market opportunities and each comprise more than 30% of the overall market by 2009.

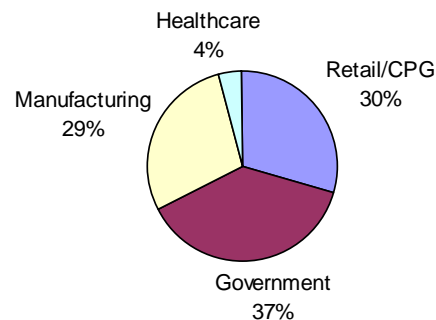
Exhibit 44

**RFID VERTICAL SNAPSHOT—2004 VERSUS 2009**

**RFID Hardware Market - 2004**



**RFID Hardware Market - 2009**



Source: Piper Jaffray & Co.

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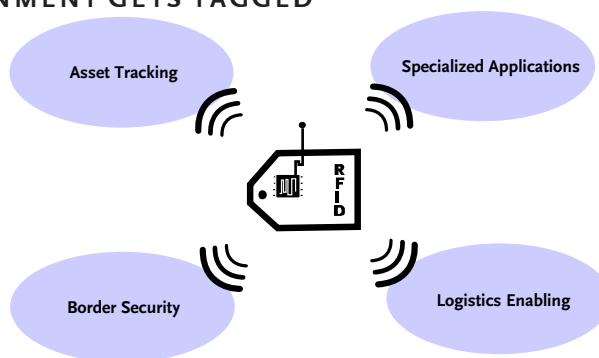
Government Markets

**Market Forecast:** We estimate government spending on RFID infrastructure will grow from \$170 million in 2004 to nearly \$1.9 billion in 2009 with a CAGR of 55%. Exhibit 46 depicts the breakdown in terms of individual line items.

The U.S. government will turn out be one of the early adopters of RFID and one of the largest users of the technology. Like the corporate sector, government is motivated by the tremendous cost savings and improved productivity that RFID promises.

Exhibit 45

**THE GOVERNMENT GETS TAGGED**



Source: Piper Jaffray & Co.

**Applications:** While there are a myriad of applications of RFID technology in the government space, we have focused on the two most critical applications—Defense Logistics and Security Applications.

**Defense Logistics:** The U.S. DoD has one of the largest logistics operations in the world. With forces deployed all over the world at isolated locations, the logistic operations are relatively more expensive as compared to retail chains, which typically have a cluster of stores to optimize operations. In addition, logistics play a critical role in the outcome of a war and efficient logistics operations can result in faster deployment.

**Security:** Security applications vary from container security initiatives to checked baggage tagging. Container security has been getting increasing attention as containers can be used by terrorists to smuggle in a biological or radiological device in the United States. According to various estimates, 14 million containers arrive at U.S. ports annually. Given the huge number of containers and relative ease with which weapons can be smuggled in using containers, the U.S. government is looking for ways to make the containers tamper-proof. One of the leading solutions is to use an RFID seal that indicates its status as soon as an RFID reader interrogates it. If the seal has been tampered with, it will either not transmit its status to the reader or will indicate that it has been tampered with.

Checked baggage tagging to streamline the flow of bags through explosive detection systems (EDS) and to keep track of bags in an airport is another emerging application. If the EDS machine identifies a bag for further examination for explosives, it writes the information on the RFID tag attached to the bag. As the bag passes through the conveyor system, the readers read the tags attached to all the bags and routes the bags that need further inspection for physical examination or for scanning by more advanced machines.

Other potential applications include travel document authentication (passport and visa) and boarding pass authentication.

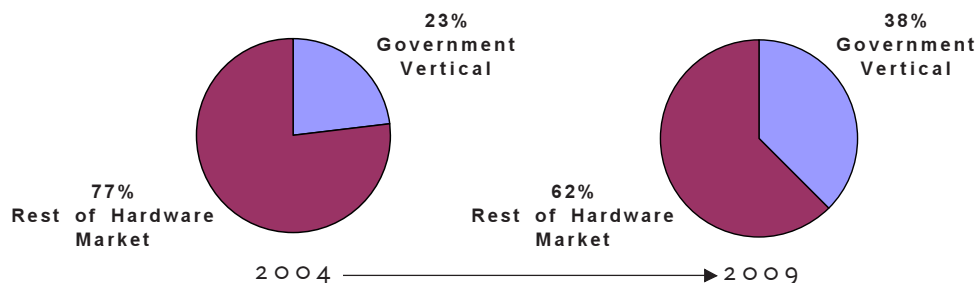
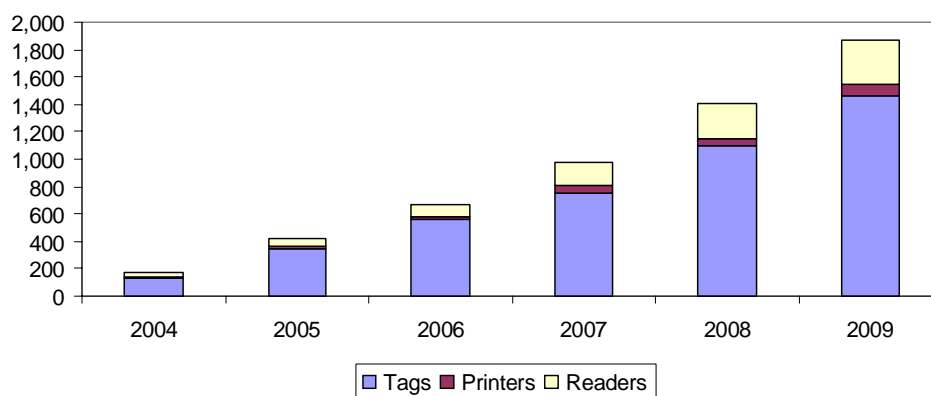
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Exhibit 46

**PIPER JAFFRAY U.S. GOVERNMENT RFID HARDWARE MARKET BREAKDOWN**

Market size in \$ million	2004	2005	2006	2007	2008	2009
Tags	132	342	559	753	1,093	1,464
Printers	7	22	22	51	61	84
Readers	31	60	82	170	254	323
<b>Total Govt. H/W Market</b>	<b>170</b>	<b>424</b>	<b>664</b>	<b>975</b>	<b>1,408</b>	<b>1,872</b>

**Government RFID Hardware Market in \$ Million**



Source: Piper Jaffray & Co.

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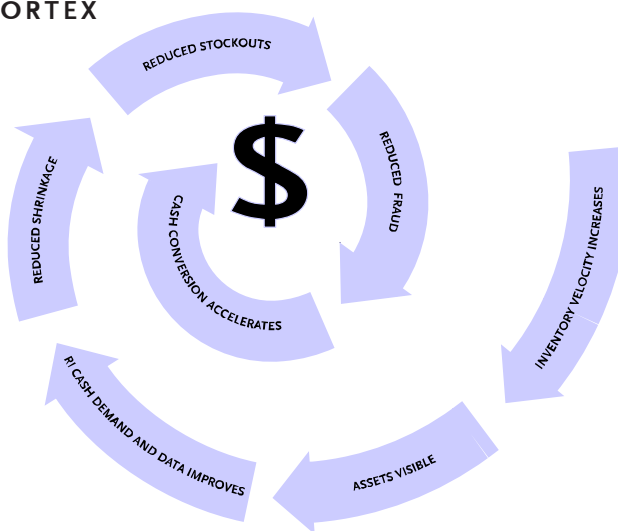
Retail

**Market Forecast:** In our retail industry forecasts, we have included consumer packaged goods companies that sell their goods primarily through retailers. The retail market is expected to grow from \$141 million in 2003 to \$1.5 billion in 2009 at a CAGR of 54%. Exhibit 48 details the breakdown of various components of the market.

The most critical RFID application in the retail and consumer packaged goods markets during the initial years of our forecast is in supply chain management. Although, we expect to see a large opportunity for RFID deployments in areas such as product authentication, counterfeit protection, and theft prevention to materialize toward the middle of our forecast period.

Exhibit 47

**RFID RETAIL VORTEX**



Source: Piper Jaffray & Co.

Real-time asset visibility along the supply chain is the panacea of RFID deployments. Increasing velocity of inventory, elongated supply lines, more aggressive inventory, and cash conversion cycles, and a growing number of customer mandates are making RFID adoption an imperative. As item volume within the supply chain increases, retailers and their suppliers are trying to find ways to accelerate goods through the supply chain and speed cash conversion cycles. While the estimates on the costs of this in-transit inventory vary, the numbers most often cited are in the multiple billions of dollars range. Obviously, retailers and suppliers are anxious to cut down on this non-productive capital. Wal-Mart is leading the charge for real-time and complete asset visibility in its supply chain and is turning to RFID as the enabling technology to reach its goal. We believe retailers and CPG companies have largely exhausted supply-chain efficiency gains with legacy auto ID technologies and need RFID to continue to increase productivity and efficiency.

Theft and item counterfeiting are other areas that cost retailers and CPG companies billions annually. RFID is the most promising and perhaps most economical solution to these problems, in our opinion. RFID use in theft and counterfeit deterrence is already taking off for high-end goods such as jewelry and perfume. And as the technology costs drop, we expect to see more widespread use for mid-priced items such as brand-name apparel.

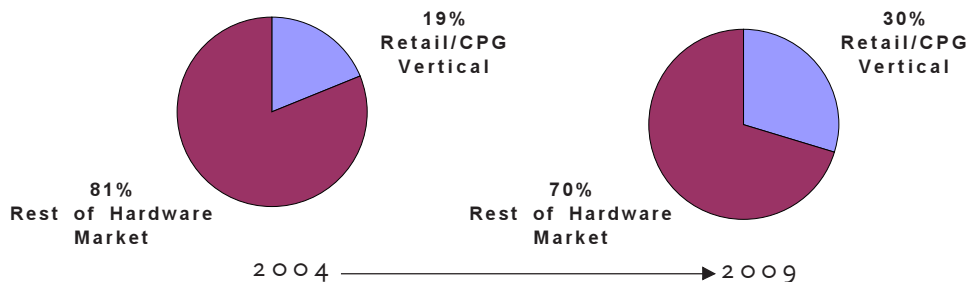
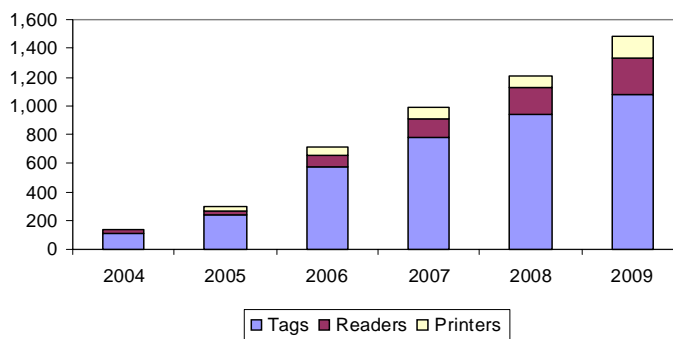
April 2004

Exhibit 48

**PIPER JAFFRAY U.S. RETAIL/CPG RFID BREAKDOWN**

Market size in \$ million	2004	2005	2006	2007	2008	2009
Tags	111	234	569	781	937	1,077
Readers	24	34	84	124	185	260
Printers	6	27	54	79	86	142
<b>Retail H/W Market Size</b>	<b>141</b>	<b>295</b>	<b>707</b>	<b>983</b>	<b>1,208</b>	<b>1,479</b>

**Retail/CPG RFID Market in \$ Million**



Source: Piper Jaffray & Co.



