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# Supply Chain Technology

## RFID To Get Boost, But Investment Options Remain Limited

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## Action

Wal-Mart is expected to announce today that it will encourage its top 100 vendors to develop radio frequency identification (RFID) supply chain applications. We view this as helpful in lowering the barriers to RFID adoption, not as a signal that RFID is ramping up. We are publishing this note in response to significant inquiry activity, and while we are enthusiastic about RFIDs opportunities, we view near-term investment potential as limited.

## Summary

- RFID is a semi-conductor based wireless technology that enables advanced item tracking, similar in concept to bar coding.
- To date, RFID as been implemented in niche applications. These have largely been limited to large assets, where RFID's relatively high cost is easily offset by the incremental tracking benefits of higher cost items.
- We believe RFID faces several impediments to mass adoption, including high cost, underdeveloped standards, privacy concerns and weak market understanding of the technology.
- However, we expect RFID will receive a boost today from Wal-Mart, which is expected to announce that it will ask its top 100 suppliers to adopt RFID technology by 2005.
- While we expect Wal-Mart's endorsement will be helpful in reducing several of the abovenamed impediments, we continue to expect that the technology will see only measured adoption for the next several years, not a significant rollout.
- We view near-term investment opportunities as limited.
- Currently, RFID has relatively few public players. The companies with the most exposure include Unova (Intermec), Philips and Texas Instruments. Zebra, Fargo, Symbol, NCR and Brady are emerging players. Key private companies include Alien Technologies, Matrics and Savi. Checkpoint and Tyco participate in a sister technology to RFID, electronic article surveillance (EAS).

# Details

Radio Frequency Identification (RFID) is a technology that provides wireless identification and tracking capability. The tracking capability is similar to that of a bar code. RFID, which was developed during WW II, first appeared commercially in the early 1980s. The technology has historically been used for high-end asset tracking and security applications. We expect the RFID market, which is relatively underpenetrated, will improve its position in the broader supply chain market. According to market research firm Venture Development Corporation, and our own estimates, the worldwide market potential for RFID technology is expected to reach roughly $2.0 billion by 2005, up from just under $1.0 billion at the end of 2002, resulting in annual growth of approximately 25% per year. These figures include hardware, software and services.

To date, RFID has been implemented in mostly niche applications. These have largely been limited to higher-end items, where the relatively high cost of RFID is easily offset by incremental tracking benefits (see explanation below for the incremental tracking benefits from RFID). For example, Ford uses RFID to track engine blocks through their harsh production process. The Gap uses RFID to track blue jeans through the supply chain. Mobil / Exon's SpeedPass product is based on RFID technology.

Despite the success in niche applications, we expect RFID will face significant impediments to mass adoption in the near term. First, RFID has a relatively high cost. The lowest end RFID tags currently cost over $0.50, which is very expensive relative to bar code labels, which cost less than $0.01. Further, the current item tracking infrastructure is largely oriented towards bar coding (i.e., laser scanners). Second, RFID standards remain in a development phase. Most technologies require standardization before any significant adoption, and we view RFID as no different. Several national and international standards bodies are composing standards, but several issues remain. Third, many in the market have privacy concerns. Because RFID tags are generally embedded into an time, privacy advocates have sounded alarms that end users may be tracked without their knowledge. Such concerns led Benneton to stop an RFID pilot that it had underway. Fourth, we believe that most resellers lack significant understanding of the RFID technology and, therefore, have not developed any meaningful end market solutions.

Nonetheless, we expect RFID will receive a boost today from Wal-Mart, which intends to announce that it will ask its top 100 suppliers to adopt RFID technology by 2005. Wal-Mart will ask these suppliers, which represent large consumer product companies, to use RFID technology to improve their overall supply chain capability. Wal-Mart, and several manufacturers, have been piloting RFID technology during the past several years. This group includes Proctor & Gamble, Gillette (note that Gillette has announced that it intends to purchase 500M tags from Alien Technologies), International Paper, Kraft, Johnson & Johnson and Unilever. We believe Wal-Mart's official endorsement will aid in reducing the hurdles listed above, particularly in standards development and reseller knowledge. We expect a large retail player like Wal-Mart, which can drive the associated consumer products companies to adopt the technology, will accelerate the standards development process. Further, since most of these players lack any meaningful RFID knowledge, we expect the reseller community will be significantly incented to develop solutions (we expect the few resellers that have strong RFID understanding will initially be inundated).

