BEAR STEARNS

Equity Research

# Supply-Chain Technology

## Track(ing) to the Future

### The Impending RFID-Based Inventory Revolution

- **A REVOLUTION IS COMING . . .** After a slow start in the 1970s, appearing first in grocery, bar coding has evolved to become ubiquitous in retail and logistics, increasing precision and productivity within the global supply chain. We expect the impending change to radio frequency identification (RFID) to look more like a revolution. Enormous potential productivity and visibility improvements across the supply chain and the existing bar code infrastructure should trigger a much faster adoption cycle than bar codes experienced, and change the way inventory is produced, warehoused, and distributed.

- **. . . PROBABLY SOONER THAN YOU THINK.** Broader adoption of RFID is approaching quickly as major retailers and CPG firms begin requiring suppliers to be RFID-compliant next year and in 2005. Moreover, open standards for RFID are expected to be available by September as this initiative gains momentum, driven largely by materially lower-cost RFID devices with improved performance. In fact, Wal-Mart is expected to announce shortly that its suppliers must be RFID-compliant by January 2005.

- **OPPORTUNITY FOR SUPPLY-CHAIN LEADERS.** Within our coverage universe, we believe supply-chain software leader Manhattan Associates (rated Outperform) is best-positioned and more focused on RFID than its competitors, and UPS (Outperform) is better prepared than its rivals for the migration to RFID tracking.


| Edward M. Wolfe | Philip Alling | Harry D. Schwefel | Scott D. Brown |
|---|---|---|---|
| (212) 272-7048 | (212) 272-6905 | (212) 272-4349 | (212) 272-5998 |
| ewolfe@bear.com | palling@bear.com | hschwefel@bear.com | scott.brown@bear.com |

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*All pricing is as of the market close on June 2, 2003, unless otherwise indicated.*

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# Executive Summary

Radio frequency identification (RFID) is a technology used to track assets throughout the supply chain. Very small RFID transponders or tags containing a unique identifier are placed on assets (pallets, cases, or individual items), and these tags communicate with RFID readers. The RFID readers then associate this unique identifier with information about the product to which the tag is attached. In our view, the next generation of inventory management technology and supply chain efficiency hinges on broader adoption of RFID technology for tracking at the pallet and case level initially, and ultimately at the item level as well.

RFID has the potential to materially change how inventory is managed in the supply chain — in warehouses, in transit, in distribution centers, and on store shelves and check out counters — by improving visibility of that inventory in near real time and, importantly, at an economically feasible cost. RFID is not necessarily new (in fact, some closed-loop systems designed for supply chain use have been operational for years, and other RFID applications such as electronic tolling and access control have been up and running even longer). However, we think the market is on the verge of accelerating its adoption of the technology on a broader scale for supply chain applications for several reasons:

- Vendors of RFID technology are embracing the economics of lower-cost production in higher-volume scenarios that could bring individual tag costs below $0.10 (and some say as low as $0.05, though that is a controversial projection);

- Large retailers such as Wal-Mart, Target, and Home Depot have been involved in pilot tests of RFID solutions based on the latest technology and are reportedly making plans to require their suppliers to start equipping arriving pallets and cases with RFID devices in the not-too-distant future, perhaps as early as January 2005, in Wal-Mart's case;

- Consumer product goods (CPG) firms such as Procter & Gamble and Gillette have been at the forefront of initiatives to use RFID to reduce shrinkage in the supply chain for high-value goods such as razor blades and batteries, and are eager to begin realizing benefits from day-to-day use of the technology;

- Industry-sponsored research on standards for RFID tracking applications should facilitate use of the technology in open-loop supply chains on a broad scale, and a set of Electronic Product Code (EPC) specifications is scheduled to be released in September; and

- Results from the latest series of field trials and implementations suggest that the performance in terms of read range and accuracy is well-suited to applications in the supply chain space.

Exhibit 1 provides a sample list of some current players in the RFID space.

**Exhibit 1. A Sample of RFID Players**

| Tag Vendors | Reader Vendors | Software Players | Early Adopters |
|---|---|---|---|
| Alien Technology Corporation | Intermec Technologies Corp. | Descartes Systems | Boeing |
| Intermec Technologies Corp. | Matrics Inc. | EXE Technologies | Chep |
| Matrics Inc. | Psion Teklogix Inc | GlobeRanger | Georgia Pacific |
| Philips Semiconductors | SAMSys Technologies Inc | Manhattan Associates | Gillette |
| Savi Technologies | Symbol Technologies | OATSystems | International Paper |
| Texas Instruments | Tagsys | RedPrairie | Marks & Spencer |
| | Tyco Sensormatic | SAP | Wal-Mart |

Source: Bear, Stearns & Co. Inc. estimates.

Do we think RFID will supplant bar codes for logistics, supply chain, and retail applications? Certainly not in the near term, and for low-cost goods at the item level, probably never. Label manufacturers (e.g., Zebra) are already printing shipping labels with bar codes, human readable text, and RFID transponders. During a transition period, the two technologies will likely co-exist, but over time we expect RFID to become the primary means for tracking inventory in the supply chain (and the way companies will improve cash flow by more efficiently managing inventory).

The key benefit of RFID tracking over bar coding is that the physical line of sight needed for bar code scans is not required in the case of RFID. This permits the near-simultaneous "scanning" of many pallets and cases fitted with transponders that are, for example, passing through a dock door equipped with an RFID reader system. Bar codes would require each item to be scanned individually, which takes more time and requires specific positioning of labels. There are many more touch points along the supply chain where inventory equipped with RFID transponders could be tracked, and there are numerous ways this improved visibility could be put to good use. These are benefits unique to RFID.

In this report, we tried to compile comprehensive lists of 1) implementations and pilot projects of RFID technology in the supply chain space, and 2) hardware manufacturers (including transponder and reader system developers, as well as shipping label manufacturers), software vendors, systems integrators, retailers, and CPG firms that are driving next-generation supply chain tracking with the latest RFID technology.

In the next section, we describe why we expect an RFID revolution in the supply chain space, discussing the benefits of RFID over bar coding, as well as risks to broader RFID adoption. Our Investment Conclusion highlights our thoughts on the best-positioned companies to take advantage of this growth opportunity. We also examine RFID technology and manufacturing processes as well as standardization issues and other RFID application areas.

The final two sections of the report contain the vendor directory, featuring summaries of RFID activities of firms in this space, and a list of RFID implementations and pilot projects.

**SUPPORT FOR BROADER ADOPTION**

- **With Lower Cost Will Come Broader Adoption.** While RFID technology has existed for many years, we believe the time for broader adoption is at hand because the price of RFID tags is finally approaching levels where placing tags on individual items is not far from being economically feasible. With broader adoption and increased demand for mass quantities of RFID tags, vendors believe they can bring the cost of individual tags to below $0.10. This becomes possible because, with increased demand, materials such as silicon can be purchased in larger quantities and thus at lower prices. Also, new tag manufacturing processes, such as Alien Technology's fluidic self-assembly (FSA) can reportedly produce chips in larger quantities and shorter time frames than traditional pick-and-place machines, which were slower and more expensive to run.

  But these new processes operate according to economies of scale and require mass production to reach optimal pricing points. Given the attention that RFID technology is receiving from large retailers and CPG firms, it looks as if less expensive manufacturing processes that will allow for the mass production of a low-cost RFID tag have arrived in time to encourage broader adoption.

- **Demand Driven by Retailer Requirements.** Large retailers, such as Wal-Mart, Target, and Home Depot, have all taken a significant interest in RFID technology and the potential it harbors for creating a more efficient supply chain with increased visibility. These retailers, as well as many others, have been involved in pilot tests of RFID solutions using the latest technology. After seeing encouraging results, some are making plans to require their suppliers to begin equipping arriving pallets and cases with RFID devices in the not-too-distant future. Further, Wal-Mart (the world's largest retailer and, for many, the most revered distribution and logistics company) appears to have given some of its suppliers a date of January 2005 as the time by which it would require all pallets and cases arriving at its stores to be equipped with RFID tags. Pressure from large retailers on their suppliers should serve to push up the timing of broader adoption of RFID technology.

- **Involvement of CPG Firms.** In our view, interest in RFID among CPG firms such as Procter & Gamble and Gillette — which, we note, are early sponsors of the RFID standards organization, the Auto-ID Center — will promote wider adoption of the technology. These two firms have been at the forefront of initiatives to use RFID to reduce shrinkage in the supply chain of relatively high-value goods, including razor blades and batteries, and both appear eager to realize the benefits of day-to-day use of the technology. Specifically, Gillette's recent order of 500 million RFID tags from Alien Technology underscores the importance of RFID in Gillette's strategy going forward, and we expect that many other CPG firms will follow suit in order to remain competitive.

  While tracking at the item level has not yet proven to be feasible for all items, item-level tracking will continue to gain traction in areas where severe shrinkage or out-of-stocks occur. We also anticipate that CPG firms will feel pressure from

retailers to begin utilizing RFID technology, thus placing the initial burden on CPG firms, and this will serve as a major push for RFID adoption by CPG firms.

- **Standards Work Progressing.** Industry-sponsored research on standards for RFID tracking applications should facilitate the use of RFID technology in open-loop supply chains on a broad scale. We note that the International Organization for Standardization (ISO) is currently working on various technical RFID standards, as is the Auto-ID Center (an academic think tank based at the Massachusetts Institute of Technology), which is working in conjunction with the Uniform Code Council (UCC). In May, the Auto-ID Center and the UCC announced plans to form Auto-ID Inc., which will give the UCC (which was originally organized to develop and manage standards for bar codes) commercialization rights to the Auto-ID Center's Electronic Product Code (EPC) technology.

  Although the EPC technology does not yet have ISO approval, clearly the negotiations between the Auto-ID Center and the UCC represent a significant step forward with respect to RFID standards. As standards work continues to progress, potential users of the technology should become less reluctant to make investments in RFID, thus increasing market penetration.

- **Technology's Performance in Line with Supply Chain's Requirements.** A fundamental issue with RFID technology is that read range and high-frequency 13.56 MHz applications were hindered by the limited maximum read distance (at best a couple feet), which is not conducive to use throughout the supply chain. However, ultra-high-frequency (UHF) RFID applications have read ranges of up to three to four meters, and results from the latest field trials and pilots with UHF are demonstrating performance that is well-suited to applications in the supply chain space.

  With UHF, readers can be installed at dock doors. When trucks are unloaded and loaded at the manufacturer, the distribution center, and the back of the store, the goods can be pushed right through the dock doors, with RFID readers able to scan tagged pallets and cases as they pass. Also, the newer RFID technology being tested now has accuracy rates that approach 99%-plus, making it applicable for tracking valuable inventory that must be accounted for as it moves through each stage of the supply chain. Lower-frequency applications with shorter read ranges were not suited to tracking applications in distribution centers and warehouses.