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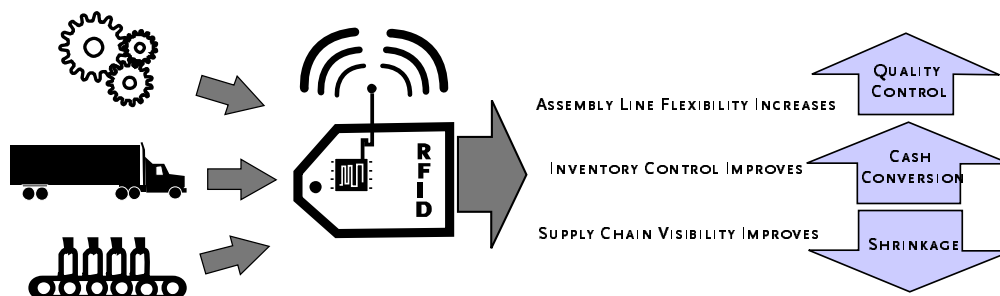
Manufacturing

**Market Forecast:** We expect the RFID use in the manufacturing sector to grow from \$404 million in 2004 to roughly \$1.4 billion in 2009 at a CAGR of 26%. Exhibit 50 details the different components of the market.

Manufacturers have been one of the early adopters of RFID, in particular active RFID technology. The auto industry's use of RFID has streamlined the manufacturing process and seems to be serving as a blueprint for other manufacturers' implementations. There are multiple applications in the manufacturing sector for RFID. Initial applications will likely continue to surface along the assembly line.

Exhibit 49

**MANUFACTURING TUNES TO RFID FOR PROFIT**



Source: Piper Jaffray & Co.

**Assembly Line Flexibility:** Manufacturers have been trying to customize mass produced products to meet the needs of specific customer groups. Increasing competition, changing demographics, and globalization are the key contribution factors toward this trend of "mass customization." Customer predisposition to customized products has increased the number of raw materials and finished goods in the system and has put stress on the overall manufacturing processes. RFID has been used as the "guiding light" by many manufacturers to automate their processes while enhancing their quality. The technology has proven particularly useful on assembly lines where the tagged object identifies itself and instructs the line worker on what to do with the item.

**Supply Chain Efficiencies:** Much has been talked about supply chain efficiencies throughout this report. Manufacturers will benefit in a manner similar to retailers by getting real-time and complete visibility in their supply chains. RFID should be the enabler to run inventories leaner, assemble products faster, improve quality, and reduce shrinkage. We expect to see the manufacturing market continue to add RFID technology to its processes during our forecast period.

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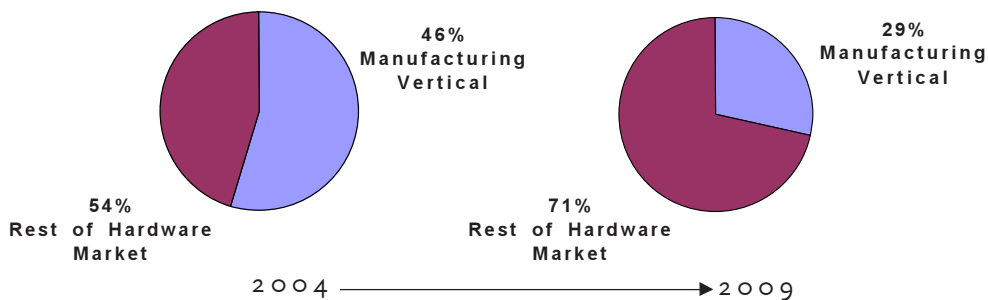
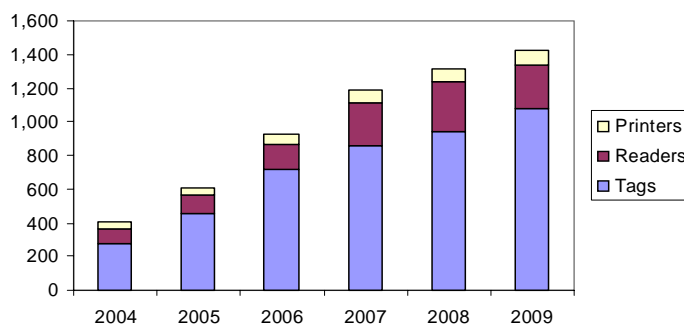
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Exhibit 50

**PIPER JAFFRAY U.S. MANUFACTURING MARKET BREAKDOWN**

Market Size in \$ Million	2004	2005	2006	2007	2008	2009
Tags	279	455	713	857	945	1,077
Readers	80	106	153	255	293	261
Printers	45	49	62	74	77	84
<b>MFG H/W Market Size</b>	<b>404</b>	<b>609</b>	<b>927</b>	<b>1,186</b>	<b>1,314</b>	<b>1,422</b>

Manufacturing RFID Market Size in \$million



Source: Piper Jaffray & Co.



April 2004

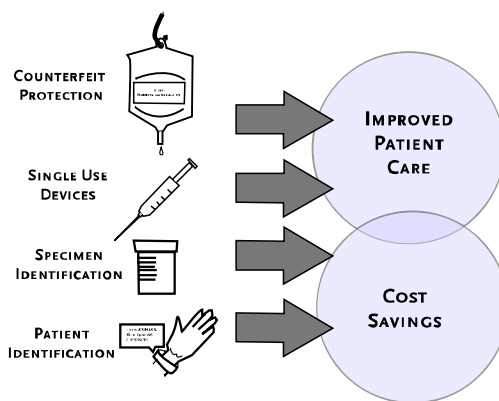
Health Care

**Market Forecast:** We expect the RFID use in the health care segment to grow from \$27 million in 2004 to \$211 million in 2009 at a CAGR of 45%. Exhibit 52 details the different components of the market.

Although the health care market will be a substantial opportunity longer term, we believe it will take a little longer to materialize than the other vertical markets in our forecast. Initial deployments will focus on compliance and patient care. The most compelling uses initially, in our view, are positive patient identification, drug counterfeit protection, and tracking medical instruments and their use.

Exhibit 51

**RFID—HEALTH CARE RX**



Source: Piper Jaffray & Co.

**Positive Patient Identification:** The current patient identification system is prone to error given its reliance on human intervention. RFID can economically and efficiently address this problem. The tags on patient wrists are often typed or even hand written. These tags are processed manually whenever care is administered to a patient. Increasing staff shortages and the growing size of health care facilities have led to increased cases of patient misidentification. Consequently, there has been a rising rate of deaths and injury due to hospital error. RFID can provide a means of a highly accurate and non-transferable positive patient identification that is far less human intensive than the means used today.

**Drug Counterfeit Protection:** RFID can prove to be an effective tool against the growing problem of counterfeit drugs. The FDA recently recommended that drug manufacturers, distributors, and pharmacists use RFID by 2007 to deter counterfeiting. Many in the industry are embracing the FDA guideline. RFID tags are more difficult to counterfeit and offer a greater degree of protection against unauthorized access. Manufacturers can attach RFID tags to the drug bottles at the point of origin. At each subsequent handling point, the information on the tag is updated. At the point of patient delivery, a pharmacist can check the authenticity of the drug by checking the history stored on the RFID tag. In addition to counterfeit protection, RFID could facilitate more efficient drug recalls.

**Medical Instruments/Device Use Tracking:** RFID can be used to ensure that certain instruments and devices are used only once. Hospitals are now requiring that many surgical instruments be used only once to prevent spreading potentially infectious disease. RFID tags can also provide a tamper-resistant means to ensure that syringes and surgical instruments are used only once, and that after single use, they are not reintroduced in the supply chain either by error or by design.

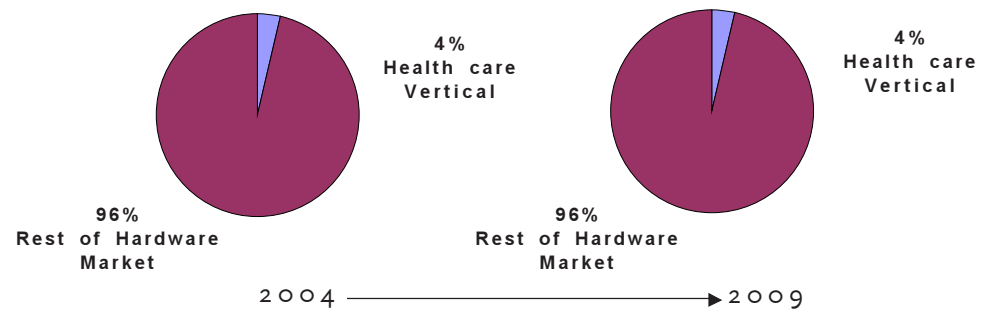
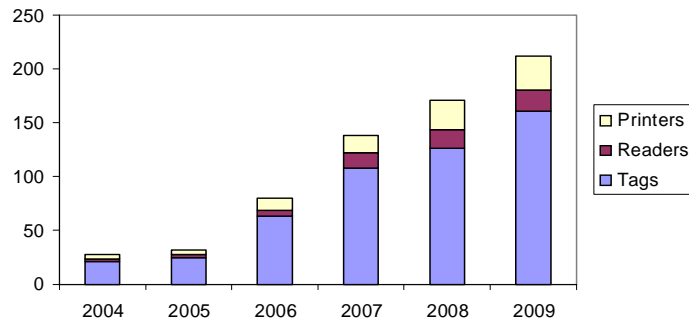
April 2004

Exhibit 52

**PIPER JAFFRAY U.S. HEALTH CARE RFID HARDWARE BREAKDOWN**

Market Size in \$ million	2004	2005	2006	2007	2008	2009
Tags	22	25	63	108	127	161
Readers	3	3	6	14	17	20
Printers	3	4	12	16	28	31
<b>Total H/C RFID H/W Market</b>	<b>27</b>	<b>32</b>	<b>81</b>	<b>138</b>	<b>171</b>	<b>211</b>

Health Care RFID Hardware Market in \$ million



Source: Piper Jaffray & Co.

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Not A Question Of If  
But *When*

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Ready or not, here it comes. *RFID will be mass adopted over the next few years.* The technology is too powerful. The sponsors are too dominant. And there is too much money being invested in RFID to assume otherwise. Clearly, adoption has been helped by the sponsorship of retailing giant Wal-Mart and the DoD. The forceful deployment push by these two juggernauts will drive down costs for others. At the same time as prices are declining, RFID implementation risk will be declining. Lower cost with less risk will equate to higher adoption.

The RFID learning curve over the past few years has been steep, but we believe RFID adoption is almost ready for widespread use. We expect to see some seeds sprout in a material way for RFID vendors beginning in 2005 as we move from pilots or isolated implementations to more widespread use. Standards are not yet finalized although the industry is moving toward what we believe will be the widely adopted standards. The technology and standards issues should be finalized within a year, setting the stage for RFID to make the giant leap into mass markets.