However, while we expect Wal-Mart's announcement will improve RFIDs opportunities, we remain cautious in the near term. We expect that even with Wal-Mart's clout, generating standards and reseller solution development will take time. Also, given that other hurdles need to be addressed, we expect that the technology will see only see measured adoption for the next several years.

Currently, RFID has relatively few public players. The companies with the most exposure include Unova, Philips, Texas Instruments as well as other several international players. Unova's Intermec unit produces RFID tags. Philips produces the semi-conductors which go into RFID technology. Texas Instruments is the largest tag producer, but represents an immaterial amount of total company revenue. We expect that several players in the bar code industry, such as Zebra, Fargo and Symbol, will increase their presence in RFID. Zebra has two products capable of encoding RFID tags. Fargo's HDP printing technology is used for smart carding applications. SBL is expected to introduce several new RFID products by year end. Key private players include Alien Technologies, Matrics and Savi. For a full list of industry players, please refer to Baird's Supply Chain Technology Industry Overview, published in February 2002.

The sections below explain several of the RFID basics. It may be more than you would like to know, but we wanted to provide some detail since the technology is relatively new to most in the investment community.

## A Comparison of RFID and Bar Coding

Conceptually, bar coding and RFID are similar; both are intended to provide rapid and reliable item identification and tracking capability. The primary difference between the two technologies is that bar coding scans a printed label with optical laser and imaging technology, while RFID scans, or interrogates, a semi-conductor tag using radio frequency (wireless) technology. Historically, bar coding, because of its low cost, established standards and broad-based deployment, enjoys wide acceptance, while RFID, with generally superior functionality, has been limited to niche applications because of its incomplete standards, relatively higher cost and lack of market understanding. As a result, bar coding has a substantially larger market position than RFID. However, we expect that the need for increased tracking and security capability, combined with RFID's significantly underpenetrated market position, will allow RFID to experience greater growth relative to bar coding in the next several years. We expect RFID and bar coding will act as complementary technologies for the foreseeable future.

### Key Attributes of RFID (with respect to bar coding)

The key attributes to consider when comparing RFID and bar coding center around reading capability, reading speed, tag or label durability, amount of information, flexibility of information, security, cost, standards, education and supporting infrastructure. In this section, we compare and contrast RFID and bar coding with respect to each of these important attributes.

***Reading Capability*** - Unlike bar code scanning, RFID does not require line-of-sight to read the tag information as the radio frequency (RF) signal is capable of traveling through a wide array of materials (although metals and liquids create difficulty). This

capability is particularly advantageous in warehouse receiving operations, where an entire pallet of boxes can be scanned without having to break down the pallet. This attribute may also be important in operations where information needs to be collected from items which may have an inconsistent orientation, such as airport baggage handling or package sorting applications. In addition, an RFID reader is able to distinguish and interface with an individual tag despite multiple tags that may be within the given read range. We believe this capability is particularly critical in environments such as large warehousing and distribution centers where hundreds of different items may be in close proximity to each other.

***Reading Speed*** - In terms of speed, RFID tags can be read far more rapidly than a bar code label can be scanned. RFID readers are capable of interpreting up to 50 tags per second, where bar code scanners read one label at a time. The speed of RFID has great value in high-volume receiving and shipping applications where a large number of items need to be accounted for quickly. Since the process of collecting information requires less time, less labor hours are required. Workers can spend more time on value-added tasks, resulting in greater inventory efficiency.

***Durability*** - Because RFID tags can be encased in hardened plastic substrates, they are significantly more durable than bar code labels, which are typically paper based. The added durability of an RFID tag allows for item tracking through harsh production processes. Further, the durable nature of RFID tags allows them to last longer than bar code labels.

***Amount of Information*** - RFID tags can store significantly more information than a bar code label. The traditional linear or 1D bar code stores up to 20 alphanumeric characters, while a 2D bar code can store up to 2,000 characters. High-end RFID tags can contain up to one megabyte of memory (one million characters), although most tags only contain a small fraction of this memory. This increased information storage capability creates a portable database of information, allowing a greater number of product attributes to be tracked, including bill of lading information, special care instructions (i.e., hazardous material) and a history of transport log.