## BENEFITS OF RFID OVER BAR CODING

- **No Physical Contact, Line of Sight Required.** Because RFID does not require physical contact or line of sight with an item being tracked, it is generally more efficient than traditional bar coding. For example, a case full of items with individual RFID tags attached can be read by a reader in one step as the items pass by, whereas identifying these items using the traditional bar code method takes longer, since each item must be scanned one by one.

- **Increased Visibility to Supply Chain.** RFID technology has the ability to track items in real time as they move through the supply chain with more touch points than would be possible using a conventional bar code scanning solution. By

tracking items in near-real time, users of RFID technology have greater visibility to their supply chain, providing opportunities to lower inventory carrying costs, as well as reducing the need for storage warehouses, thereby improving cash flow, boosting productivity, and reducing overhead.

- **Reduced Shrinkage.** With the availability to monitor the movement of goods throughout the supply chain more closely with RFID tracking, CPG firms and retailers are looking to RFID as a way to reduce shrinkage (stock loss), including theft. Shrinkage has long been a supply chain problem, particularly for high-volume goods; RFID technology is expected to help pinpoint the specific spot where the problem is occurring and ultimately help prevent the problem.

- **Tags Can Withstand Harsh Conditions.** In order to function properly, bar code readers must have clean and clear optics, and the label it is reading must be clean and free of abrasion as well. RFID, on the other hand, enables tag reading from great distances (up to 100 feet for active tags), even in challenging environments.

**IMPEDIMENTS TO BROADER ADOPTION OF RFID**

While from an efficiency standpoint, many companies stand to gain from the use of RFID, certain impediments to the broader adoption of RFID technology still remain.

- **Tag Cost.** Although certain RFID tag vendors have claimed that, with volume, they are capable of producing tags at a cost of as low as $0.05 (given advanced manufacturing processes), the reality — and feasibility — of this remains to be seen. We estimate that current production volumes yield a price point of about $0.45, including raw materials and associated manufacturing costs. While the buzz about the availability of a $0.05 chip brought new attention and enthusiasm to RFID technology, this has proven to be a double-edged sword given that it has set pricing expectations for potential customers of RFID technology.

  Upon being introduced to RFID, it seems that certain companies interested in the technology were under the impression that $0.05 chips were currently available, and as a result, some will continue to refrain from using the technology until tags do reach this price point. Furthermore, in order for the use of RFID to be feasible at the item level, tag costs would have to be reduced significantly. Without volume, that is unlikely to happen. For example, it might make sense to place a $1.00 RFID tag on a $200 leather coat, but it would not likely make sense to place the same tag on a $3.00 box of cereal. As a result, it appears that widespread adoption of RFID technology hinges on the ability of RFID vendors to offer tags at lower prices, which is a risk to broader adoption in the near term.

- **Cost of Implementation.** While much of the focus surrounding RFID has been on the price of RFID chips or tags, implementing a fully functional RFID system incurs multiple costs, including the cost of readers (typically anywhere from $1,000 to several thousand dollars) and the cost of creating a sufficient infrastructure capable of supporting and managing the RFID-related data, which varies depending on complexity. In our opinion, the cost of implementing an RFID system has been overlooked or underestimated by many potential users of the technology, given the infrastructure that may be required to accept and manage the data held in an RFID system. Should widespread adoption occur, the costs associated with this infrastructure may prove to be more of a concern than chip cost.

  It is also our sense that, because low-cost RFID is in its infancy, implementations will prove more costly in the beginning stages of adoption given the likelihood of first-time mistakes and the lack of best practices.

- **Interoperability and Lack of Standards.** There are currently no "universal" standards for RFID — specifically related to the "air interface" (how tags communicate with readers). We see this as a primary risk to the technology. Currently, various vendors are offering RFID technology, yet there are no distinct, official standards for any of them to follow. Both the Auto-ID Center (which recently announced plans to form a joint venture with the UCC called Auto-ID Inc.) and ISO are currently working on separate initiatives focused on establishing air interfaces, and because these two separate entities are working to

develop standards, it seems likely that the result will be interoperability among vendors that have built their technology according to one and not the other.

Users, along with vendors, stand to lose as the result of this lack of standards, if products that currently work turn out to be incompatible upon the establishment of a definitive set of standards. It is also our sense that potential customers may be hesitant to purchase RFID technology until universal standards have been established, which could delay broader adoption of RFID.

- **Global Spectrum Allocation.** Just as there are no air interface standards, there is also currently no set of global frequencies for RFID technology. Although we understand that the high-frequency (HF) band — which operates at 13.56 MHz — works globally, the read range on this frequency is relatively short (about one meter), thus limiting its use to certain applications of RFID. We also gather that the spectrum of other operating frequencies (including LF, UHF, and microwave) is either 1) unavailable globally or 2) not feasible from a global perspective given differences in frequency allocations and power/bandwidth in various countries. For example, the UHF band is currently not permitted for use in Japan, underscoring the unavailability of this spectrum (which happens to be ideal for supply chain applications given its relatively long read range) on a global basis.

- **RF Transmission Distance.** RF transmission distance may also serve as an impediment to broader RFID adoption, given that passive tags currently have a maximum read range of about three meters. Active tags have a considerably longer read range but are also significantly more expensive. When longer read ranges are desired, certain users may be unwilling to purchase active tags, thus delaying broader adoption until vendors can create low-cost, passive RFID tags with longer read ranges.

- **Tag/Reader Sensitivity.** Currently, RFID readers are prone to both reader collision (which occur when signals from two readers within the same coverage universe collide) and tag collision (which occur when more than one chip sends a signal back to a reader, thus confusing the reader). In addition, as more RFID readers and tags come into use, it is likely that the number of instances of this interference will increase. This presents a risk, since it compromises the accuracy of RFID systems. Also, because of the varying frequencies used, cell phones, other wireless devices, and industrial equipment may be affected as well. Because widespread adoption of low-cost RFID has not yet taken place and radio frequency technology is in its infancy, it is difficult to predict the impact this will have in the future and the complications that could result.

- **Privacy Concerns.** While few can deny that RFID can afford major benefits from a business perspective, these benefits do not necessarily come without repercussions, such as concerns about consumer privacy. For example, the thought that an RFID tag could be located on an item of clothing beyond the point of checkout is threatening to many people, as they view this as an invasion of privacy. We believe that Benetton, a European clothing retailer that originally announced plans to tag individual articles of the clothing it sells, has decided to tag only at the pallet and case levels near term because of negative feedback related to privacy concerns. Certain vendors/retailers have indicated that tags on

individual items would be "turned off" after an item is purchased, but because these tags are so small in size (comparable to a grain of sand, or even smaller, in many cases), consumers may be skeptical given that they cannot see the tag being removed, and even if they could, they cannot be assured that another tag does not exist.

We believe the key to controlling privacy concerns related to RFID technology lies in educating consumers about this technology and its limitations. Also, it seems likely that legislative proposals requiring RFID tags to be turned off after purchase may gain momentum, and if such legislation is enacted, consumers' acceptance of RFID will increase.

## Investment Conclusion

We are confident that the RFID revolution will be widely evident over the next several years and also that many private and publicly held companies will benefit materially from this development. Companies that produce RFID tags, reader systems, software to process the transaction data, as well as shipping labels and antennas all seem like potential candidates for ways to play the impending revolution. In addition, companies that are leaders in software and services for the warehouse and transportation industries seem like obvious candidates to benefit from the increased focus on updating the global supply chain to become more efficient.

Currently, we believe that Manhattan Associates (rated Outperform; Supply-Chain Technology sector rating: Market Weight) is the company among our coverage that is best-positioned for the impending RFID revolution. As the leading supply chain execution company, Manhattan provides software and services for inventory control in warehouses, transportation, and trading partner collaboration and is looked to by a host of different industries to provide efficient, compliant, leading-edge inventory controls. We suspect that as large retailers, CPG companies, and manufacturers require suppliers to become RFID-compliant, these companies will increasingly be required to update their inventory management processes to meet this requirement. Manhattan will be well-positioned to both consult on and implement new warehouse management systems (WMS) and transportation management systems (TMS) that are RFID-compliant for these companies, in our view.

Exhibit 2 below shows our estimates of the impact that broader adoption of RFID could have on Manhattan Associates' financial performance in 2004 and 2005, based on various license revenue growth rates associated with potential license upgrades among existing customers. For the purpose of this exercise, we have estimated the RFID related upgrade as costing $150,000 (or roughly one-fifth of Manhattan's estimated average selling price of $750,000). Given this, we assume that, in order to achieve 2.5% license revenue growth in 2004 from RFID, approximately ten of Manhattan's customers would need to purchase an RFID upgrade ($150,000 x ten customers = $1.5 million in incremental license revenue). We have also assumed a license revenue-to-services revenue ratio of approximately 1:1.25x, implying that for every license upgrade of $150,000, Manhattan will also generate approximately $187,500 in associated services, and we are not assuming any impact to hardware revenue. Finally, we have assumed that, given the sale of RFID-related upgrades, Manhattan's core expenses will remain flat on an absolute basis, that gross margins will remain flat on a percentage basis, and its tax rate remains constant.

We note that, based on our analysis, given a range of 2.5%-10.0% in license revenue growth attributable to RFID upgrades, we estimate that Manhattan could generate about $3.4-$13.9 million in incremental revenue in 2004, and that this would be accretive to adjusted EPS by 4.0%-16.3%. In calendar 2005, given 5.0%-15.0% in license revenue growth attributable to RFID upgrades, we estimate that Manhattan could generate roughly $8.9-$27.0 million in incremental revenue, and that this would be accretive to adjusted EPS by a range of 8.7%-26.5%.

More so than selling upgrade licenses to existing customers, broader adoption of RFID in the supply chain space should translate into significant new sales opportunities for Manhattan. New RFID compliance requirements from major retailers should accelerate the upgrade cycle from proprietary in-house developed inventory management systems to the latest package software applications with up-to-date integration capability and middleware functionality designed specifically to work with RFID tracking systems. In the same way that Manhattan reported revenue growth in the 50%-plus area leading up to Y2K, we suggest Manhattan could realize incremental license revenue growth north of 25% in 2005 and beyond stemming from broader adoption of RFID. Exhibit 2 (in the two columns on the right) shows our estimates of 25% and 50% incremental license revenue growth from new sales of RFID-compliant inventory management software. These estimates assume a mix of sales to new customers and upgrade licenses to existing customers. We also assume a 1:1.5x ratio of license revenue to service revenue, reflecting additional implementation services that would be expected in new sales (over license upgrades). Our estimates suggest a 25% increase in license sales in 2005 would translate into $50 million in incremental total revenue, and would be accretive to adjusted EPS by $0.68, or 48% on a base of $1.40. At a 50% increase in license sales, we estimate incremental total revenue in 2005 would be $100 million, and would be accretive to adjusted EPS by $1.35, or 97% on a base of $1.40.