Adoption Timeline

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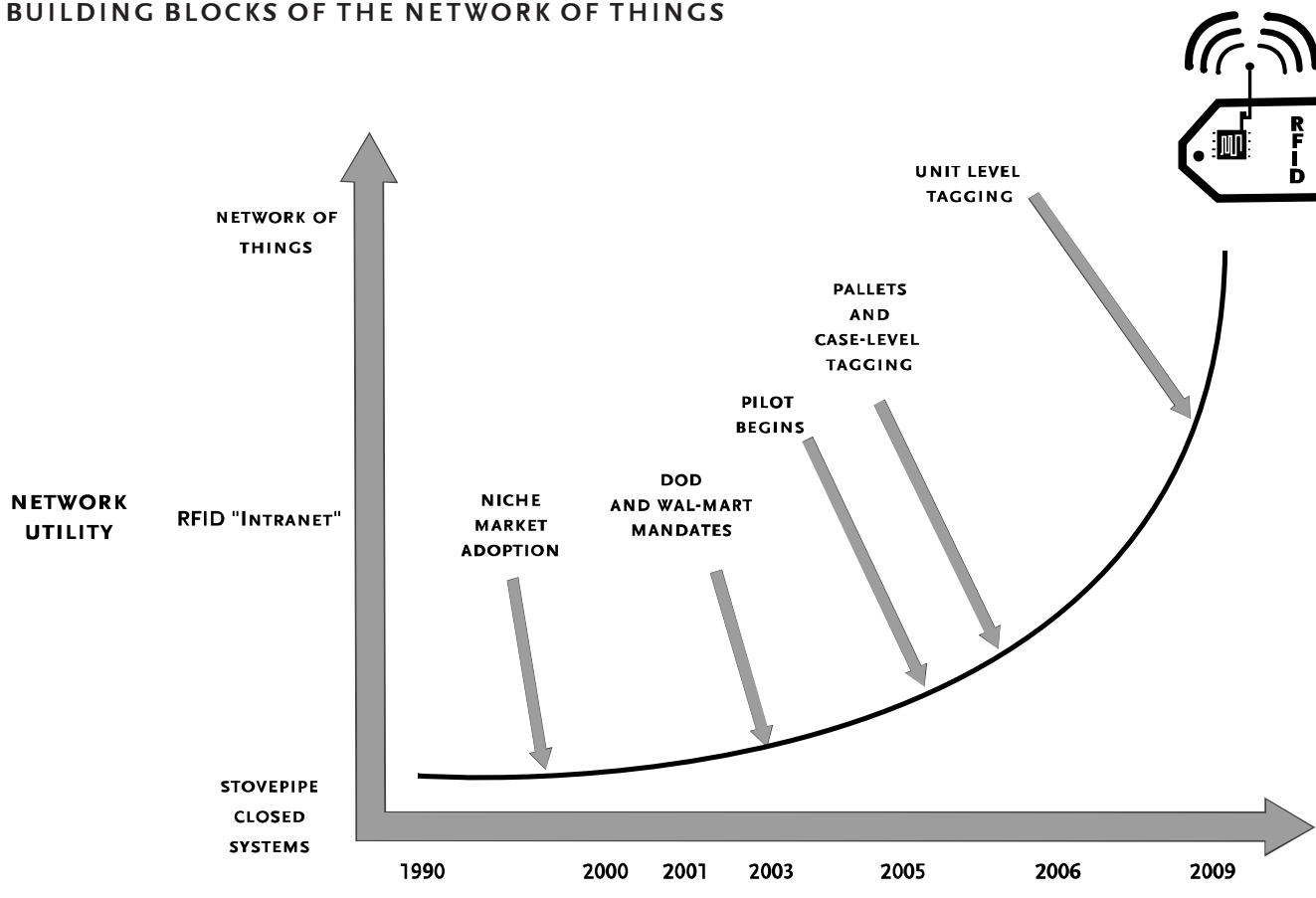
We believe “momentum” will be the best way to describe RFID adoption. Expect some inertia to initially hold up mass deployment but once adoption begins, we believe it will be hard to stop. RFID will experience exponential growth in adoption as measured by the number of tags used. Currently, RFID deployments are best described as pilots or test programs. Early commercial deployment will begin in 2005, led by Wal-Mart and the DoD. *By the middle of 2006, RFID will cross the proverbial chasm into mass markets, marked by increasing volume and rapidly declining prices for tags and other hardware.*

We expect the RFID adoption to be in the form of waves. The current wave will result in pallet and case-level tagging and adoption in areas like security, consumer packaged goods, and manufacturing companies. The second wave beginning in the 2008-09 time frame should bring about item-level tagging. At this point, we expect the price of RFID tags to fall to a penny per piece.

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Exhibit 53

### BUILDING BLOCKS OF THE NETWORK OF THINGS



Source: Piper Jaffray & Co.



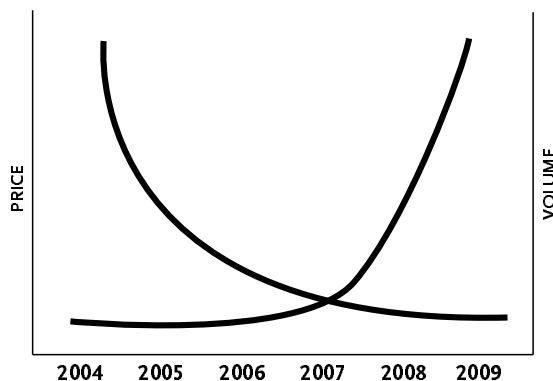
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Adoption Factors

**Costs:** The cost of tags is perhaps the most important determining factor in adoption of RFID. As the tags cost comes down, adoption will increase as shown in Exhibit 54. Currently, the passive tags cost around a dollar, and we expect the cost to decline to a nickel in 2008. Beyond 2008, we expect the cost to decline to a penny, and at that point we will witness widespread adoption of RFID at item level.

Exhibit 54

**TAG ADOPTION CURVE**



Source: Piper Jaffray & Co.

**Standards:** Standards are one of the important factors affecting adoption of any new technology. In the case of RFID, standards will play an even more critical role, as they will be the key driver for the cost of the tags. Standardization is a complex and lengthy process and involves the participation of all stakeholders—end users, technology providers, government agencies, and academic institutions—each competing for its own interest. Typically, a few standards evolve from multiple trade groups. These standards either compete in the marketplace and one of them wins, or the standards eventually converge. We expect the latter to happen in the RFID space.

Standards enable end users to select vendors without getting anchored to a proprietary system. At the same time, standards reduce the risks for vendors by providing a clear road map for technology and product development. Vendors are able to realize economies of scale, as they have to develop and manufacture products for a larger unified customer group adopting a common standard than for small fragments of customer groups owning proprietary systems.

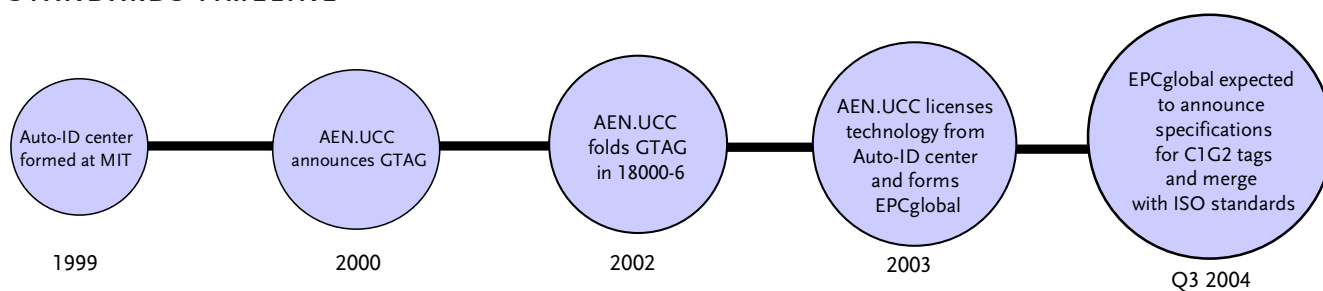
The standards for RFID are still in the evolutionary stage with two organizations working on a different set of standards. While some believe that lack of universally accepted standards poses a risk to the vendors and the users, we believe that the two standards will eventually converge. Our belief is based on the fact that the users and vendors are already moving in that direction, largely motivated by the promise of lower tag costs and speedy adoption of RFID technology. Contrary to the popular belief, so far we have seen little evidence of any impact of uncertainty over standards on vendors' and users' plans. On the contrary, lately we have seen significant cooperation among all the major stakeholders to reach a consensus on standards. Standards evolution is a continuous process in which all the stakeholders work together to reach a consensus. History has taught us well that setting "de facto standards" or "fighting it out in the market" benefits only a few.



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Exhibit 55

STANDARDS TIMELINE



Source: Piper Jaffray & Co.

Currently two organizations, ISO (International Standards Organization) and the recently created EPCglobal, are working on a different set of standards for various aspects of RFID technology. The contention is the standard UHF air-interface—the way RFID tags communicate with the readers in the Ultra-High Frequency (UHF) band. Currently, the proposals by ISO and the EPCglobal for UHF air interface are non-compatible. The UHF band attains its significance from the fact that it is the most suitable band for supply-chain applications and therefore most of RFID hardware products will operate in this band.

**ISO:** ISO is the principal standards body in the world and is composed of representatives of national standard bodies of most of the countries. ISO sets international standards relating to almost everything imaginable—technologies and protocols, business and government processes, construction, engineering, materials, medicine, weights and measurements, etc. For RFID, ISO has set standards pertaining to air interface for all the frequency bands and for various applications. ISO 18000 is the proposed standard for air interface and has seven parts as described in the following table.

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Exhibit 56

**ISO STANDARDS FOR RFID AIR INTERFACE**

Standard	Description
18000-1	Definitions of parameters to be standardized
18000-2	Parameters for air interface communications below 135 kHz
18000-3	Parameters for air interface communications at 13.56 MHz
18000-4	Parameters for air interface communications at 2.45 GHz
18000-5	Parameters for air interface communications at 5.8 GHz (Withdrawn)
18000-6	Parameters for air interface communications at 860 – 930 MHz (UHF)
18000-7	Parameters for active RFID air interface communications at 433 MHz

Source: Piper Jaffray &amp; Co.

**Auto-ID Center:** The Auto-ID center was founded in 1999 with the charter to provide next-generation auto ID technology and to set standards that would facilitate a network of physical objects or "Internet of Things." The center was established by MIT and involved five other leading academic institutions in the world—University of Cambridge in England, Adelaide University in Australia, Keio University in Japan, Fudan University in China, and St. Gallen University in Switzerland. Many consumer and technology companies funded the center. The Auto-ID center developed the EPC network system. The EPC system is based on a unique identification number called the electronic product code (EPC) and uses RFID technology to gather information and link it to an open and accessible network for real-time identification and data management.

**EAN:** Founded in 1977, European Article Numbering International (EAN) is a non-profit organization involved in the development of item-level identification standards for multi-industry global supply chains. EAN has 101 organizations representing 103 countries. UCC (Universal Code Council) is the North American representative of EAN and manages UPC (uniform product code), the barcode standard in North America. The two organizations proposed the EAN.UCC system as a means of product identification across the globe. In 2000, EAN.UCC proposed GTAG (global tag) as an RFID standard for supply-chain management applications. ISO, at that time, was already working on 18000-6, the air-interface standard for UHF band (860-930MHz). In 2002 EAN.UCC decided to merge GTAG with ISO's 18000-6. However, there is one major difference. ISO standards do not prescribe data formats for the tags, but GTAG has a data structure that the tags should adhere to in order to be GTAG-compliant.

**EPCglobal:** In May 2003, the EAN and UCC announced that they had licensed the EPC technology from MIT with the intention of commercializing it. EAN and UCC formed a new joint venture called Auto ID Inc. In October 2003 Auto ID Inc. changed its name to EPCglobal. Auto-ID Center ceased operations on October 26, 2003, and EPCglobal is now responsible for developing and managing standards based on the EPC network.

As of now, EPCglobal has defined standards for class 0 and class 1 UHF tags and class 1 HF tags. The class 1 and class 0 are open standards and any vendor can produce these tags and readers. However, these two tags are not interoperable—a reader of one class cannot necessarily read tags of the other class. Either two readers of each class will be needed or a multi-protocol reader will be needed. Currently, EPCglobal is developing standards for the next generation of the UHF class 1 tag called "Class 1 Generation 2" or c1g2. This generation of specification is expected to incorporate interoperability between class 0 and class 1 tags.