***Flexibility of Information*** - With respect to information dynamics, RFID tags are able to support read/write operations, enabling real-time information updates as an item moves throughout the supply chain. This feature can be of critical importance as production schedules, delivery dates and locations, and shipment contents can change on a regular basis. Bar codes, by contrast, contain static information and, therefore, must be replaced with a new label in order to update information.

***Cost / Infrastructure*** - RFIDs' robust functionality can easily lead to significant improvements in supply chain operations; however, we believe overall system cost is a key reason why this enhanced functionality remains under-used. A low-end RFID tag costs approximately $0.50, with high-end tags reaching up to $250 each. That compares to less than $0.01 for a bar code label. In addition, RFID requires new infrastructure, such as RFID readers that can cost $100 or more each. Further, RFID solutions often involve a challenging front-end integration process. As a result, even with the enhanced functionality, many end users have found it difficult to justify the cost of an RFID system.

***Standards / Education*** - Two other key issues that have impeded the adoption of

RFID are standards and education. Current industry RFID standards are largely incomplete with respect to addressing a number of technology and application issues. We believe the lack of standards keeps potential users from investing in RFID for fear that supply chain partners may use an incompatible RFID format, or that future standards may obsolete current RFID formats. We view the lack of standards as a key factor in preventing RFID from achieving lower costs. By contrast, bar coding, over the past 25 years, has been widely adopted as the technology is relatively standardized.

From an education perspective, we believe the majority of potential RFID users, and resellers, lack a clear understanding of the potential RFID benefits, instead they remain weary of RFID's relatively high cost. We believe that penetration will increase as value-added resellers learn and deploy creative new RFID applications and provide end users with a thorough understanding of RFID's benefits. In the past year, vendors have placed an increased emphasis on reseller education. Again, by contrast, bar coding applications are relatively well understood, even at the consumer level. As a result, supply chain participants seem to understand the strong value proposition associated with bar coding.

## RFID Overview

At its core, RFID uses wireless and semi-conductor technology as a means of identifying and tracking items. The typical RFID system requires a transponder tag, which is a semi-conductor capable of storing significant amounts of information (up to one megabyte), an antenna, tag programming equipment and a tag reader. RFID tags can be affixed to a wide variety of items for the purpose of identification and tracking. Each tag has an unchangeable manufacturer installed unique identification code as well as additional available memory. When an RFID tag passes within the given read range, the reader, which may be handheld or stationary, detects the tag and interprets the corresponding RF signal via the antenna. The reader is capable of storing and transferring item information, which may include the item stock number, current location, status as well as a wide variety of other potential information, to an ERP or other host computer system.

### Types of RFID Tags

RFID tags come in two major classes, active and passive. The primary difference between an active and passive tag is the power source, which in turn determines a number of key attributes, including signal strength, memory capability, size and cost.

A passive tag does not contain a local power source (i.e., a battery) for signal transmission, and therefore, relies on power created by the reader itself. An RF transceiver, or module, projects RF energy from the reader that is capable of providing the necessary power to a passive tag. Note, however, that passive tags may use a small battery to maintain tag memory. Since energy from the reader supplies transmission power, passive tags operate only over relatively short ranges, and have difficulty performing well in environments where a large degree of interference is present. Without an internal battery for memory, passive tags also have limited memory capability. Passive tags are less expensive, smaller in size, lighter in weight, have longer lives and are subject to less regulation relative to active tags.

Active tags contain a battery that acts as a local power source for transmission purposes. This enables a stronger signal, which gives active tags a number of advantages over passive tags, including longer read ranges, less susceptibility to interference and greater memory capability. However, due to the addition of the battery, active tags are typically larger, more expensive, and have shorter life expectancies than passive tags.

Tags also have differing types of memory, including read-only, read/write, and write-once read-many (WORM). Read-only tags, which are typically passive, are relatively low capacity (less than 128 bits) and contain data that is permanently programmed during the manufacturing process. In this respect, they are similar to a bar code where stored information is used primarily in an "identifier" capacity. This category of tag offers a high-degree of security since the pre-specified information cannot be altered. Read-only systems are generally used in applications where a central or host computer contains and controls the information associated with the item to be identified, such as in library checkout or video rental applications.

By contrast, read/write tags store data that can be read and updated on an as-needed basis. Read/write tags typically have larger memory capacity and thus can function as portable databases. The ability to capture, store and communicate more information about an item can facilitate improved information flow and result in more informed decision-making, ultimately improving productivity and reliability. While read/write tags are more expensive than read-only tags, they are beneficial in applications where data may need to be altered throughout a product's life, such as in a manufacturing process or parcel delivery.