**Exhibit 2. Manhattan Associates — Scenario Analysis of RFID Impact** ($ in millions)

| | 2004E | | | 2005E | | | Assuming RFID-Based New Sales | |
|---|---|---|---|---|---|---|---|---|
| | 2.5% License Revenue Growth | 5% License Revenue Growth | 10% License Revenue Growth | 5% License Revenue Growth | 10% License Revenue Growth | 15% License Revenue Growth | 25% License Revenue Growth | 50% License Revenue Growth |
| **? in License Revenue** [1] | | | | | | | | |
| Absolute Basis | $1.5 | $3.1 | $6.3 | $4.0 | $8.0 | $12.0 | $20.1 | $40.2 |
| Percentage Basis | 2.5% | 5.0% | 10.0% | 5.0% | 10.0% | 15.0% | 25.0% | 50.0% |
| **? in Services Revenue** [2] | | | | | | | | |
| Absolute Basis | $1.9 | $3.8 | $7.7 | $4.9 | $9.9 | $15.0 | $30.1 | $60.2 |
| Percentage Basis | 1.1% | 2.3% | 4.7% | 2.3% | 4.8% | 7.2% | 14.4% | 28.8% |
| **? in Total Revenue** | | | | | | | | |
| Absolute Basis | $3.4 | $6.9 | $13.9 | $8.9 | $17.9 | $27.0 | $50.2 | $100.4 |
| Percentage Basis | 1.4% | 2.7% | 5.5% | 2.7% | 5.6% | 8.4% | 15.5% | 31.1% |
| **? in Adjusted EPS** | | | | | | | | |
| Absolute Basis | $0.05 | $0.10 | $0.20 | $0.12 | $0.25 | $0.37 | $0.68 | $1.35 |
| Percentage Basis | 4.0% | 8.0% | 16.3% | 8.7% | 17.6% | 26.5% | 48.3% | 96.5% |

(1) Assumes RFID upgrade is equal to $150K, or 1/5 of Manhattan's average selling price of $750K.
(2) Assumes a license revenue to services revenue ratio of 1:1.25. For our 25% and 50% license growth scenarios in 2005, we're assuming a 1:1.5 ratio.

Source: Bear, Stearns & Co. Inc. estimates.

We see an enormous opportunity for transportation and logistics providers to utilize RFID to become more productive and to make their customers more productive. For instance, FedEx and UPS have huge package hubs with acres of conveyor belts and sort equipment designed to read bar codes within a field of sight. Currently, RFID technology, which does not require line of sight, can materially reduce the time, amount of space, and number of people required to handle inventory. Future uses of RFID will without question lead to better ability to manage inventory in motion and to less stationery inventory. Quicker-turned inventory, faster throughput warehousing, and faster transit times are in the offing. However, it remains to be seen if the logistics and transportation carriers will be able to capture the productivity benefit or whether they will have to pass productivity gains through to customers.

With respect to RFID tags, privately held Alien Technology generated a buzz after securing an order earlier this year for 500 million tags from Gillette, and the company

maintains its fluidic self assembly (FSA) manufacturing process is a competitive advantage for low-cost RFID. But Alien is not alone in pursuing this opportunity or in developing lower-cost manufacturing techniques. Matrics, also private, is noted for its tags' superior read range and orientation insensitivity. Texas Instruments currently has the most experience with transponders up and running in the field, though at lower frequencies that don't appear to be as well-suited to supply chain applications in warehouses and distribution centers due to limited read range. Though we question whether Alien and Matrics currently have the manufacturing capacity to handle demand for billions of units, participants in recent field trials have given their solutions higher marks in terms of performance than hardware from other vendors.

We will not be surprised if smaller vendors with leading technology (e.g., Alien and Matrics) end up licensing their technology to larger manufacturers such as Texas Instruments, Philips, or Unova's Intermec unit. Though so far there has been less focus on reader system manufacturers than tag vendors, we believe the best-positioned companies to benefit from the expected boost in demand for RFID reader systems (given their manufacturing capabilities and experience in wireless scanning and the retail and distribution verticals) are Checkpoint (CKP-14; Peer Perform), Intermec (Not Rated), Symbol (SBL-13; Peer Perform), and Tyco-Sensormatic (Not Rated).

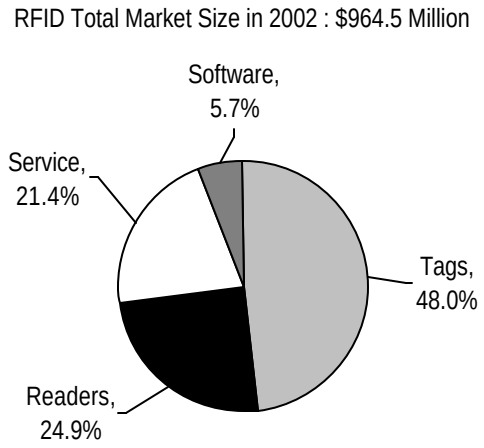
## RFID Market Opportunity

Major CPG firms and retailers ship hundreds of billions of units of goods annually. To the extent that RFID can become the tracking methodology of choice for an increasingly large percentage of that volume, there should be considerable upside for the RFID space, in our view. Despite a difficult macroeconomic environment and many companies' reluctance to spend on new initiatives (particularly ones involving new technology), the RFID market has grown at an estimated compound annual growth rate of 8% since 2000. Venture Development Corporation (VDC), a market research and strategy firm specializing in the RFID industry, estimates that in 2002, global shipments of RFID systems reached about $965 million (see Exhibit 3 below).

Specifically, that figure includes revenue generated from the sale of tags, readers, software, and services. VDC estimates that the RFID industry will grow at a five-year compound annual growth rate of 22.6%, putting the market size at about $2.7 billion in 2007. It reached that number by interviewing suppliers of RFID, distributors, and integrators of the technology, as well as industry analysts and potential end-users such as government agencies and companies. We also see material growth in the RFID space given that costs associated with the technology are scaling down, the pilot interest in RFID has reached an all-time high, and large retailers and CPG firms like Wal-Mart, Gillette, and Procter & Gamble are stepping up the timetable for broader adoption of the technology. Other industry analysts believe that the total RFID market could reach $15-$30 billion by 2010, with the technology infiltrating numerous high-volume end markets across many industries.

Such projections may prove to be too aggressive, since adoption of lower-cost RFID for supply chain applications is in its infancy. However, it seems clear that the market opportunity is huge, and our sense is that the performance of the technology, the work on the standards and pilot testing, as well as the focus on lower-cost solutions have resulted in an environment where RFID can thrive in the supply chain space.

**Exhibit 3. Estimated 2002 RFID Market Size and Breakdown**

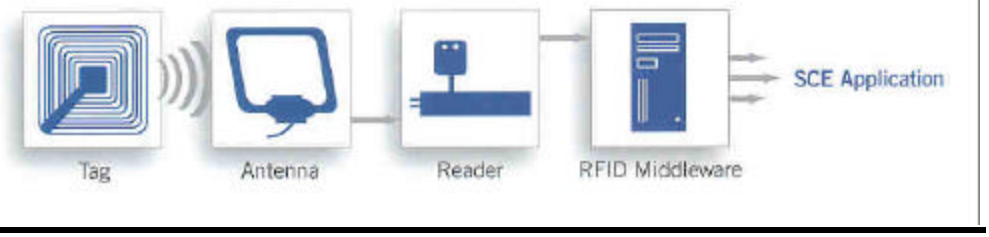



Source: Venture Development Corporation.

## What Is Radio Frequency Identification?

Radio frequency identification (RFID) is a technology used to track assets throughout the supply chain. Very small RFID tags containing a unique identifier are placed on assets (pallets, cases, or individual items), and these tags communicate with readers when they enter the reader's RF field (see Exhibit 4 below). Currently, the most common method of reading tags at close range is termed "inductive coupling," in which the coiled antenna of the reader creates a magnetic field with the coiled antenna of the tag. The energy generated by this field is used by the tag to send back waves to the reader, which turns these waves into digital information. The reader then transmits this data to the RFID system middleware, which associates the unique information stored on the particular tag with information about the product to which the tag is attached. After the middleware processes the information received from the readers, it filters the data to the company's supply chain execution (SCE) software, which updates its inventory data accordingly.

**Exhibit 4. Components of an RFID System**



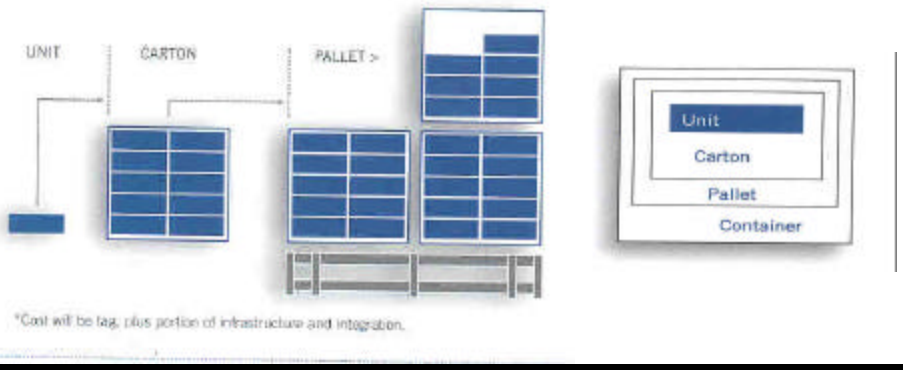

Source: Manhattan Associates Annual Report.

While RFID technology is currently being used by various consumer product goods (CPG) companies, retailers, and logistics providers on a limited basis, the Auto-ID Center (an organization that was formed to develop RFID technology and related standards) recently announced its intention to move from the research and development stage to the commercialization stage through a new joint venture with the Uniform Code Council (UCC) called Auto-ID Inc. In our judgment, this could accelerate adoption.

### LEVELS OF TRACKING

In utilizing RFID in the supply chain for inventory management, the technology is typically used to track assets at three levels — pallet, carton, and unit. As can be seen in Exhibit 5 below, tagging at all three levels allows each to possess its own identity or be associated with the others for tracking at various stages in the supply chain. RFID tags attached at the unit level allow the item to be tracked individually, which is useful at the retail location where it will be unpacked and sold, but also to be associated with the carton it is placed in when being transported. The tagged cases also have their own identity when moving through the supply chain but can be associated with the RFID tag on a particular pallet they are placed on. With these associations made possible by RFID, when a pallet passes through a reader, the RFID system can identify the pallet and check its location into the software system, at the same time recognizing the corresponding cartons and units that it is carrying.

**Exhibit 5. Levels of Tracking Possible with RFID Technology**




Source: Manhattan Associates Annual Report.