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**EPC Network Architecture**

The grand vision of the architecture is to create an "Internet of Things" very much analogous to the Internet—network of computers. Every item in the world will have an EPC—a unique identifier analogous to the IP address that identifies individual computers on the Internet. This EPC will be encoded on an RFID tag attached to each item. Using this EPC, the EPC network would enable computers to identify all items in the world and would be able to trace and monitor the items.

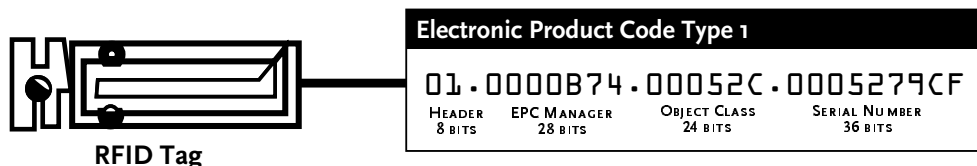
The EPC network comprises five elements.

**Electronic Product Code (EPC)**

EPC is a product identification code that can be used to identify every individual item in the world. It is very similar to the ubiquitous barcode but contains few extra bits that are used for identifying individual items. EPC is the only information that's stored on the EPC tags, and this unique EPC identifier is used to reference product information in a dynamic database that can be updated continuously.

EPC has four parts.

- Header (8 bits) : EPC's Version Number.
- EPC manager field (28 bits): Name of the enterprise (usually the manufacturer).
- Object class field (24 bits): Class of product (usually the stock keeping unit (SKU)).
- Serial number field (36 bits): Uniquely identifies the individual item.



**EPC Tags And Readers**

The EPC is stored on RFID tags that are attached to physical objects. RFID readers capture the EPC information from the tags using radio frequency. The information is then passed on to host computers for further processing. Based on the capabilities, tags have been classified into generations.

Exhibit 57

**EPC TAG CLASSES**

EPC Class	Capabilities	Comments
Class 0	Passive, Read Only, Factory Programmed	Available from Matrics
Class 1	Passive, write-once read many(WORM)	Available form Alien
Class 2	Passive with read write capabilities	Specifications not yet finalized
Class 3	Semi passive with read write capabilities, built in battery to support extended read range	Specifications not yet finalized
Class 4	Semi passive or active tags that can communicate with other active tags and readers in same frequency band	Specifications not yet finalized
Class 5	These are tags with reader capabilities. They can power and communicate with other classes of tags	Specifications not yet finalized

Source: Piper Jaffray & Co.



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Object Name Service (ONS)

The role of ONS is to match the EPC of an item to the information associated with that item. ONS is very similar to Domain Name Service (DNS), which points computers to the sites on the Internet.

Physical Markup Language (PML)

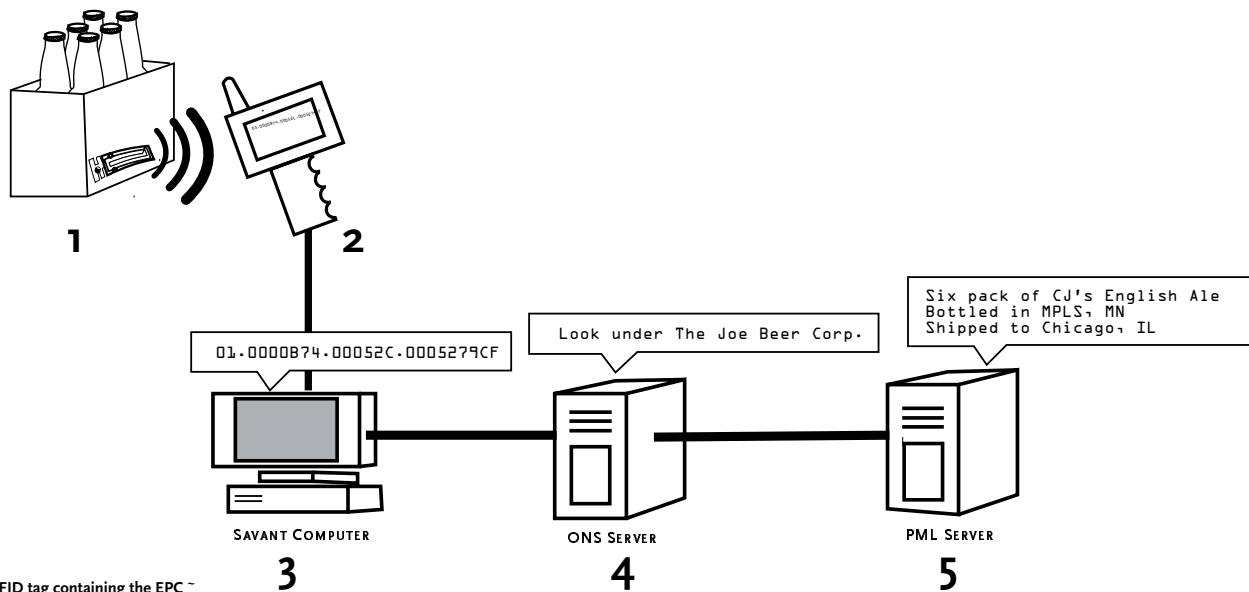
PML is a new standard language for describing physical objects and is intended for use by both humans and machines. The primary goal of PML is to serve as a common interface between software applications, databases, and analytical tools so as to fully leverage the EPC network. PML, along with EPC and ONS, provides the elementary framework needed to automatically link information with physical products.

Savant

Savant acts as the nervous system of the EPC network and manages the flow of information. It uses distributed computing architecture and runs on different computers in an organization rather than on one central computer. Given the amount of data that can be generated using RFID tags, it is prudent to have many computers processing the data rather than a single computer that can be overwhelmed by a constant barrage of data from millions of tags. Savant is organized in a hierarchical manner. For example, Savants could be running at factories, distribution centers, stores, or even trucks. Each level of Savant gathers, stores, and processes information and interacts with Savants at other levels.

Exhibit 58

EPC ARCHITECTURE



- 1 An RFID tag containing the EPC of an item is attached to the item.
- 2 An RFID reader reads the tag. The EPC data is sent to a computer running Savant.
- 3 Savant queries the Object Name Service(ONS) database using the EPC
- 4 The ONS uses EPC to determine where on Internet item's information is stored
- 5 The PML server contains the stored information about the item.

Source: Piper Jaffray & Co.

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Exhibit 59

**EPC STANDARDS FOR RFID AIR INTERFACE**

<b>EPC Class</b>	<b>Frequency Band</b>	<b>Status</b>
Class 0	UHF	Defined
Class 1	HF	Defined
Class 1	UHF	Defined
Class 1 Generation 2	UHF	Expected Q304

Source: Piper Jaffray &amp; Co.

**The State Of The Standards:** There are currently four major players in the standards battleground. In addition to the formal standards bodies that include the ISO and EPCglobal, the U.S. Department of Defense (DoD) and the retail industry, led by Wal-Mart, are contributing to future RFID standards. While Wal-Mart and the retail industry plan to use technology based on the EPC system, the DoD is more inclined toward using ISO standards. DoD has traditionally adhered to ISO standards as a matter of policy so that its equipment and processes operate worldwide. Making the tags ISO-compliant would make them more expensive, and these tags are not amenable to the retail industry, the primary backers of EPC. However, in a policy memorandum issued in October 2003, the DoD has acknowledged EPC by saying that it would adopt technology that leverages EPC and compatible tags but still insists that it will conform to appropriate ISO standards. Later in December 2003, the DoD confirmed that it is working with EPCglobal to develop standards that can be incorporated in ISO standards. We, and many industry analysts, believe that all the groups involved will reach a compromise in Class 1, Version 2 tags that EPCglobal is currently working on. This EPCglobal standard will likely be incorporated in ISO standards for RFID.

With the formation of EPCglobal, we are more hopeful of a speedier resolution of standards issues. EAN.UCC has a successful history of managing standards worldwide, and we believe ISO and EPCglobal will work together to set the standards uncertainty to rest. Taking EPC out of the realm of academic research and into the commercial marketplace should aid in faster adoption of RFID, primarily driven by businesses' motivation to profit from the technology.



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## Tuning Into Other Hot Topics

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**Technology Learning Curve:** Given the demands placed on RFID technology, both vendors and users will undergo a learning process to best utilize the technology. Vendors will have to tweak product while users will have to fine-tune processes to meet the design specifications. Most new technologies experience similar technical hurdles, which are eventually removed. As tag deployment increases, manufacturers will learn from a larger installed base, and through a continuous learning process, they will be able to meet the required reliability requirements. Our research indicates that tag read rates have been steadily climbing and are on track to meet the 99% read reliability.

**Implementation Complexities And Costs:** RFID will require the companies to re-engineer key business processes and retool information technology infrastructure. Companies will have to install RFID middleware and integrate it with their Enterprise Resource Planning (ERP) Systems to leverage the technology to the fullest. Corporations will likely invest heavily on software and hardware and on processes in order to take advantage of RFID's many benefits. There is always a resistance to change, and we expect resistance in this market as well. Resistance may be higher in this case as the incumbent technologies are deeply rooted in most corporations.

Although RFID is a radical technology, we believe that corporations will be able to deploy it without encountering major long term issues. RFID is an automation technology that over time should drastically reduce human intervention and the corresponding human error associated with human touch. This, in turn, will shift the operational onus on the silicon. At the same time, data volumes will be exploding and velocity will be accelerating through IT infrastructures. This is sure to tax IT infrastructures beyond current capabilities. In this age of hyper-competition, companies have shown remarkable agility in their ability to re-engineer their business processes.

## Remember Metcalfe

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**Metcalfe's Law States The Utility Of A Network Increases By The Square Of Its Users.** Network effect will be one of the primary drivers for RFID adoption. Network effect is similar to viral marketing of the Internet bubble era—every user that joins the network brings many more with him/her and the network grows exponentially. Applied in the RFID world, this means that as more companies adopt RFID, they will push their suppliers and customers to adopt RFID to realize the full benefits of technology across a seamless and totally integrated supply chain. For every company that adopts RFID, many of its vendors and prospective customers will adopt RFID and the cycle perpetuates.

## Consumer Privacy Concerns

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Privacy concerns raised by many consumer and privacy groups are minor impediments in the near term. Though few niche retailers may delay their adoption plans, we do not expect privacy concerns to have a major impact on RFID adoption over the next few years. Initially most of the RFID use will be limited to pallet and case level tagging or tagging of high value individual items such as expensive clothing, perfume, and jewelry. If at all, privacy concerns will become more of an issue when item-level tagging starts toward the end of the decade.

Most of the privacy concerns stem from the abilities of RFID technology to track individual actions. We believe a few of the privacy concerns are just outlandish—such as the ability to track a person having an RFID tag on an article he/she is carrying using satellites. Although many concerns are misinformation, there are a few genuine concerns as well. Stores can use information from RFID tags in a customer's shopping cart or personal possessions to promote products and services or to track a person's buying habits.

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RFID vendors, users, and standard bodies plan to address consumers' concerns by means of technology solutions. These solutions include kill codes and blocker tags. Kill codes are PIN-protected commands that permanently disable the RFID tags so that they are no longer readable. They can be used at checkout registers so that when the customer leaves the store, all RFID tags are disabled. However, rendering a tag useless could make the returns and recalls difficult, as the item identifier is unreadable from the RFID tag. The blocker tag idea proposed by RSA Laboratories overcomes the limitations of the kill codes but involves the use of one extra tag. This blocker tag interferes with any unauthorized reader that tries to read the actual RFID tag containing the item information.