Incorporating features of both read-only and read/write tags, a write-once, read-many (WORM) tag enables users to store information only once, after which users cannot alter the stored data. As a result, it has the security benefits of read-only tags while incorporating some of the additional functionality offered by read/write tags. We believe these tags will be used where security is a key factor in a number of supply chain tracking applications, such as distribution and logistics.

Also important in determining the characteristics of an RFID system is the frequency employed. In general, the higher the frequency, the more robust set of RFID characteristics with respect to read-range and reading speed. Higher frequencies tend to be more expensive as well. We expect supply chain related applications will be increasingly focused on the higher frequency ranges.

**Applications**

While we have indicated that the development of standards will be the key catalyst in driving RFID growth, we believe that RFID currently fits into a number of niche applications, which we believe will generate near-term growth. These niche applications exist where bar coding is either an incomplete or only partial solution, or where the benefit of the RFID functionality is greater than its relatively higher cost. The following highlight some current RFID applications.

***Industrial Applications*** - From an industrial perspective, we expect RFID to gain momentum in the tracking of higher-value items, where the relative cost of the tag becomes immaterial. In addition, we expect RFID will become more common in

environments where direct line of sight is not always a feasible or convenient option, such as item-level tracking of components through an entire manufacturing process, particularly in harsh environments, or in warehousing and package receipt applications. We believe RFID will see increased penetration in environments where current bar coding processes still require a large degree of manual intervention. For instance, in high-speed sortation settings, the use of bar code labels requires manual intervention in order to "face" the label with the scanner. Using RFID eliminates this manual process as line of sight is not necessary.

***Logistics Applications*** - RFID tags can be placed on pallets or on large containers, helping to automate the process of loading and unloading, tracking, highway compliance, manifest confirmation, etc. Savi, through the use of its software product, has created a solution that uses both bar coding and RFID. Savi's solution allows smaller packages that are typically bar coded to be aggregated up to the pallet level, which is tracked via RFID. Thus the single RFID tag can account for all bar coded packages until the pallet is broken down, then the bar codes allow tracking of individual items.

***Retail Applications*** - At the consumer level, Mobile/Exxon's Speedpass solution allows consumers to use a unique RFID transponder, which can fit on a key chain or reside in the vehicle, to authorize purchases at the gas pump or in the store. The RFID system is linked to the consumer's credit card information. The Speedpass solution is at use in over 3,800 Mobile stations and by over 4 million customers. The key chain Speedpass RFID solution has also been extended to several McDonald's restaurants on a test basis, where customers pay using the Speedpass RFID tag.

Another common application for radio frequency tagging in retail is security, which is called electronic article surveillance (EAS), a sister technology to RFID. EAS systems prevent theft of items in the retail environment through a tag attached to an item sold at retail. The EAS system sounds an alarm when unpurchased items are passed beyond the checkout station. Checkout clerks disable the tag when an item has been purchased. Tyco (Sensormatic) and Checkpoint are key EAS players.

***Toll Collection Applications*** - Another common consumer application is toll collection, where drivers no longer have to stop at the booth to pay a toll. Instead, the RFID transponder in their car allows the car to automatically register at the booth. A pre-paid account is appropriately debited, thus allowing the car to drive through the booth without having to stop.

***Livestock Tracking Applications*** - RFID tags can be attached or embedded directly into livestock for use in tracking feeding, breeding practices, disease management and other processes. Using RFID technology can make farm management and research a more automated process.

***Smart Carding Applications*** - RFID tags are increasingly being placed into plastic identification cards for a wide variety of applications. Key application examples include security authorization and healthcare, where a complete medical history as well as insurance information is contained on the card.

***Supply Chain Applications*** - We believe a substantial longer-term opportunity

exists in creating complete supply-chain RFID solutions, not just for niche applications. Combining the portable database capability and the ease of data communication makes RFID a powerful solution to improve the amount and flow of supply chain information. We believe solutions that allow the tracking of items on a cradle-to-grave basis will significantly enhance marketing and operational intelligence, thus improving supply chain delivery capabilities. One key to achieving this capability is for all supply chain participants to operate off of the same RFID solution, which will require continued standards development and partnering.

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