- **Pallet.** RFID can be used to track assets at the pallet level (pallets are typically used to carry and transport cases of goods and/or products). Tracking at the pallet or tote level is particularly attractive to those parties interested in monitoring and tracking items entering and leaving warehouses and distribution centers, since it enables pallets to be identifiable across the supply chain. For example, the movement of a pallet may be tracked from a manufacturer to a distribution center, and then to a store that intends to sell the product(s) being carried on the pallet. The Auto-ID Center's Phase I field trial consisted of asset tracking at the pallet level.

- **Carton/Case.** RFID technology can also be used to track assets at the carton or case level. Tracking assets at the case level may be necessary for high-value goods, and can be accomplished either in conjunction with pallet tagging or by itself. Tracking at the case level provides more specific tracking than tracking at the pallet level, and it may be more attractive for those wishing to track individual cases of products within a distribution center once a pallet is unloaded. The Auto-ID Center's Phase II field trial consisted of asset tracking at the case and pallet levels.

- **Item/Unit.** Although it has not yet been widely adopted, the use of RFID technology to track individual items has become increasingly attractive, as evidenced by multiple pilot programs announced by several CPG firms to track individual products (see "RFID Implementations and Pilot Programs" section later in this report). We note that the Auto-ID Center's Phase III field trial (currently under way) consists of asset tracking at the case, pallet, and item levels. However, using RFID technology to track at the item level is still in its infancy, and it is our sense that the primary driver of truly widespread adoption here is significantly lower transponder cost at the $0.05 or lower level.

## TYPES OF RFID TAGS

Although RFID technology depends on two primary components of hardware, RFID tags and RFID readers, most of the focus tends to surround RFID tags, given that they are primarily seen as a low-cost driver of RFID adoption. Similarly, while our report chiefly focuses on low-cost, passive RFID tags, there are three main types of RFID tags used to track assets today:

- **Active RFID Tags.** These tags are battery powered in order to transmit a signal to a reader, and are generally used for high-value goods that need to be tracked over long ranges (100 feet or more). Active tags are usually more expensive than passive tags, typically priced as much as $20 apiece.

- **Passive RFID Tags.** These tags are not battery powered, and instead draw power from electromagnetic waves given off by an RFID reader. The read range for passive tags is usually under three meters, and these tags can be priced at less than a dollar. Passive tags require no maintenance, and are primarily intended to track items at the pallet, case, and individual levels. These low-cost tags are the focus of the Auto-ID Center, and are being used in its field trials.

- **Semi-Passive RFID Tags.** These are similar to active tags because they have batteries, but the battery is used only to run the microchip's circuitry, not to power communications with the reader. These tags are typically priced above a dollar and are generally used for tracking high-value goods, with longer read ranges.

**TYPES OF RFID CHIPS**

The microchips contained within RFID tags can be identified as read-write or read-only.

- **Read-Write RFID Chips.** New information can be added to these chips, or existing information on these chips can be written over when the chip is within range of a reader. These chips are generally more expensive than read-only chips and are typically used to track high-priced, valuable items.

- **Read-Only RFID Chips.** Generally less expensive than read-write chips, these chips store information that can never be changed unless the chip is reprogrammed electronically. We note that read-only RFID chips can also use electrically erasable programmable read-only memory (EEPPROM), in which case the data stored on the chip during the manufacturing process can be overwritten through an electronic process that is able to erase and reprogram the data on the chip.

**WHICH TAG MANUFACTURERS ARE WELL-POSITIONED AND WHY?**

From speaking with what we consider to be some of the key early adopters, implementers, and pilots of RFID technology, we have concluded that Alien Technology, Matrics, and Texas Instruments (Not Rated) are best-positioned as tag manufacturers to benefit from wider adoption of the technology.

### *Matrics*

There are several reasons why we believe Matrics is poised to be a leading manufacturer of RFID tags:

- Channel checks have indicated that the company's tags have superior read ranges, accuracy, and reliability given that they are orientation-insensitive (i.e., its tags do not need to be facing square to the reader to register a successful scan);

- The company offers a low-cost RFID solution that is compliant with the Auto-ID Center's Electronic Product Code (EPC) system, which we believe has increasingly better chances of gaining acceptance given the Auto-ID Center's planned merger with the Uniform Code Council (UCC) to form Auto-ID Inc.;

- Matrics' tags are ultra-high-frequency (UHF) and, at least in the initial phases of broader adoption on the pallet and case level, appear to be the best-suited frequency for supply chain applications; and

- Its technology has been validated by several large companies that have piloted various RFID systems from numerous other vendors and subsequently indicated that they plan to use Matrics' tags for their first large roll-out of RFID beyond the pilot stage.

We note that Matrics currently offers tags that are compliant with the Class 0 protocol (see Exhibit 12) of the EPC system, which operates solely at the read-only protocol. Although our channel checks have indicated that read-only functionality is generally sufficient for most supply chain applications, we also note that other companies (e.g., such as Alien Technology) offer tags that are compliant with the EPC system's Class 1 protocol (those that are write-once, read-many). This may prove to be a disadvantage for Matrics if this classification of tags creates more demand than Class 0 tags.

### *Alien Technology*

Alien Technology, whose 500 million-tag order from Gillette has received a substantial amount of attention, also appears well-positioned for the broader adoption of RFID technology, largely because of both its involvement in the Auto-ID Center's field trials and its patented manufacturing process called fluidic self-assembly (FSA), which may serve as a key differentiator. We think this process for manufacturing RFID chips (detailed later in this report) has the potential to produce large quantities of chips at low cost provided that demand is adequate. Upon broader adoption of the technology, Alien may also choose to license this patented chip assembly process,

which would likely prove to be a lucrative strategy for capitalizing on broader adoption.

As mentioned earlier, Alien's tags are compliant with the EPC system's Class 1 protocol, which characterizes them as read-once, write-many tags. We also believe that Alien is on the verge of securing several additional large orders for its Auto-ID Center-compliant RFID tags from other participating sponsors.

### *Texas Instruments*

Texas Instruments is well-positioned to benefit from broader adoption of low-cost RFID given that the company is already a large player in the RFID space and arguably has the greatest number of implementations of RFID technology and also of tags currently operating in real-world situations. Because Texas Instruments is an established company with a mature business and a successful history of selling its technology, we see it as in a position to compete with the likes of Alien and Matrics by the time RFID has experienced widespread adoption.

However, we note that historically, Texas Instruments has focused on high-frequency (HF) 13.56 MHz solutions, which will likely prove to be the best-suited frequency for item-level tagging (such as in smart shelf applications) but will not be the focus initially for supply chain applications, given HF's shorter read ranges. In our view, that poses a risk. Though we believe that Texas Instruments is working to develop a UHF tag, the company may not have the type of first-mover advantage that Alien and Matrics enjoy, especially given its choice not to become a sponsor of the Auto-ID Center or to embrace its EPC specification thus far. Given the coming merger between the Auto-ID Center and the UCC, we think the EPC system may gain greater support, putting Texas Instruments at a further disadvantage until it produces an EPC-compliant tag. With UCC administration of the EPC code, we suspect Texas Instruments will increase development efforts on EPC-compliant solutions.

## WHO ARE THE LIKELY MANUFACTURERS OF READER SYSTEMS?

There has been less focus on RFID readers by potential adopters of the technology. The RFID tag seems to have attracted the majority of the attention, with the main focus surrounding both the degree to which it works (specifically read range and accuracy) and the cost per tag. Despite the lack of attention, the RFID reader hardware cost will be significant, as the devices will need to be placed strategically throughout the supply chain and in stores in order to track products. Herein, we believe, lies a significant opportunity for reader manufacturers.

The fact that many tag manufacturers also make readers that are designed to read their own tag technology and are sold along with the tags in pilots and implementations has also contributed to the lack of focus on readers, in our view. In presenting their RFID technology for potential adopters to evaluate, RFID tag vendors tend to use their own readers to demonstrate the functionality of their tags. We believe that this often leads the customer to purchase the reader along with the tags from the same vendor as a package. However, upon broader adoption of RFID, we believe that manufacturers will likely choose to focus on one or the other rather than a full RFID system, particularly when demand is as large as we think it eventually will be. For instance, Alien Technology has indicated that while it

currently manufactures readers for use with its tags, it will not be doing so in the long term.

We believe that Intermec Technologies, Symbol Technologies, and Matrics Inc. are all well-positioned to become leaders in the manufacture of reader systems.

### *Intermec Technologies*

This company offers wired and wireless automated data collection, RFID, and mobile computing systems. Given Intermec's focus on RFID technology, which includes a broad array of patents, we believe the company is well-positioned to capture a portion of the RFID reader market share early on. Unlike many of its auto-ID competitors that manufacture technology for reading bar codes, Intermec actually has a full-scale RFID offering independent of its bar coding technology and has devoted significant research and development resources to it. The company offers both tags and readers and has been involved in numerous low-cost RFID pilots in addition to full-scale implementations.

Also, Intermec's readers can read multiple forms and protocols, which we believe will remain an important capability, at least in the near to medium term, given the current lack of RFID standards combined with the numerous tag vendors that exist. Given Intermec's existing RFID technology, particularly reader equipment, coupled with its established position in the auto-ID market, we believe the company is well-positioned to become a leading manufacturer of RFID reader systems.

### *Symbol Technologies*

This company offers secure mobile information systems that integrate application-specific handheld computers with wireless networks for data and voice and bar code data capture, and we believe this background in bar code scanning should serve as an advantage to the company in manufacturing a low-cost RFID reader. Symbol is already involved and partnered with various RFID manufacturers and is developing readers that have the capability of reading both RFID tags and bar codes, which will likely be an important feature in the initial adoption of RFID technology given that bar codes will remain in use.

While thus far Symbol does not appear as focused on RFID as some of its competitors, the company's established position as a provider of bar code scanner equipment as well as its solid penetration of the retail vertical (the leading supplier of auto-ID solutions) should provide it with a significant customer base to sell RFID-enabled readers upon broader adoption of the technology.

### *Matrics*

While the company focuses mainly on RFID tags, it also manufactures readers that work in conjunction with its tags. Broader adoption will likely cause RFID vendors to choose a focus, in our view, but we feel that Matrics might end up in a position to capitalize on the reader side of the technology in addition to the RFID tag side, for if its tags take an early lead in adoption, the company may be in the strongest position (at least initially) to offer readers to work along with them.

Because we feel that Matrics' tags could achieve broad adoption given their superior read ranges, we believe an opportunity may exist for Matrics to also play an early role in the manufacturing of readers. Moreover, channel checks have revealed that Matrics' tags have been difficult for some independent reader systems to interrogate, implying a market opportunity for Matrics in readers. And in the same way that Matrics may license technology for its tags, so too could it do so for reader systems.

**WHO WILL CAPTURE THE SOFTWARE OPPORTUNITY, AND WHY?**

Given the level and complexity of data that will need to be managed as the result of broader adoption of RFID technology, we see a significant opportunity for supply chain execution software vendors. We note that various supply chain vendors — including Manhattan Associates, SAP, EXE Technologies, and privately held RedPairie — have indicated that they intend to pursue the RFID space.