#### Corporate Data Security

As with any wireless technology, corporate users are worried about illegal snooping and eavesdropping of corporate data exchanged between the tags and the readers. While many of their fears are genuine, rarely ever have they slowed the adoption of a radical technology. Wireless LAN and cell phones are classic examples. Over time, technologies mature to offer stronger security and users adopt practices to protect data.

RFID vendors are coming up with solutions to protect the data exchanged between tags and the readers. Though tags do not transmit data over long distances, readers can transmit tag data over a few hundred feet. Shielding readers would reduce their effectiveness and therefore is not an option. Few techniques have been proposed to address this problem. The first, proposed by scientists at MIT, is called silent tree walking—a modification to a reader's protocol so that it does not broadcast the tag data. The second method proposed by RSA Laboratories requires a tag to have multiple identifiers, which it emits at different times. The identity of tags keeps changing and only legitimate readers are capable of reading the tag using the different identifiers. An eavesdropper cannot read the tags using an unauthorized reader.

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## CASE STUDIES

Fort McPherson

**Client:** U.S. Army

**Vendor:** Intermec Technologies Corporation

**Problem:** The heightened state of alert post-9/11 has prompted a need for enforcing a better and more efficient means of securing defense and other critical installations. The proposed technologies and solutions in addition to being economical should not impede the movement of vehicles and people in and out of the installations.

**Solution:** RFID is the most suited technology for addressing physical security and access control issues as it eliminates the manual labor for physical authentication of vehicles and documents. Additionally, RFID-based solutions allow for easy reconfiguration and monitoring and thus add another element of security.

Intermec and Micromation proposed a solution that included Intermec's Intellitag technology and Micromation's Intelligent Gate Controller and access control software. Intermec's RFID windshield decals were installed on all vehicles allowed to enter the base. The decals were installed on the driver's side of the vehicle and coded with information pertaining to vehicle owners' access and security privileges. As vehicles approach the installation's entry gate, Intermec's RFID readers are activated to read the RFID decals on the vehicle. The information read from the decals is passed onto the access control software that determines whether the vehicle is authorized to enter the base. If access is allowed, for automated entry points, the gate is opened automatically and for manual checkpoints, the sentry is signaled to open the gate. If the vehicle is unauthorized, an alarm is generated and information related to the vehicle is passed on to military police personnel. Historical data related to all vehicles approaching the entry point is maintained and can be easily searched if needed.

**Result:** An efficient and secure physical access control system that is economical and does not impede movement.

**Implications:** Adoption in access control and security markets could be substantial, driven by the need for an efficient and secure physical access to defense and critical installations.

April 2004

Procter &amp; Gamble

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**Client:** Procter & Gamble, Spain**Vendor:** Escort Memory Systems**Problem:** Procter & Gamble (P&G) needed to implement an inventory and shipping tracking system to reduce errors due to lost or misplaced pallets. Losing pallets or loading pallets on the wrong truck is extremely costly.**Solution:** After tests and performance evaluations, RFID was chosen in favor of barcode. Engineers determined that barcode scanners would take 40% more time to load a truck as compared to RFID and mirrors would have to be installed in order to provide line of sight. P&G used an innovative mechanism to keep track of movement of forklifts and pallets. Instead of sinking the antennas in the concrete and tagging the pallets, P&G installed the antennas on the underside of the forklifts and drilled tags into the concrete at the loading docks. The tags had the location information coded on them. As the forklift loads the pallets as they come off the production line, a fixed barcode scanner reads the product information and relays it to the onboard computer on the forklift. As the forklift passes over the RFID tags at the loading docks, the antenna on the underside of the forklift reads the location information from the tags and passes it on to the onboard computer on the forklift. The UPC information loaded earlier from the barcode scanner and the location information from the RFID tags are bundled together. This information is used to keep track of shipping information of all the outgoing pallets.**Result:** Pallet loss was reduced while shipping efficiency improved.**Implications:** Adoption in supply-chain management and asset tracking could be the launch pad for widespread RFID adoption.

April 2004

McCarran International  
Airport

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**Client:** McCarran International Airport, Las Vegas

**Vendor:** Matrics Inc.

**Problem:** Passenger traffic growth and increased security needs required a technology solution to reduce costs while expanding throughput, improving security, and increasing customer satisfaction.

**Solution:** RFID is a natural technology to help resolve many airport security and efficiency issues. McCarran is one of the first airports to recognize the potential of RFID. McCarran is one of the top ten most traveled domestic airports, handling more than 70,000 passengers a day, and seems to gain in popularity on a weekly basis. One area that airport officials wanted to address was increased visibility on non-human inventory—more specifically checked luggage.

McCarran selected Matrics to supply and implement an RFID solution. During the 5-year contract, Matrics is expected to deliver nearly 100 million tags. The Matrics baggage tracking system is based on passive UHF RFID tags. At passenger check-in, smart tags are printed and affixed to checked luggage. The luggage then proceeds into the airport's conveyor system and is routed to the appropriate EDS (explosive detection system) and ultimately to the passenger's matching airplane. RFID readers are installed at various points along the conveyor system. At these points, the readers activate the smart labels evoking a response and providing airport operators with real-time visibility of luggage during the check-in, screening, and loading processes.

**Result:** Fewer lost bags and real-time view of luggage during the security inspection process will be the likely outcomes.

**Implications:** Airport adoption could be substantial over the next several years. Are smart boarding passes a natural extension of the McCarran solution?

April 2004

DoD's Combat Feeding  
Program

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**Client:** Defense Logistics Agency

**Vendor:** Alien Technology Corporation

**Problem:** The DoD wants to have real-time visibility of its food supply for the soldiers in combat zones. Both quantities and quality of food are required to be tracked. The DoD wants to determine the suitability of passive tags and its readiness to handle RFID technology.

**Solution:** A pilot was conducted by the Natick Soldier Center DoD Combat Feeding Program and the Defense Logistics Agency at the Defense Depot in San Joaquin, CA. The pilot simulated 10 nodes in the supply chain. Alien Technology supplied the tags for the pilot. A class 1 tag containing EPC information was put on each case of MRE (meals ready to eat) and UGR (unitized group ration). As a pallet was stacked with cases of MREs or UGRs, tags attached to cases were read to ensure the right cases and the right number of cases were put on each pallet. The pallet was then shrink-wrapped and a class 1 check tag was put on the pallet to ensure the integrity of the pallet. An Alien 2.45 GHz BAP (battery-assisted passive) tag with temperature sensor was also attached to each pallet and EPC numbers of all the cases on the pallet were written on it. A forklift equipped with RFID readers picked up the pallets. As the forklift loaded the pallets onto a shipping container, the pallets were removed from warehouse inventory and pallet information was written to another BAP tag attached to the container. This BAP was further loaded with destination and other information. When the containers arrived at the simulated depot, the BAP tag attached to it was read and the depot inventory was automatically updated. The temperature sensors attached to each pallet were read to determine the quality of food. As the containers were broken down into pallets to forward locations, depot inventory was automatically updated in real time. At the forward location, the pallets were broken down into cases and read with a handheld reader, simulating arrival at a station.

**Result:** Class 1 EPC tags used in conjunction with BAP tags can meet the requirements of the DoD.

**Implications:** The DoD is not only committed to using RFID in its supply chain, but it is also dedicated to fielding multiple flavors of RFID including active, passive, and BAP

April 2004

Central Command

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**Client:** United States Department of Defense - Central Command

**Vendor:** Savi Technology

**Problem:** Logistics bottlenecks with DoD deployments were causing problems with receiving items, ranging from bombs and bullets to food and uniforms.

**Solution:** Nothing stresses a supply chain like war. Historically, the DoD's logistic systems were paper-based and imprecise. Often deployed U.S. troops didn't know when supplies were coming and what supplies actually arrived without opening crates and pallets. RFID technology was a logical fit to inject order and precision into the logistics chain. Catalyzed by problems that occurred during Operation Desert Storm, the DoD began to test RFID technology in earnest in the mid-1990s.

Savi got in at the ground level with the DoD and continues to be the major RFID player in the defense logistics market. For Operations Enduring Freedom and Iraqi Freedom, Savi provided the DoD with a near turnkey RFID system that included RFID transponders, a variety of reader types, necessary software and middleware infrastructure, and services. The system has enabled the DoD to achieve near real-time visibility along its supply chain. The DoD policy for the real-time RFID-enabled logistics is Total Asset Visibility (TAV). The ITV is the largest active RFID logistics system that we are aware of and is used to track DoD shipments at more than 800 locations in 45 countries. Savi was instrumental in building the RFID infrastructure or the In-Transit Visibility Network (ITV) that enables TAV. The system was heavily used in Iraq and the user feedback was strong. At the beginning of the conflict in March 2003, Savi readers registered more than 2 million hits throughout the network.

**Result:** The DoD can deploy much more efficiently. According to the DoD, Operation Iraqi Freedom used 30% less manpower than during Desert Storm but an amazing 90% fewer containers were shipped.

**Implications:** The immediate implication is NATO's decision to begin testing use of Savi's active RFID logistics technology between Afghanistan and Europe. Longer term, we expect current Savi users will expand their network nodes and new users will begin erecting similar networks.

*April 2004*

| COMPANY SNAPSHOTS

timlee11



April 2004

Avery Dennison Corporation  
NYSE:AVY

Pasadena, CA



**COMPANY DESCRIPTION:**

Founded in 1935, Avery Dennison Corporation is a leading provider of pressure-sensitive technologies and self-adhesive solutions for consumer products and labels. Products include Avery-branded office products, self-adhesive materials, reflective highway products, specialty tapes, and chemicals. RFID product offerings include smart labels. The company is leveraging its strong traditional label heritage to be a materials supplier and specialty RFID label provider.

**KEY PRODUCTS AND MARKETS:**

Office products, self-adhesive materials, reflective highway products, specialty tapes and chemicals, and smart labels

	2003	2004E	2005E
Revenue (Mil.)	\$4,820	\$5,014	\$5,275
EPS	\$2.67	\$2.92	\$3.32

**RECENT EVENTS:**

Date	Event
March 2004	Raises low end of Q104 guidance
March 2004	Declares RFID as a major growth area

**MANAGEMENT:**

Philip M. Neal, CEO  
Daniel R. O'Bryant, Senior VP and CFO  
Dean A. Scarborough, President and COO

**MARKET CAP:** \$7 billion

**PRICE:** \$63.36

**SHARE PRICE HISTORY**

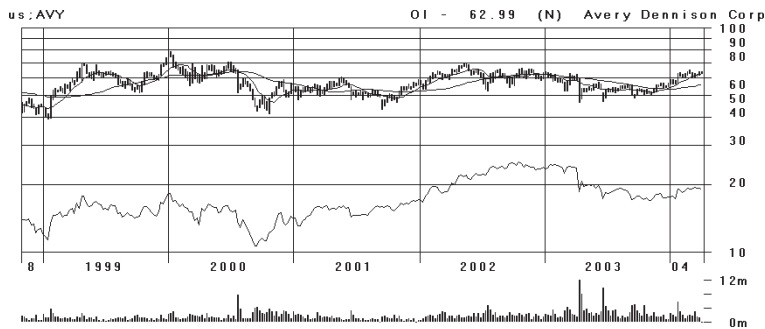


Chart courtesy of Bridge Information Systems

April 2004

Checkpoint Systems, Inc.  
NYSE: CKP

Thorofare, NJ



**COMPANY DESCRIPTION:**

New Jersey-based Checkpoint Systems is an industry leader enabling companies to identify, locate, and protect assets from its supply chain to the storefront. The company's technology solutions include EAS, label and ticketing, CCTV, RFID, and more. The company is the leading provider of RFID solutions to the library industry and is leveraging its incumbent position with retailers, CPGs, and others to broaden its RFID reach beyond the library space. In 2003, Checkpoint generated sales of roughly \$433 million and employed roughly 4,000 personnel.