### *Manhattan Associates*

In our judgment, Manhattan Associates (our favorite name in the supply-chain execution space) is best-positioned among these vendors to take advantage of the RFID market, given its 1) satisfied installed base of nearly 900 customers, which should provide a substantial opportunity for up-sell; 2) proven history of providing supply chain execution solutions that offer ROI; 3) superior understanding of how assets move throughout the supply chain and where value can be added; and 4) aggressive pursuit of the RFID space, as underscored by its relationships with hardware vendors in the space, including Alien Technology.

We note that the next release of Manhattan's integrated supply chain execution solution (expected in July 2003) will be capable of handling larger transactional volumes, which to us is a strong indication of the progressive action the company is taking to become RFID-ready. Also, as part of its plan to support its customers' future roll-out of RFID, Manhattan is configuring an "RFID-in-a-box" solution that will include a limited test license for its trading partner management solution; five RFID readers with two antennas each; 100,000 RFID tags; five remote supplier printers; and middleware that it has developed. The tags and readers will be those of privately held Alien Technology, and the purpose of the "RFID-in-a-box" is to allow customers to test the application and better understand it before they are required to start using the technology for pallet and case tracking by their customers.

Because of Manhattan's early moves into RFID, we believe the company will be in a strong position to capitalize on the upgrade cycles for enhanced software that will be necessary to successfully utilize RFID and realize the technology's full tracking and identification benefits, which will provide greater supply chain visibility.

### *SAP*

SAP (SAPG.DE-€93; Peer Perform) has also made early moves into RFID, as it is working to integrate into its software the functionality to manage data related to assets moving throughout the supply chain. Specifically, SAP worked with Metro AG in a pilot program to track assets moving into its store, at the case and pallet levels. While we are not aware of any specific planned software releases from SAP that will incorporate RFID functionality, we believe the company will be well-positioned to capitalize on the software opportunity that will exist upon broader

adoption of RFID technology given the company's large installed base and general success in the ERP market.

**WHICH SYSTEMS INTEGRATORS (SI) ARE PURSUING RFID?**

Some SIs currently pursuing the RFID space include Accenture, IBM Global Services, U.K-based Intellident, and privately held Xterprise (see our "SI profiles" section below). We note that Manhattan Associates is currently collaborating with Accenture, in addition to Alien Technology and Symbol Technologies, on its RFID initiatives. Broader adoption of RFID technology will provide a large opportunity for SIs pursuing the space.

While most of the buzz surrounding RFID to date has primarily been focused on the RFID tag, we expect more and more attention to be paid to the infrastructure that must be in place to support the level and complexity of the information communicated by RFID tags and readers. Accordingly, we feel SIs will play an instrumental role in working with companies to develop their RFID strategy as well as helping them implement and integrate the proper infrastructure required for an effective RFID system, very similar to the way SIs are used to implement other enterprise software systems currently.

Because RFID is still so very nascent, we also expect SIs to develop best practices for implementing RFID systems for various purposes, including (but not limited to) improved demand planning, theft protection, shrinkage, general asset tracking and improved supply chain visibility. We expect that RFID vendors will partner with SIs in hopes of leveraging these relationships to win deals, and that certain SIs, such as IBM, will similarly leverage the relationship to provide not only services, but hardware (e.g., servers) as well.

**WHAT IMPACT WILL RFID HAVE ON LOGISTICS COMPANIES?**

RFID technology could have a large effect on logistics companies — those that offer transportation and warehouse management services — given its direct supply chain applications, specifically related to inventory management and supply chain visibility, although we do not feel that logistics companies will be the drivers of this space. We sense that large CPG firms and retailers will serve as the primary drivers for RFID, and that logistics companies will gradually adopt the technology as 1) they begin to feel pressure from customers to use the technology, and 2) it becomes more economically feasible, given their existing investment in bar coding technology.

Our research suggests that UPS (rated Outperform) (which is a sponsor of the Auto-ID Center and is currently involved in RFID pilot projects, including work with Gillette and Wal-Mart) is more closely involved with RFID technology than FedEx (which, to our knowledge, is not currently focusing on RFID development), although UPS is by no means driving adoption of the technology at this point. DHL Worldwide is also involved in piloting RFID technology, working with Nokia and TRI-MEX to track phones through the supply chain.

Our conversations with third-party logistics providers (3PL) have indicated that the use of RFID technology at their distribution centers and warehouses can greatly reduce check-in/check-out time, unloading time, and time needed to record inventory, in addition to reducing the amount of human labor needed, which often translates into fewer errors. By using RFID technology, pallets and cases can automatically and simultaneously be checked in as they are moved past an RFID reader, whereas the

more time-consuming alternative requires manually checking each pallet or case through the use of bar coding, which requires line of sight through scanning devices.

In fact, Marks & Spencer, a leading British retailer that has tagged about 3.5 million of its reusable trays and containers used in its refrigerated foods supply chain, has found that RFID technology reduces the time it takes to read multiple trays and containers stacked on a pallet by approximately 80% when compared with bar coding. The company has indicated that a complete dolly or pallet with 25 trays can be scanned in a single pass through an RFID-enabled portal in five seconds with high accuracy, while the same task with bar codes takes about 29 seconds. Moreover, the time needed to unload a truck and check all the goods into a distribution center has been reduced to three minutes with RFID versus 18 minutes previously with bar codes.

Many 3PLs indicated that their customers are becoming more interested in RFID technology as well, and that some are pushing them to begin implementing the technology. We anticipate that logistics companies will utilize RFID technology by tagging at the case and pallet levels, and that readers will primarily be placed at dock doors. We also believe that 3PLs may experiment with RFID in other ways, such as placing RFID readers on forklifts, which can then be driven around a warehouse in order to perform inventory checks. With the traditional method, a warehouse may have to shut down for a number of days in order to complete a manual inventory check.

A near-term impediment to broader adoption of RFID tracking in the logistics space is the significant infrastructure investments that have been made in bar code-based scanning equipment. For this reason, we expect retail and CPG firms to be the drivers of broad adoption, more so than logistics providers. And within the logistics space, our research suggests that UPS is best-positioned to migrate to RFID-based tracking and will likely adopt it sooner than its competitors. Logistics companies will adopt RFID when their major customers compel them to, in our view.

**WHAT LABEL AND LABEL PRINTER VENDORS ARE TARGETING RFID?**

In addition to tag and reader vendors, label and label printer vendors also have the potential to become a key component of RFID systems if widespread adoption of the technology occurs. In the case of label printing, RFID labels (complete with ultra-thin RFID tags) are printed so that these labels can be placed on pallets, cases, or items that need to be tracked.

These so-called "smart labels" typically include bar codes, human readable text, and RFID tags. Below, we describe some of the companies that are pursuing this space:

- **Zebra Technologies.** This company is a sponsor of the Auto-ID Center and is also working jointly with Manhattan Associates in order to integrate with trading partner management (previously called infolink) and PkMS, two of Manhattan's supply chain execution solutions. The joint solution with Manhattan will allow PkMS to capture, accept, and then execute the smart label information in the distribution center to receive, put away, replenish, pick, pack, and ship the goods with the Zebra smart labels, as well as read and print the smart labels from remote locations using infolink to tell the printers what information to encode the chip with.

- **Avery Dennison.** Another vendor pursuing RFID label printing is Avery Dennison, also a sponsor of the Auto-ID Center. Avery, which has been developing smart label technology, has a strategic partnership with Alien Technology. To date, Avery has not released information related to its smart label products.

- **Flint Ink.** We also note that Flint Ink, a privately held manufacturer of inks and coatings, has developed a way to print inexpensive antennas using conductive inks. Flint has collaborated with Scotland-based RT Circuits, which has developed a proprietary technology for printing conductive antennas, as well as Alien Technology, in an attempt to shift from etched solid metals antennas to printed antennas.

- **KSW-Microtec.** Last year, this Germany-based RFID tag and label maker unveiled RFID smart labels with integrated temperature sensors (intended for the meat processor, grocery, and pharmaceutical industries) as well as two washable RFID labels — one that can be sewn or ironed directly into the fabric of a garment, and one that can be mounted on a polyester substrate and then sewn into a garment. These labels are targeted at the U.S. apparel and uniform rental markets.

Others pursuing the space include Intermec, Toshiba TEC, and SATO Corporation.

Will RFID ever replace bar coding? Can RFID and bar coding co-exist harmoniously, supplementing one another? Such questions are the subject of considerable debate.

**A BRIEF HISTORY OF BAR CODES**

Bar coding, which is a standard method for identifying the manufacturer and product category of an item, came into use by grocery markets in the 1970s, and gained wider adoption in the 1980s and 1990s among various other industries as well. At a grocery industry meeting in 1971, RCA demonstrated a "bull's-eye" bar coding system that allowed a bar code to be scanned from any direction. A year later, RCA began an 18-month pilot program in a Kroger store in Cincinnati, but printing and scanning difficulties caused the code to appear less than effective. In 1973, the Uniform Product Code (UPC) became the industry standard for bar coding, which served as a catalyst for wider adoption of the technology. It is our understanding that in 1978, less than 1% of grocery stores nationwide used bar coding technology and by the early 1980s this figure jumped to more than 30%. Today, bar coding technology has also been adopted by retailers, CPG firms, and transportation and logistics firms, among others.

We believe RFID will meet with a steeper adoption curve because the concept of automatic identification and data capture (AIDC, or auto-ID) is already proven by bar codes. UPC and other symbologies penetrated retail and logistics more slowly, we think, because the very concept of an item identifying itself to a machine was novel and unproven. Thirty years later, the bar code has achieved near total penetration in these vertical markets, in which item self-identification has become the key component of efficiency and operational transparency. Because of this, to such users, RFID is novel only in that it uses radio waves rather than beams of light to transfer information. That it can transmit far greater information than a bar code at much higher degrees of accuracy makes its adoption all the more compelling.

Another factor arguing for rapid adoption in the retail and logistics industries is the higher degree of consolidation of these markets versus 30 years ago. Never before has a single retailer, such as Wal-Mart, had such a degree of leverage over its supply chain. Kroger's testing of bar codes in the 1970s mentioned above led to only a trickle of compliance-driven product bar coding initiatives. By contrast, we would expect a mandate from Wal-Mart to its suppliers to have a knock-on effect that would ripple through the entire consumer goods economy.

**HOW DOES BAR CODING WORK?**

Bar codes consist of characters that are displayed in the form of dark vertical bars and light spaces. When scanned, a beam of light passes across the bar code, the dark bars absorb the light, and the light spaces reflect it. A detector translates the reflected light into electrical pulses, which are recognized by a computer as characters. The characters collectively represent the manufacturer and the product category of the item being scanned.

**USAGE OF BAR CODES**

Today, bar codes are generally used anywhere that data related to an item or group of items needs to be captured, stored, and retrieved. Grocery stores, banks, warehouses, libraries, and the post office are just a few of the areas where bar coding is in use.

Because bar coding is generally viewed as a standard for capturing data about product, and because many firms have made significant investments in bar coding technology, this poses a threat to the future of RFID. As a result, we believe the ability of RFID to differentiate itself from the traditional bar coding process — and thus add enough value to encourage its use — will play a large role in determining its adoption.

## RFID Applications

RFID technology has been used for many years, dating back to the second World War. However, until recently, RFID, which allows the tracking of individual items, has not been feasible for many commercial applications given its high cost and technological limits. Today, companies such as Alien Technology and Matrics are developing RFID components (e.g., tags, readers, etc.) at a much lower cost than was formerly possible, creating a wider opportunity for RFID. Below we examine some of the traditional applications of RFID technology that were in place prior to the low-cost RFID that a number of companies (e.g., Gillette, Gap, and Wal-Mart) are piloting today.

- **Security.** RFID technology can be utilized for access control to ensure that only authorized personnel can enter restricted areas. Similarly, the technology can be used to identify and locate key personnel, and track employees working in critical areas. This type of security might be utilized by airports, buildings, maritime ports, railway stations, and bus terminals.

- **Theft Prevention.** Because RFID allows an item to be tracked in real time, this technology has been used to prevent theft of various items. Traditionally, this technology was primarily used for relatively high-priced items. More recently, with the cost of RFID having come down dramatically in the past few years, RFID is being piloted as a means to track inexpensive items such as Gillette's Mach 3 razors.

- **Library Use.** Given the volume of books that libraries must track as they are checked in and out, RFID is a logical choice. When a book is scanned using RFID technology, the tag identifies the book and then links it to the bibliographic record. As a result, if a book that has not been properly discharged passes through a security gate, an alarm sounds that not only reveals that the item hasn't been checked out, but also identifies which book it is. RFID vendor Checkpoint currently offers an RFID system tailored for libraries called Checkpoint Intelligent Library System, which eliminates manual checkout and return in addition to controlling theft. Various other vendors offer RFID systems designed for a library setting as well, such as VTLS and 3M. The library of Rockefeller University in New York City is a current user of RFID technology.

- **Electronic Toll Collection.** RFID is used for electronic toll collection, essentially replacing the use of coins, cash, and toll tickets. One such system is E-ZPass, in which drivers pre-pay tolls and attach a small electronic device (an RFID tag) to the windshield inside their vehicles. This tag contains information about a user's account. With this system, as E-ZPass customers pass through toll lanes, an antenna at the toll plaza reads the vehicle and account information contained in the tag and tolls are automatically debited from pre-paid accounts. As a result, drivers do not need to stop at the toll, nor do they need to scramble for correct change.

- **Consumer Payment Systems.** Similar to electronic toll collection, gasoline, food, and various types of merchandise can be purchased using RFID

technology, most commonly though Exxon Mobil's Speedpass system (which is similar to Shell's ezPAY system). Speedpass uses an RFID reader located in a gasoline pump or cash register that communicates with a handheld RFID transponder (made by Texas Instruments) to automatically charge purchases to a credit or debit card. Speedpass has been also been adopted by Stop & Shop grocery stores and McDonald's restaurants. Exhibit 6 displays the use of RFID technology through Speedpass at an Exxon station. FreedomPay, a privately held competitor in Wayne, Pennsylvania, has an offering similar to Speedpass, but it uses a store-value system that replenishes itself from a user's credit card in increments of $25. For example, when a user's account drops under $5, FreedomPay bills the user's card for an additional $25. McDonald's has piloted FreedomPay in addition to Speedpass. Other fast food restaurants that use RFID include Pizza Hut, Taco Bell, and KFC.

**Exhibit 6. Speedpass Technology in Use at an Exxon Station**


Source: http://www.speedpass.com/exxon/index.jsp

- **Inter-Modal Rail Tags.** By utilizing RFID technology, rail companies track and monitor their rail cars and shipments in real time. Trucking companies and inter-modal container carriers can similarly utilize RFID technology to identify trucks and contents as well as they pass RFID readers in ports or terminals.

- **Military Applications.** The U.S. Department of Defense (DoD) utilizes RFID (and GPS) technology to track major shipments of military supplies. RFID tags are attached to boxes, pallets, and containers to track the movement of each. Dubbed the Total Asset Visibility (TAV) network, the DoD began using an RFID system provided by Savi Technology about eight years ago after some problems developed related to the shipment of supplies during the first Gulf War. In 1994, the DoD awarded Savi a $70 million contract, followed by a $112 million contract three years later in 1997 to install its RFID hardware and software for item-level tracking in containers to be shipped around the world. Most recently, the DoD signed a three-year contract with Savi to expand its existing RFID system. We note that Intermec sold over 4,000 readers to the government as a Savi subcontractor.

- **Tracking Prisoners.** RFID technology has recently been leveraged to track prisoners, as Technology Systems International Inc. (TSI), a subsidiary of Alanco Technologies Inc., signed a $3 million contract to install its Prism inmate

tracking system in a unidentified prison in the Midwest. Prisoners wear wristbands containing tamperproof transmitters that communicate with readers that are installed throughout the prison. Software is used in conjunction with the RFID technology to determine the position of inmates. In addition to tracking prisoners, the utilization of RFID technology in this case also aims to reduce prison violence and provide protection for guards and prisoners alike.

**FREQUENCY AVAILABILITY**

RFID tags and readers operate at various frequencies, and at the moment there is no universal set of global frequencies (although we note that the 13.56 MHz band is considered global). Although some vendors claim to have created a universal, or "agile" reader (capable of reading tags operating at multiple frequencies), RFID tags generally operate at the low-frequency, high-frequency, ultra-high-frequency, or microwave levels. Each frequency has advantages and disadvantages that make it more suitable for certain applications. Typically, the lower the frequency, the slower the data read rate, and the better the ability to read on (or near) wet or metal surfaces, which typically interfere with radio waves and tend to short radio waves. We summarize some information about the different frequencies of passive RFID tags in Exhibit 7 below.

- **Low Frequency (LF).** These tags generally operate at 125 KHz and typically have a read range of less than half of a meter. They have a relatively slow data rate, are relatively inexpensive, and are less subject to interference compared to high-frequency tags. LF tags are commonly used for access control, animal tracking, vehicle immobilizers, and various point-of-sale applications (such as Mobile SpeedPass). We gather that while the LF spectrum is available globally, because of slight differences in frequency and power levels worldwide, it is not considered by everyone truly to be a global frequency.

- **High Frequency (HF).** These tags generally operate globally at 13.56 MHz, have a read range of about one meter, can transmit data faster than low-frequency tags, and also use more power than low-frequency tags. HF tags are commonly used in smart cards and smart shelves for item level tracking, and are also currently used to track library books and airline baggage.

- **Ultra High Frequency (UHF).** These tags generally operate at 860-930 MHz, have a longer read range (about three meters) compared to HF tags, and operate at greater speeds compared to HF tags. The downside is that radio waves will not pass through items with high water content (e.g., fruit) at high frequencies such as these. Also, they use more power and are more expensive than those operating at a lower frequency. Currently, UHF spectrum is not universally available at the same frequency and power levels worldwide (for instance, it is not permitted in Japan or Korea); it is being used in pilot projects to track assets at the pallet and tote levels. We note that this is the frequency that is best-suited for supply chain applications of RFID, given the longer read range capabilities, and it is also the frequency that the Auto-ID Center is focusing on in relation to its EPC system.

- **Microwave Frequency.** These tags generally operate at 2.45GHz/5.8 GHz and have a faster data read rate compared to UHF tags. We believe there are no real defined areas of application for this frequency, but it has been used for item identification, for tracking airline baggage, and in other areas where the UHF band is being utilized. We understand that due to varying power levels of this spectrum in different countries, it is not considered a global frequency.

**Exhibit 7. RFID Operating Frequencies (passive tags)**

| | Frequency Range | Read Range | Data Rate | Typical Use |
|---|---|---|---|---|
| **Low Frequency (LF)** | 125 KHz | < 0.5 meter | Slower | Access control; animal tracking; vehicle imobilizers; POS applications (i.e.- SpeedPass) |
| **High Frequency (HF)** | 13.56 MHz | 1.0 meter | | Access control; Smart Cards; Smart Shelves; item level tracking(i.e. airline baggage, library books) |
| **Ultra High Frequency (UHF)** | 860 MHz - 930 MHz | 3.0 meter | | Pallet tracking; tote tracking; electronic toll collection |
| **Microwave Frequency (uW)** | 2.45 GHz / 5.8 GHz | 1.0 meter | Faster | Supply chain management; electronic toll collection |

Source: Bear, Stearns & Co. Inc. estimates.

**COMPONENT COSTS**

The two primary component costs of RFID are RFID readers or interrogators, and RFID tags or transponders. We understand that RFID readers cost anywhere from about $1,000 to several thousand dollars, depending on complexity. We note that certain vendors are working on "agile" readers — those that can read RFID tags operating at multiple frequencies — and that these vendors hope to get to the point where the readers can be produced for a few hundred dollars or less. There has been limited focus on low-cost readers, however, since most of the recent focus on low-cost RFID has been on tag cost. Some tag vendors claim that they are capable of producing a tag for less than a dime, given high production volumes and advanced manufacturing processes. We estimate the average cost of a low-cost RFID chip to be $0.45.

RFID chips can be broken down into the following components, which are also outlined in Exhibit 8 below.

- **Integrated Circuits (IC).** ICs, or silicon wafers (which make up approximately 80% of the materials cost of an RFID tag), often represent the primary barrier to reducing the cost of an RFID tag. This is partially due to the preparation required for the IC to be assembled with the tag's antenna, in which case the manufacturing method used becomes a critical factor. We discuss different manufacturing methods below.

- **Substrates.** Substrates are generally made of plastic or silicon, and along with antennas, represent approximately 20% of the materials cost of an RFID tag. The substrate serves as the foundation into which ICs are packaged before being attached to an antenna. While the substrate does not represent the bulk of the cost of an RFID tag, many companies are experimenting with various materials to lower the overall cost of the tag.

- **Straps.** Once an IC is packaged in a substrate with interconnects, a "strap" is formed, which is essentially the basic building block for RFID tags and labels, and it is used in conjunction with an antenna to become fully functional. The cost of a strap includes the cost of the ICs and the cost of the substrate containing the ICs. Given the average costs for ICs and substrates, the cost of a strap represents approximately 85% of the materials cost of an RFID tag.

- **Antennas.** Once a strap is attached to a antenna, a functional RFID tag is created. We estimate that antennas typically represent about 15% of the materials cost of an RFID tag. Currently, most RFID tags are stand-alone devices, but there is also discussion about straps being added to packaging in which antennas are already integrated/printed.