	2003	2004E	2005E
Revenue (Mil.)	\$433	\$514	\$570
EPS	\$0.96	\$1.01	\$1.11

**RECENT EVENTS:**

Date	Event
March 2004	Checkpoint and Matrics ink RFID tag supply deal
February 2004	Checkpoint acquires Goliath
November 2003	Checkpoint launches EPC solutions center

**MANAGEMENT**

George W. Off, CEO  
W. Craig Burns, Executive VP and CFO

**MARKET CAP:** \$33.83 billion

**PRICE:** \$18.14

**SHARE PRICE HISTORY**

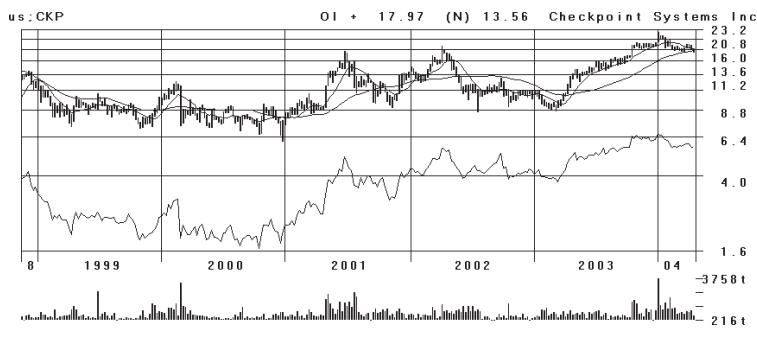


Chart courtesy of Bridge Information Systems



April 2004

Escort Memory Systems  
PNK: DLGCF.PK

Scotts Valley, CA



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**COMPANY DESCRIPTION:**

Founded in 1985, Escort Memory Systems is a division of Italy's Datalogic Group and provides RFID solutions for supply-chain applications. Products include a host of RFID products: tags, labels, PCBs, antennas, controllers, and network interface modules for use in tough industrial environments. EMS's customer roster includes names like Toyota, Mercedes, General Motors, Italian Post, P&G, and Gillette.

**KEY PRODUCTS AND MARKETS:**

RFID tags, labels, PCBs, antennas, controllers, and network interface modules for tough industrial environments

**RECENT EVENTS:**

<b>Date</b>	<b>Event</b>
October 2003	Introduces tags that can withstand temperature up to 392° F
June 2003	Crisplant chooses EMS for airport baggage tracking
November 2002	Luciano Mattioli takes over as CEO

**MANAGEMENT:**

Luciano Mattioli, President and CEO

April 2004

Intermec Technologies Corporation  
NYSE: UNA

Everett, WA



**COMPANY DESCRIPTION:**

Founded in 1966, Intermec Technologies Corporation is a provider of supply-chain technology solutions. Intermec is a division of UNOVA, Inc., a \$1.3 billion industrial technologies company. Intermec's products include barcode scanners and printers, as well as RFID tags, readers and printers, WLAN solutions, and application software tailored to specific vertical markets. To address the RFID market, Intermec acquired IBM's RFID technology in 1997 and Amtech's RFID business, known as Amtech Transportation Systems, in 1998. Intermec plans to leverage its leading technology position and strong customer relationships as a platform for selling its RFID line.

**KEY PRODUCTS AND MARKETS:**

Handheld barcode scanners, handheld computers for retail, logistics, health care, and manufacturing markets. RFID tags, readers, and printers.

	2003	2004E	2005E
Revenue (Mil.)	\$1,145	\$1,187	\$1,293
EPS	(\$0.07)	\$0.46	\$0.88

**RECENT EVENTS:**

Date	Event
March 2004	Tom Miller named president of Intermec
February 2004	CTO to co-chair EPCglobal C1G2 work group
February 2004	Joins EPCglobal

**MANAGEMENT:**

Larry Brady, CEO  
Michael Keane, Senior VP and CFO  
Tom Miller, President of Intermec

**MARKET CAP:** \$1.19 billion

**PRICE:** \$19.66

**SHARE PRICE HISTORY**

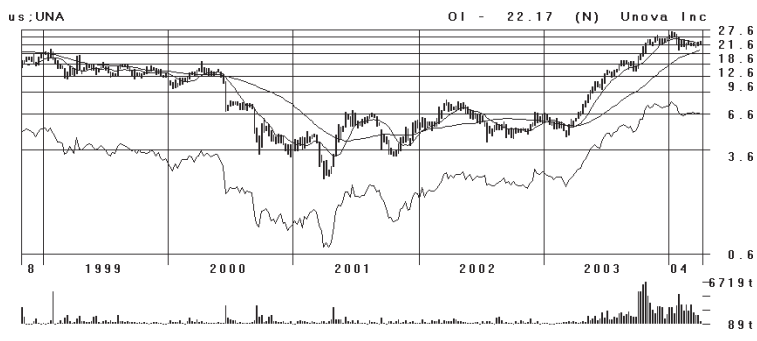


Chart courtesy of Bridge Information Systems



April 2004

Paxar Corporation  
NYSE: PXR

White Plains, NY



**COMPANY DESCRIPTION:**

Paxar is a leading provider of merchandising systems to retailers and apparel manufacturers. Products include barcode printers and scanners; tags and labels for apparel and other retail articles; label and tag printers for apparels; anti-counterfeit solutions; and consulting services. Paxar's RFID offerings include label printers, labels, and tags. Paxar has been providing supply-chain management and asset-tracking solutions to the retail and apparel industry under the brand name, Monarch, and has deep roots in conventional labeling and tagging technologies. The Monarch 9855 is Paxar's RFID Tabletop Barcode printer that the company is selling as an RFID encoder.

**KEY PRODUCTS AND MARKETS:**

Barcode printers and scanners, RFID printers, tagging, and labeling products for retail and apparel industries

	2003	2004E	2005E
Revenue (Mil.)	\$712	\$763	—
EPS	\$0.80	\$1.02	\$1.22

**RECENT EVENTS:**

Date	Event
March 2004	CFO, Jack R. Plaxe retires
March 2004	Announces availability of RFID kit for Wal-Mart suppliers
February 2004	RFID Printing solutions approved for use with Manhattan Associates' SCM software

**MANAGEMENT:**

Arthur Hershaft, President and CEO

**MARKET CAP:** \$97.45 million

**PRICE:** \$15.07

**SHARE PRICE HISTORY**

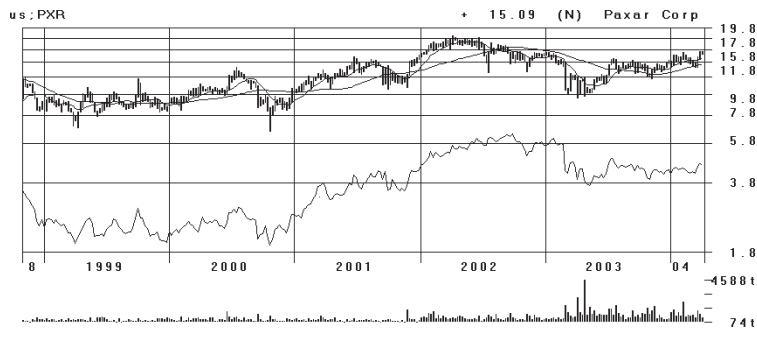


Chart courtesy of Bridge Information Systems

April 2004

Philips Semiconductors  
NYSE: PHG

Amsterdam, Netherlands



**PHILIPS**

#### COMPANY DESCRIPTION:

Philips Semiconductors, a division of electronics product giant Royal Philips Electronics, is an early pioneer in RFID technology. The company provides the RFID ICs to many tag and reader makers, most notably Intermec and Escort Memory Systems (EMS). Philips offers a complete portfolio of RFID IC products across all frequency bands from 135KHz to 2.45GHz. Recently, the company announced an alliance with IBM to address the growing market for RFID and Smart Card technologies used in day-to-day business processes. Retailer Metro Group, an early RFID adopter in Europe, is using Philips' RFID technology to improve supply-chain efficiencies and customer satisfaction.

#### KEY PRODUCTS AND MARKETS:

Semiconductors for various applications, RFID ICs for tags and readers, and ICs for smart cards

	2003	2004E	2005E
Revenue (Mil.)	\$34,100	—	—
EPS	\$0.75	\$2.24	\$2.34

#### RECENT EVENTS:

Date	Event
January 2004	Announces alliance with IBM to develop RFID and Smart Card solutions
September 2003	Announces EPC-compliant 13.56 MHz RFID IC
April 2003	Announces Metro group using tags based on Philips ICs

#### MANAGEMENT:

Gerard Kleisterlee, President and CEO  
Jan Hommen, Executive VP and CFO

MARKET CAP: \$36.72 billion

PRICE: \$28.87

#### SHARE PRICE HISTORY

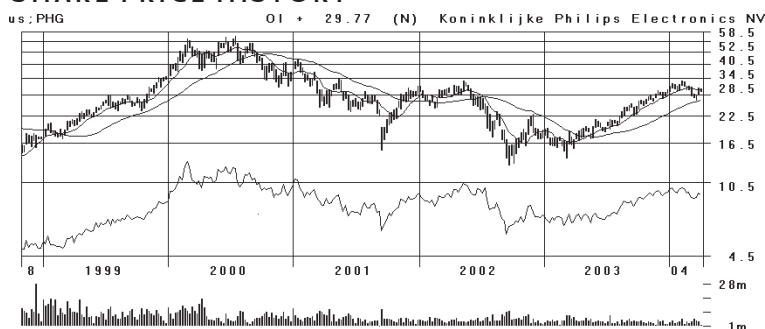


Chart courtesy of Bridge Information Systems

April 2004

Printronix, Inc.  
Nasdaq: PTNX

Irvine, CA



**COMPANY DESCRIPTION:**

Founded in 1974, the name Printronix, Inc. is synonymous with line printers. Currently, the company focuses on industrial and back-office enterprise printing solutions for a variety of industry groups including retail and apparel, automotive, manufacturing, and health care. Products include line matrix printers, laser line printers, and thermal printers for barcode applications. RFID products include smart-label printers and smart labels. Printronix is selling a broad set of technologies, including RFID solutions, tailored to specific industry solutions.