We also estimate that the cost of assembly associated with manufacturing RFID chips equals approximately 20% of the total cost of an RFID chip.

**Exhibit 8. Estimated Component Cost of a Passive RFID Tag**

| | |
|---|---|
| **Cost of Materials:** | |
| Integrated Circuit (IC) | $0.28 |
| Substrate | $0.02 |
| Strap [1] | $0.30 |
| Antenna | $0.05 |
| ***Total Cost of Materials*** | **$0.35** |
| ***Total Cost of Assembly*** | **$0.10** |
| **Total Component Costs** | **$0.45** |

(1) Strap represents the combined cost of the IC and Substrate.

Source: Bear, Stearns & Co. Inc.

## MANUFACTURING COSTS

- **Conventional Method: "Flip-Chip"/"Pick and Place."** Most companies that manufacture RFID chips use what is referred to as the "flip-chip," and "pick and place" methods — i.e., they use expensive robots to pick the microchip up off of a silicon wafer, flip it over, and then place it on an antenna, thus creating an RFID chip. Two very small pads located on the chip must then touch the ends of the antenna to make an electrical connection, and we note that there are multiple ways in which to bond the antenna to the pads. Just the process of connecting the chip to the antenna can make up to an estimated 10% of the total cost of an RFID tag, and the current "flip-chip"/"pick-and-place" method is often slow because the robots must move the chip a foot or more and place it with great precision (usually within ten to 20 micrometers of the target). As chips become smaller, picking them up and placing them becomes more difficult. Thus, RFID chip manufacturers have been developing alternative, "advanced" assembly methods that they hope will allow them to produce chips (given high volume) at significantly lower costs than current assembly methods yield.

- **Alien Technology Corp. Method: "Fluidic Self-Assembly" (FSA).** This is a proprietary technology process for manufacturing RFID chips (patented by UC Berkeley) used by Alien Technology Corp., in which specifically shaped semiconductor devices (ranging in size from ten to several hundred microns) are suspended in liquid and flowed over a substrate that has correspondingly shaped "holes" or receptors on it, into which the devices settle. The shape of the devices and the holes is designed so that the devices fall easily into place and are self-aligning, creating RFID chips. Alien claims that its first roll-to-roll FSA machine (its second-generation machine) can place up to 250,000 integrated circuits (ICs) per hour, equivalent to 50 pick-and-place machines. It expects its third-generation machine (which is being developed) to allow assembly of more than two million ICs per hour.

### *Detailed Steps*

1. The process begins with single crystal silicon wafers containing microelectronic devices, which are produced by large commercial semiconductor foundries.

2. Each microelectronic device is freed from the wafers via an etching process, which slices the silicon wafer into thousands or millions of separate functional devices having three-dimensional shapes (Alien has trademarked the term "Nanoblock" to describe the devices freed from the silicon wafers).

3. The underlying substrate (to which the Nanoblocks will be bonded) has holes that specifically correspond to the Nanoblock shapes.

4. The Nanoblocks are then suspended in fluid, and as they pass over the substrate surface, they drop into the correspondingly shaped holes.

5. The Nanoblocks that do not assemble into holes in the substrate surface are removed from the fluid, cleaned, re-suspended in clean fluid, and flowed again over another substrate.

6. The Nanoblocks that did self-assemble into the holes in the substrate are electrically connected via standard metallization techniques to create the final integrated RFID chip.

- **Philips Method: "I-Connect."** Philips has developed this process in order to solve problems that have arisen in assembling chips for RFID labels. Specifically, I-connect is a package for the chip, consisting of a small strip with metal connectors. Rather than moving the chip across a coiled antenna, the robot only has to move it into a narrow strip that is part of a long roll. The I-connect strip has metal connectors that are bonded to the microchip using existing flip-chip techniques, but because the pads on the strip are large, it is much easier to attach the strip to an antenna (i.e., it is similar to placing a single piece of glitter on a strip of tape and taping it to a piece of paper, as opposed to gluing the glitter directly onto the paper).

  Philips anticipates having the first machine on-line by the end of 2003, and expects this new technique to reduce the cost of assembly from 10% of the total RFID label cost to a mere 1%. The company plans to use this technology when demand for RFID chips reaches one to ten billion units per year.

- **Philips' Future Method: "Vibratory Assembly."** Philips is also working on this advanced assembly technique, which would be used if demand for RFID chips climbs beyond ten billion per year. Rather than using robots that pick up and place chips, this mass assembly technique would consist of a vibrating drum that would slide chips into cavities on a substrate, where they would be connected to nodes on packages and bonded to an antenna.

  While this method is comparable to Alien's fluidic self-assembly process, Philips hopes to differentiate its method by developing vibratory assembly so that it can be brought on-line in stages. Development efforts for vibratory assembly are well under way, and Philips expects to introduce this method in four or five years, depending upon whether demand for low-cost chips materializes.

Currently, there are no universal standards for RFID technology. We think that this poses a potential risk for vendors and users pursuing this space, given that 1) current RFID hardware and software may or may not be compliant with what may be determined as the standard in the future, and 2) a universal standard may never evolve, in which case incompatibility among RFID hardware and/or software will be inevitable. It is also our sense that this lack of standards may serve as an impediment to broader adoption of RFID technology.

The primary issue with respect to RFID technology standards surrounds what is referred to as the "air interface" protocol, or the mechanism that allows RFID tags to communicate with RFID readers. Right now there are three primary organizations that are taking steps to create standards for RFID technology: 1) the International Organization for Standardization (ISO); 2) the European Article Numbering/Uniform Code Council (EAN.UCC); and 3) the Auto-ID Center. We note that the UCC and the Auto-ID Center recently announced a deal in which the UCC will license the EPC technology developed by the Auto-ID Center, providing the UCC with exclusive rights to this technology.

Accordingly, the two organizations have formed a joint venture called Auto-ID Inc. in order to commercialize the technology. In our view, this announcement provides somewhat better visibility to a set of universally followed RFID standards, although standards work still remains somewhat fragmented among various organizations. Below we take a closer look at the RFID air interface issue in addition to various organizations that are currently working on RFID standards.

### THE "AIR INTERFACE" ISSUE — ISO VERSUS THE AUTO-ID CENTER

As previously explained, the primary focus with respect to RFID standards has been related to the air interface — in other words, the way in which RFID tags communicate with RFID readers. Two groups that have been receiving most of the attention in this area are ISO and the Auto-ID Center, and specifically, the UHF air interface being developed by each. This is partially attributable to the fact that the UHF band is generally regarded as the most suitable frequency for tracking assets in the supply chain. At the moment, the UHF air interface being developed by the Auto-ID Center (under its EPC system) is not compatible with that being developed by ISO (under its proposed 18000-6 standard). In other words, an RFID reader that is developed according to the air interface of the Auto-ID Center's EPC system will not be compatible with an RFID tag that is developed according to ISO 18000-6. We note that the Auto-ID's EPC system consists of various components (explained below), but the ISO 18000 series deals exclusively with the air interface. Thus, we gather that the only portion of the EPC system that is currently inoperable with ISO is that related to the air interface.

### INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO is a network of national standards institutes from 145 countries working in partnership with international organizations, governments, industry, business, and consumer representatives. Currently, ISO has more than 13,700 international standards for business, government, and society. With respect to RFID, ISO has three technical committees that deal with the technology: 1) TC104, which is focused on freight containers; 2) TC204, which is focused on road informatics; and 3) TC122,

which is focused on packaging. ISO has also formed a Joint Technical Committee (JTC1), which consists of various groups within ISO and the International Electrotechnical Committee (EIC) in order to publish IT standards in the areas of electrical, electronic, and related technologies.

The subcommittee within JTC1 that is responsible for automatic identification and data capture technology (AIDC) — under which RFID falls — is named SC31. Within SC31, there are four work groups: 1) WG1, which deals with bar code standards; 2) WG2, which deals with data capture; 3) WG3, which deals with conformity; and 4) WG4, which deals with RFID issues. ISO has a six-step process that must be followed in order to move a proposal to a final standard, as illustrated in Exhibit 9 below.

**Exhibit 9. ISO Standards — A Six-Step Process**

| Stage | Description | Voting Period |
|---|---|---|
| Stage 1- Proposal Stage | New work item proposal (NP) is submitted | 3 months |
| Stage 2- Preparation Stage | A Working Draft (WD) is prepared | NA |
| Stage 3- Committee Stage | A Committee Draft (CD) is under consideration | 3 to 6 months |
| Stage 4- Enquiry Stage | A Final Committee Draft (FCD) is under consideration | 4 to 6 months |
| Stage 5- Approval Stage | A Final Draft International Standard (FDIS) is under consideration | 2 months |
| Stage 6- Publication Stage | An International Standard (IS) is published (1) | NA |

(1) All International Standards are reviewed at least once every five years by the responsible Technical Committees/Subcommittees.

Source: Bear, Stearns & Co. Inc. estimates.

Within WG4 (which, as noted earlier, deals with RFID issues), there are multiple subgroups, and Subgroup 3 is focused on RFID for automatic identification and item management (i.e., RFID for tracking assets in the supply chain). Specifically, Subgroup 3 is responsible for ISO 18000, which is a proposed standard dealing with the air interface (the way RFID tags communicate with RFID readers) for frequencies used around the world (we note that ISO 18000 does not specify criteria related to data content). ISO 18000 has seven parts, as described below in Exhibit 10.

**Exhibit 10. ISO 18000 Supply Chain Standard — Seven Parts**

| Part | Description | Status |
|---|---|---|
| 18000-1 | Generic parameters for air interfaces operating at globally accepted frequencies | Final Committee Draft (FCD) approved on 2/8/03<br>Final Draft International Standard (FDIS) ballot expected to close in August 2003<br>Publication expected in September/October 2003 |
| 18000-2 | Air interface for RFID operating at 135 KHz | Final Committee Draft (FCD) approved on 2/8/03<br>Final Draft International Standard (FDIS) ballot expected to close in August 2003<br>Publication expected in September/October 2003 |
| 18000-3 | Air interface for RFID operating at 13.56 MHz | Final Committee Draft (FCD) approved on 2/8/03<br>Final Draft International Standard (FDIS) ballot expected to close in August 2003<br>Publication expected in September/October 2003 |
| 18000-4 | Air interface for RFID operating at 2.45 GHz | Final Committee Draft (FCD) approved on 2/8/03<br>Final Draft International Standard (FDIS) ballot expected to close in August 2003<br>Publication expected in September/October 2003 |
| 18000-5 | Air interface for RFID operating at 5.8 GHz | Proposal rejected in January 2003 |
| 18000-6 | Air interface for RFID operating at 860 MHz - 930 MHz | Committee Draft (CD) approved on 01/07/03<br>Final Committee Draft (FCD) ballot expected to close August 18, 2003 |
| 18000-7 | Air interface for RFID operating at 433.92 MHz | Committee Draft (CD) approved on 01/07/03 |

Source: Bear, Stearns & Co. Inc. estimates.