**KEY PRODUCTS AND MARKETS:**

Line matrix printers, laser line printers, thermal printers for barcode applications, smart labels, and smart-label printers

	2003	2004E	2005E
Revenue (Mil.)	\$138.0	—	—
EPS	\$0.51	\$0.20	\$0.89

**RECENT EVENTS:**

Date	Event
February 2004	Returns to profitability with improved sales in fiscal fourth quarter
December 2003	Introduces RFID Class 1 UHF printer
September 2003	Announces alliance with Alien Technology to develop RFID printing solutions

**MANAGEMENT:**

Robert A. Kleist, President and CEO  
George L. Harwood, Senior VP and CFO

**MARKET CAP:** \$77.73 million

**PRICE:** \$13.13

**SHARE PRICE HISTORY**

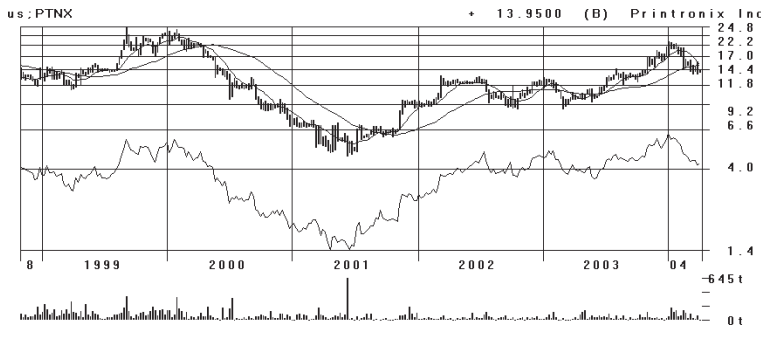


Chart courtesy of Bridge Information Systems

April 2004

Psion Teklogix Inc.  
PON.L , PON.TO

Mississauga, Ontario,  
Canada




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**COMPANY DESCRIPTION:**

Psion Teklogix was formed as a result of a merger between U.K.'s Psion PLC and Canada's Teklogix Inc. in 2000. The company provides mobility computing solutions and its products include handheld computers and scanners, network management software, WLAN solutions, and vehicle-mount computers. The company's products are used in airports, the automotive field, chain, field service, government, ports/container yards, transportation, warehousing and distribution, and other markets. The company has integrated the RFID technology in its handheld products in collaboration with Lab-ID, an Italian start-up company.

**KEY PRODUCTS AND MARKETS:**

Handheld computers and scanners, network management software, WLAN solutions, and vehicle-mount computers

**RECENT EVENTS:**

<b>Date</b>	<b>Event</b>
January 2004	Wins patent case related to barcode technologies along with other companies
May 2003	Forms alliance with Wavetrend Technologies to provide RFID solutions
April 2003	Announces partnership with Zebra

**MANAGEMENT:**

Norbert Dawalibi, President and CEO  
Michael Conway, Senior VP and CFO



April 2004

SAMSys Technologies Inc.  
SMY:TSX-VEN

Richmond Hill, Ontario,  
Canada



**COMPANY DESCRIPTION:**

Canada-based SAMSys was founded in 1995 and is publicly traded in Canada. SAMSys' primary competency lies with its innovative reader designs. These readers are multi-frequency and multi-protocol devices. SAMSys readers provide customers with flexibility in RFID deployments by supporting a variety of frequency and communications protocol. The company also provides consulting services for RFID installation and integration.

**KEY PRODUCTS AND MARKETS:**

RFID readers for LF, HF, and UHF bands

**RECENT EVENTS:**

<b>Date</b>	<b>Event</b>
March 2004	Introduces new RFID readers
November 2003	Announces partnership with SATO for RFID-enabled barcode printers
October 2003	Raises C\$13.2 million in private financing

**MANAGEMENT:**

Clifford A. Horwitz, CEO  
Tres Wiley, President and COO  
George Kypreos, VP and CFO

April 2004

Symbol Technologies, Inc.  
NYSE: SBL

Holtsville, NY



**COMPANY DESCRIPTION:**

Founded in 1975, Symbol Technologies, Inc. is a leading provider of mobility solutions for enterprise and vertical applications such as retail, transportation, manufacturing, and life sciences. Symbol's products include handheld wireless barcode scanners, wireless LAN switches, handheld computers, mobility software, and other hardware that makes organizations more agile. The company enjoys a clear leadership position in handheld barcode scanners and a comprehensive product suite geared toward improving productivity by enhancing mobility. Given its heritage as the leading barcode scanner company, it is natural for Symbol to be a player in the RFID market. Symbol is integrating RFID capabilities in its handheld barcode scanners as the market transitions from barcode to RFID.

**KEY PRODUCTS AND MARKETS:**

Handheld barcode scanners, portable computers for retail, logistics, health care, and manufacturing markets. Enterprise WLAN solutions.

	2003	2004E	2005E
Revenue (Mil.)	\$1,507	\$1,724	\$1,952
EPS	\$0.20	\$0.44	\$0.69

**RECENT EVENTS:**

Date	Event
March 2004	Two independent directors added to board
March 2004	Announces support for EPCglobal IP agreement
January 2004	Names Philip Lazo as leader of RFID division

**MANAGEMENT:**

William Nutty, CEO  
Mark Greenquist, Senior VP and CFO  
Todd Abbott, Senior VP - Worldwide Sales

**MARKET CAP:** \$3.11 billion

**PRICE:** \$13.34

**SHARE PRICE HISTORY**

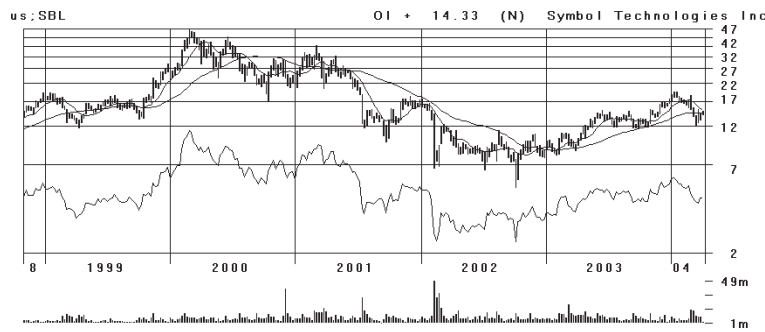


Chart courtesy of Bridge Information Systems

timlee11

April 2004

Texas Instruments  
Incorporated  
NYSE: TXN

Dallas, TX



**COMPANY DESCRIPTION:**

Texas Instruments Incorporated (TI) is the leader in semiconductor business with a wide range of products. The company's products include DSP chips, analog and mixed signal processors, logic parts, microcontrollers, and calculators. The company has established a formidable technology and market position in digital signal processing (DSP). To address the RFID market, TI established TIRIS (Texas Instruments Registration and Identification System) in 1991. TIRIS changed its name to TI-RFID in January 2001. TI-RFID has focused mainly on products in low- and high-frequency bands and has about 100 million tags in circulation.

**KEY PRODUCTS AND MARKETS:**

Semiconductors for analog, digital, and mixed signal applications

	2003	2004E	2005E
Revenue (Mil.)	\$9,834	\$12,548	\$14,212
EPS	\$0.46	\$0.00	\$1.32

**RECENT EVENTS:**

Date	Event
February 2004	Joins EPC hardware action group
September 2003	Declares intent to join EPC and develop UHF tag
September 2003	Doubles production capacity for 13.56 MHz smart-label inlays

**MANAGEMENT:**

Tom Engibous, President and CEO  
Rich Templeton , Executive VP and COO  
Kevin March, Senior VP and CFO

**MARKET CAP:** \$48.3 billion

**PRICE:** \$27.90

**SHARE PRICE HISTORY**

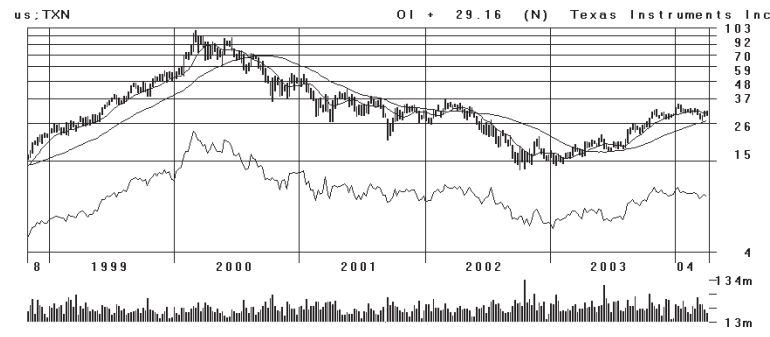


Chart courtesy of Bridge Information Systems

April 2004

Tyco Sensormatic  
NYSE:TYC

Boca Raton, FL



**COMPANY DESCRIPTION:**

Tyco Sensormatic is a unit of Tyco's Fire & Security division. Sensormatic is a leader in EAS systems, which are used to deter shoplifting and internal theft at retail outlets. Customers include the top 100 retailers worldwide. The company is utilizing its strong retailing presence to cross-sell its RFID products. RFID products include tags and readers. Sensormatic also offers software and integration services. In November 2003, the company announced the formation of the epcStars alliance to provide turnkey RFID solutions. Members of the alliance include reader technology provider ThingMagic, among others.

**KEY PRODUCTS AND MARKETS:**

Electronic Article Surveillance (EAS) products, RFID tags and readers, software, and system integration services

	2003	2004E	2005E
Revenue (Mil.)	\$36,805	\$39,119	\$41,773
EPS	\$1.30	\$1.51	\$1.81

**RECENT EVENTS:**

Date	Event
November 2003	Announces formation of epcStars
September 2003	Announces EPC-based RFID products
April 2003	Forms RFID Solutions Team to address the opportunity

**MANAGEMENT:**

Edward D. Breen, Chairman and CEO  
David J. FitzPatrick, Executive VP and CFO  
David E. Robinson, President (Tyco Fire & Security)

**MARKET CAP: \$56.82**

**PRICE: \$28.41**

**SHARE PRICE HISTORY**

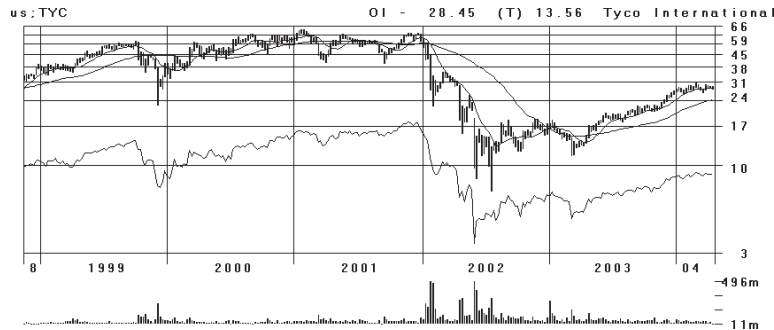


Chart courtesy of Bridge Information Systems



April 2004

Zebra Technologies Corporation  
Ticker: ZBRA

Vernon Hills, IL



**COMPANY DESCRIPTION:**

Illinois-based Zebra Technologies is the market leader, providing specialty print solutions. The Zebra brand for printing solutions is akin to the Xerox name in copiers and Kleenex tissue brand. Today, Zebra's printers primarily serve the barcode, receipt, and ID card market. The company expects to see an increasing mix-contribution from its RFID product line. Zebra will lever its installed base of more than 3 million printer, heavy commitment to R&D spend, and strong balance sheet to grow its RFID business. Zebra had sales of \$536 million in 2003 and employed roughly 2,200 people.

	2003	2004E	2005E
Revenue (Mil.)	\$536	\$611	\$703
EPS	\$1.93	\$2.24	\$2.59

**RECENT EVENTS:**

Date	Event
February 2004	Zebra supports FDA barcode mandate
February 2004	Volume production begins on EPC compliant RFID encoders
November 2003	Zebra acquires Atlantek Inc.

**MANAGEMENT:**

Edward Kaplam, CEO  
Charles Whitchurch, CFO

**MARKET CAP:** \$3.41 billion

**PRICE:** \$71.79

**SHARE PRICE HISTORY**

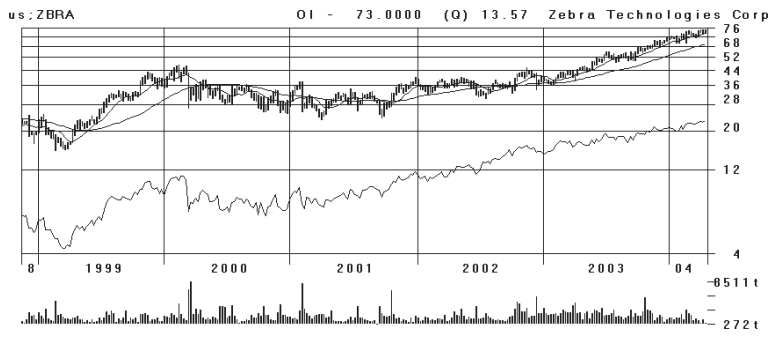


Chart courtesy of Bridge Information Systems

April 2004

Alien Technology  
Corporation

Morgan Hill, California




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**COMPANY DESCRIPTION:**

Originally founded as Beckman Display, the company changed its name to Alien Technology in 1999. Alien is a leading RFID hardware provider to a broad range of end-markets, including retail, CPG, life science, and more. The company provides a full suite of products that consist of readers, passive tags, and battery assist tags. Through a patented manufacturing process called Fluidic Self Assembly (FSA), the company plans to produce EPC class 1 tags in huge volumes at a very low price. The company has manufacturing facilities in Morgan Hill, CA and is building an expansion facility in Fargo, ND, for high volume production.

**KEY PRODUCTS AND MARKETS:**

EPC UHF RFID tags and readers, 2450 MHz passive tags and readers, 2450 MHz battery-assisted passive (BAP) tags and readers

**RECENT EVENTS:**

<b>Date</b>	<b>Event</b>
March 2004	Initial operations begin in the Fargo, ND manufacturing facility
August 2003	Receives \$38 million in Series-F financing
January 2003	Receives order for 500 million tags from Gillette

**MANAGEMENT:**

Stavro E. Prodromou, CEO  
Hohn M. Hemingway, VP Finance and CFO  
Keith Scott, Senior VP, Sales and Marketing

**BOARD MEMBERS:**

Tom Baruch, Chairman  
Stavro E. Prodromou, CEO  
Dave Shrigley, Director  
Michael E. Marks, Director  
Arno A. Penzias, Director  
John S. Smith, Director  
Ben Terk, Director  
Faysal Sohail, Director

**INVESTORS:**

Adams Street Partners	Forsythe Technology
Advanced Equities	H & S Ventures
Avery Dennison	Lago Ventures
Beagle Ltd.	Manhattan Associates
CMEA Ventures	New Enterprise Associates
Digital Bandwith	Quan Ventures
Dow Chemical Company	RHO Ventures
Equitek Capital	Sevin Rosen Funds
First Analysis	

April 2004

Matrics, Inc.

Columbia, MD




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**COMPANY DESCRIPTION:**

Maryland-based Matrics was founded in 1999 by a pair of ex-National Security Agency scientists and has evolved today into a holistic RFID solutions provider. The company delivers RFID solutions to a broad set of industry groups that include the retail, defense, CPG, transportation, and others. Matrics is end-to-end on the product side by providing a suite of hardware that goes deep and wide with some of the best-in-class readers, read/write tags, and antennas. The AR400 multi-protocol reader and a 288-bit read/write tag are examples of new products launched by Matrics, and of the company's ability to innovate leading edge products. The company's proprietary tag assembly process, named Parallel Integrated Circuit Assembly (PICA), promises to rapidly ramp tag-assembly capabilities compared to traditional flip-chip assembly processes is designed. The company has notched several impressive blue chip clients including International Paper and Las Vegas's McCarran International Airport, as well as inked many industry-specific partnerships.

**KEY PRODUCTS AND MARKETS:**

Holistic RFID Solutions: RFID tags, readers, and antennas

**RECENT EVENTS:**

<b>Date</b>	<b>Event</b>
March 2004	Checkpoint Systems Agrees to Purchase 100 million Matrics tags
March 2004	Launches AR400 Advanced Multi-protocol reader
March 2004	Introduces 288 bit read/write tags
December 2003	Matrics announces contract with International Paper

**MANAGEMENT:**

Piyush Sodha, CEO  
 Rick Mora, Senior VP, Finance and Administration  
 Tom Coyle, Senior VP, Business Development

**BOARD MEMBERS:**

A.G.W. Biddle, III - Novak Biddle Venture Partners  
 Brook Coburn - The Carlyle Group  
 Mark Ein - Venturehouse Group  
 Michael Arneson - Founder and CTO  
 Piyush Sodha - CEO, Matrics

**INVESTORS:**

Novak Biddle Venture Partners; The Carlyle Group; Polaris Venture Partners; Venturehouse Group; Silverhaze Partners; Piper, Marbury, Rudnick & Wolf

April 2004

TAGSYS

France



**COMPANY DESCRIPTION:**

TAGSYS was spawned out of Gemplus in 2001 as a result of a management buyout. Despite being a fairly young independent company, TAGSYS has a rich heritage as an RFID innovator. The company pioneered many of the RFID innovations at 13.56 MHz. Today TAGSYS remains a leading provider of RFID chips, tags, antennas, and readers primarily in the 13.56 MHz range. The company has focused on libraries and textile rental services as the near-term growth markets.

**KEY PRODUCTS AND MARKETS:**

RFID tags, readers, antennas, and chips for 13.56 MHz frequency band

**RECENT EVENTS:**

<b>Date</b>	<b>Event</b>
February 2004	Introduces RFID "tunnel" system for industrial applications
February 2004	Introduces RFID-enabled smart shelves
June 2003	Demos world's smallest EPC tag - 9mm diameter

**INVESTORS:**

AXA Private Equity  
Saffron Hill  
Endeavour L.P.





ThingMagic LLC

Cambridge, MA



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**COMPANY DESCRIPTION:**

The company's principal activities include designing and prototyping embedded intelligence technologies. ThingMagic's core competencies can be segmented into three main practice areas: RFID technologies, embedded computing, and wearables and smart fabrics. One of the company's claims to fame in the RFID arena is its development of an "agile reader"—a reader that can operate at all frequencies and can be upgraded by software. ThingMagic has licensed its agile technology to companies like Tyco-Sensormatic and OMRON. The company is partnered with Intel to develop a next-generation reader.

**KEY PRODUCTS AND MARKETS:**

Intellectual property for RFID and embedded systems

**RECENT EVENTS:**

Date	Event
September 2003	Teams up with Intel for readers
February 2003	Licensing agreement with Tyco for readers

**MANAGEMENT:**

Thomas H. Grant, Chairman & CEO

**ADVISORS:**

Thomas H. Grant  
Neil Gersherfeld

Savi Technology

Sunnyvale, CA

**COMPANY DESCRIPTION:**

Sunnyvale, CA-based, Savi Technology was founded in 1989 as an innovator providing logistics and supply chain management solutions. Savi was acquired in 1995 by Texas Instruments, sold to Raytheon in 1997, and was re-acquired by management, venture, and corporate partners in 1999 becoming a private company once again. The company introduced the "smart container" in 1992 and in the middle 1990s emerged as the DoD's primary RFID supplier. Today, Savi is a proven RFID network architect that integrates the company's active RFID tags, readers, and signposts with other partner supplied automatic identification technology including passive tags and satellite technology on a common network platform built by Savi. The company's success with the complicated DoD logistics network is leading to work with international government organizations including Britain's MOD and NATO. Savi is the largest government provider of RFID solutions.

**RECENT EVENTS**

<b>Date</b>	<b>Event</b>
March 2004	Leading RFID platform, SmartChain Enhanced
March 2004	NATO enlists Savi for RFID Logistic's Pilot
February 2004	Next-generation tag and software debuts

**MANAGEMENT:**

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 Jerry Beckwith, COO  
 Steve Cole, VP Finance

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 Oracle Corp  
 TIBCO Software  
 UPS

April 2004

WhereNet Inc.

Santa Clara, CA



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**COMPANY DESCRIPTION:**

Founded in 1997, WhereNet is a leading provider of wireless location and communications solutions for managing mobile resources in supply chain. The company's core focus is to provide solutions for optimizing supply chain flow in industrial, retail, transportation, and logistics settings. Key customers include Ford Motor Company, General Motors, BMW, GE Medical Systems, and Coca-Cola. According to the company, its customers are able to achieve a complete return on investment within nine to twelve months.

**KEY PRODUCTS AND MARKETS:**

WhereNet RTLS - an integrated wireless infrastructure for real-time location, messaging, telemetry, and 802.11b for industrial, retail, transportation and logistics applications.

**RECENT EVENTS:**

<b>Date</b>	<b>Event</b>
March 2004	Signs Tchibo as a customer
February 2004	Launches fully automated wireless solution for automotive assembly lines
November 2003	WhereNet technology deployed at BMW

**MANAGEMENT:**

Dave Wisherd, Chairman  
Dan Doles, President & CEO  
Patrick Murray, CFO

**INVESTORS:**

Bay Partners, Crescendo Ventures, Crosspoint Venture Partners, Foundation Capital, RWI Group

April 2004

**BIOGRAPHIES**

**Brian Gesuale** is a vice president at Piper Jaffray and a senior research analyst covering RFID and homeland security technologies. Previously, Gesuale followed the technology and business service segment at Piper Jaffray.

Prior to joining Piper Jaffray, he served as a Captain in the U.S. Air Force. While in the Air Force, Gesuale led a transcontinental development team that created the Air Force's first family of self-sufficient commercial satellite imagery systems, Eagle Vision, for the U.S. Air Force's Headquarters Office of Modeling and Simulation at the Pentagon in Washington, D.C. Before that, he was a program manager at the U.S. Air Force's Electronic Systems based at Hanscom AFB in Massachusetts, overseeing development of the B-2 Stealth Bomber's Mission Planning System.

Gesuale has a bachelor's degree in economics from the U.S. Air Force Academy in Colorado Springs, Colo., and a master's degree in finance from Bentley College in Waltham, Mass.

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**Parag Agarwal** is a Research Analyst at Piper Jaffray covering RFID and Homeland Security Technologies. He joined Piper Jaffray in 2003. Prior to joining Piper Jaffray, Agarwal had held marketing and engineering positions at telecommunication, networking and computer hardware companies and worked as an analyst for a technology focused venture capital fund.

Agarwal holds an engineering degree in Computer Science from M.S. University in India and master's degree in business administration from the Carlson School of Management at the University of Minnesota.

April 2004

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Distribution of Ratings/IB Services Firmwide and by Sector					RFID & Homeland Security Sector				
Piper Jaffray		IB Serv./Past 12 Mos.			RFID & Homeland Security Sector		IB Serv./Past 12 Mos.		
Rating	Count	Percent	Count	Percent	Rating	Count	Percent	Count	Percent
BUY [SB/OP]	250	54.23	46	18.40	BUY [SB/OP]	4	100.00	0	0.00
HOLD [MP]	185	40.13	20	10.81	HOLD [MP]	0	0.00	0	0.00
SELL [JP]	26	5.64	1	3.85	SELL [UP]	0	0.00	0	0.00

Notes: The boxes on the Rating and Price Target History chart above indicate the date of the Research Note, the rating, and the price target. Each box represents a date on which an analyst made a change to a rating or price target, except for the first box, which may only represent the first Note written during the past three years. Distribution of Ratings/IB Services Firmwide and by Sector shows the number of companies in each rating category from which Piper Jaffray received compensation for investment banking services within the past 12 months.

### Analyst Certification—Brian Gesuale, Vice President, Senior Research Analyst

The views expressed in this report, including the Key Points and Risk sections in particular, accurately reflect my personal views about the subject Company and the subject security. In addition, no part of my compensation was, is, or will be directly or indirectly related to the specific recommendations or views contained in this report.

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