In addition to the 18000 series, ISO is involved with some other standards related to RFID technology, as shown in Exhibit 11 below.

**Exhibit 11. Other RFID ISO Standards**

| Standard | Category | Description | Status |
|---|---|---|---|
| ISO 15961 | Technical | RFID for Item Management- Data protocol: Application interface | Committee Draft (CD) expected to close 7/14/03 |
| ISO 15962 | Technical | RFID for Item Management- Protocol: Data encoding rules and logical memory functions | Committee Draft (CD) expected to close 7/14/03 |
| ISO 15693 | Technical | RFID used for Item Management- Unique Identification of RF tag | Final Committee Draft (FCD) expected to close 8/17/03 |
| ISO 18046 | Technical | RFID Tag and Interrogator Performance Test Methods | Preliminary Draft Technical Report (PDTR) ballot expected in July 2003 |
| ISO 18047 | Technical | RFID Device Conformance Test Methods | Preliminary Draft Technical Report (PDTR) ballot expected in July 2003 |
| ISO 18185 | Application | Freight Containers- RF communication protocol for electronic seal | Is expected to be incorporated into a new standard |
| ISO 17358 | Application | Application Requirements: Supply Chain Applications of RFID | New Work Item Proposal approved on 11/22/02 |
| ISO 17363 | Application | Supply Chain Application Requirements of RFID for Freight Containers | New Work Item Proposal approved on 11/22/02 |
| ISO 17364 | Application | Supply Chain Application Requirements of RFID for Returnable Transport Items | New Work Item Proposal approved on 11/22/02 |
| ISO 17365 | Application | Supply Chain Application Requirements of RFID for Transport Units | New Work Item Proposal approved on 11/22/02 |
| ISO 17366 | Application | Supply Chain Application Requirements of RFID for Product Packaging | New Work Item Proposal approved on 11/22/02 |
| ISO 17367 | Application | Supply Chain Application Requirements of RFID for Product Tagging | New Work Item Proposal approved on 11/22/02 |
| ISO 11784 | Technical/Application | Structure of radio frequency identification code for animals | Published |
| ISO 11785 | Technical/Application | Describes the technical concept of animal identification based on RFID | Published |
| ISO 23389 | Application | Freight Containers- Read-Write RFID | Is expected to be combined with ISO 17363 |
| ISO 15418 | Technical | EAN/UCC Application Identifiers and FACT Data Identifiers and Maintenance | Published |
| ISO 15434 | Technical | Transfer Syntax for High Capacity ADC Media | Published |
| ISO 18001 | Technical | RFID for Item Management- Application requirement profiles | Waiting for Publication |
| TBA | Technical | RFID for Item Management- Application Programmer Interface (API) | Committee Draft (CD) ballot passed, awaiting resolution meeting in July 2003 |
| TBA | Technical | RFID for Item management - ET functionality for 18000 | New Work Item Proposal (NP) expected to close 7/11/03 |
| ISO 19762 | Technical | Harmonized Vocabulary | Final Draft International Standard (FDIS) is expected in November 2003 |

Source: Bear, Stearns & Co. Inc. estimates.

## EAN.UCC

Formed in 1977, European Article Numbering International (EAN) is a European UPC-compatible system, aiming to develop a set of standards to identify various assets, locations, and services. Today, EAN has 99 member organizations representing101 countries that provide support and information to local member companies. The Universal Code Council (UCC) is a nonprofit organization that was designed to establish and promote multi-industry standards for product identification. The UCC oversees and administers the Uniform Product Code (UPC), which is a bar code standard used in North America, and also provides various integrated standards and business solutions for more than 250,000 member companies that do business in 25 major industries.

Collectively, these two standardizing bodies form EAN.UCC, aiming to promote global standards for product identification, including RFID initiatives. Most notably,

EAN.UCC has worked with ISO through its GTAG initiative (described below), and also supports the Auto-ID Center's EPC system.

### *EAN.UC — The GTAG Initiative*

GTAG (or global tag) was proposed in March 2000 by the EAN.UCC in hopes of creating an RFID solution for global supply chain applications involving asset tracking. Originally, EAN.UCC submitted GTAG (which utilizes the UHF band) to ISO with the expectation that it would become a formal international standard. However, because ISO was working on ISO 18000-6, which also uses the UHF band, EAN.UCC agreed to merge its GTAG initiative with ISO 18000-6.

We find it important to note, however, that while GTAG utilizes the proposed ISO standard for tag-reader communication — or the UHF air interface — it also specifies how data should be formatted according to EAN.UCC data structures. This implies that ISO 18000-6 tags that use data structures other than what is proposed by the EAN.UCC will not be GTAG-compliant. Specifically, the GTAG specification requires that a fixed reader be capable of identifying 250 tags simultaneously, have a minimum read range of two meters, and be able to capture data from 250 tags within five seconds with 99.99% reliability. Furthermore, GTAG-compliant tags are required to have at least 124 bits of data, as well as an application family identifier (AFI), which is a number written on the chip during manufacturing that identifies it as GTAG-compliant. It is our understanding that SAMSys Technologies currently offers a GTAG-compliant reader, and that Philips Semiconductor intends to produce a GTAG-compliant tag, which it calls "I-Code HSL."

## THE AUTO-ID CENTER'S ELECTRONIC PRODUCT CODE (EPC) SYSTEM

In contrast to ISO, the Auto-ID Center aims to take a "de facto" approach to RFID standards (thus hoping that, upon widespread adoption, its EPC system will become the standard by default) and a system view of RFID technology (see our comments on the Auto-ID Center below). The technology includes specifications for RFID tags and readers in addition to network infrastructure for managing related data. The Auto-ID Center's set of standards, which are commonly referred to as the Electronic Product Code (EPC) system, focuses on UHF and serves the following purposes: 1) it provides a numbering system for unique identification; 2) it defines how data is stored and transported; and 3) it provides a carrier for the unique number in the form of a chip or tag.

We note that the Auto-ID Center and the UCC recently reached an agreement under which the UCC will license EPC technology from the Auto-ID Center, and both organizations have agreed to form a joint venture called Auto-ID Inc. as a means to commercialize this technology (see section on Auto-ID Inc. below).

Exhibit 12 below illustrates the different RFID tag specifications proposed by the Auto-ID Center, where the classification designated to each primarily refers to the communication protocol of the tag, as well as the level of complexity of the tag, which increases from 0 to 4.

**Exhibit 12. Auto-ID Center — Tag Class Specifications**

| Tag Class [1] | Characteristics |
|---|---|
| Class 0 | Read-Only; Factory Programmable |
| Class 1 | Write Once, Read Many |
| Class 2 [2] | Fully Re-Writable |
| Class 3 [2] | Active Tag (Fully Re-Writable) |
| Class 4 [2] | Relay Tag - Can Communicate with Other Tags |

(1) Classification refers to the communication protocol.
(2) The Auto-ID Center has not finalized chip design and specifications for this class yet.

Source: Bear, Stearns & Co. Inc. estimates.

We believe that, to date, Alien Technology has manufactured Class 1 tags and that Matrics has manufactured Class 0 tags, both of which work in the UHF band. We also understand that Philips and Tagsys have manufactured EPC-compliant tags and readers that work at HF (13.56 MHz).

### *Auto-ID Inc.*

In May 2003, the UCC announced that it had reached an agreement with MIT to license EPC technology, which was developed by the Auto-ID Center, thus giving the UCC exclusive rights to the technology. In accordance with this agreement, both bodies intend to form a joint venture called Auto-ID Inc. in order to commercialize the technology. It is our understanding that AutoID Inc. will have its own board, which is expected to be comprised of members from various sectors, including CPG, high tech, health care, transportation, and government. We also gather that it will report to the boards of the EAN and UCC.

The deal is expected to commence on November 1, 2003, at which point we understand that the Auto-ID Center will divide into two parts: 1) Auto-ID Inc., which will be responsible for the administrative and managerial duties involved with EPC standards development; and 2) Auto-ID Labs, which will continue to focus on research related to EPC technology at MIT in addition to five other universities. We have learned that Auto-ID Inc. will be based in New Jersey, but that it will also have a presence in Cambridge, Massachusetts, in an effort to coordinate with the Auto-ID Labs. We also believe that the UCC and EAN intend to create a implementation task group by third-quarter 2003 to start commercializing EPC technology, and that EPCs will be issued once this group is operational. Auto-ID Inc. will be a not-for-profit organization, and expects to charge a fee to those wishing to join, in addition to an annual membership fee, which will provide members the opportunity to use EPC-related technology, receive training, and participate in AutoID Inc. task groups.

In our opinion, formation of Auto-ID Inc. is a significant step forward in the development of RFID standards because 1) it will allow MIT and the Auto-ID Center to focus on their core competency, which is RFID-related research; 2) it will hand over administrative and managerial duties to the UCC, which has a proven history of developing and managing standards; and 3) it may provide more clarity with regard to RFID standards, thus accelerating broader adoption of RFID technology going forward.

We also expect Auto-ID Inc. to seek ISO approval for EPC protocols once its technology proves functional, thus giving it more credibility as a "standard" (although we note that there is no guarantee that ISO will grant this approval).

## OTHER STANDARDIZING BODIES

In addition to ISO, EAN.UCC, and the Auto-ID Center, there are other organizations working on RFID standards, including the American National Standards Institute (ANSI) and the Automotive Industry Action Group (AIAG). Exhibit 13 below lists some other RFID standards related to each.

- **American National Standards Institute (ANSI).** ANSI is a private, non-profit organization administering and promoting standards and conformity assessment systems. Through its International Committee for Information Technology Standards (INCITS), as well as through its MH10 subcommittee, ANSI has published standards related to RFID technology.

- **Automotive Industry Action Group (AIAG).** Founded in 1982, AIAG aims to bring together its members to develop and promote solutions that benefit the automotive industry. As a result, AIAG members contribute to the development of new technologies as well as to the standards surrounding these technologies.

**Exhibit 13. Other RFID Standards**

| Standard | Category | Description | Status |
|---|---|---|---|
| ANSI INCITS 256 | Technical | Radio Frequency Identification (RFID) | 2nd Edition published, 3rd Edition in progress |
| ANSI INCITS 371.1 | Technical | Real Time Locating Systems (RTLS) - 2450 MHz | Approved, waiting INCITS BOD approval in July 2003 |
| ANSI INCITS 371.2 | Technical | Real Time Locating Systems (RTLS) -433 MHz | Approved, waiting INCITS BOD approval in July 2003 |
| ANSI INCITS 371.3 | Technical | Real Time Locating Systems (RTLS) - API | Approved, waiting INCITS BOD approval in July 2003 |
| ANSI MH10.8.4 | Application | Unit Loads and Transport Packages - RFID Tags for Returnable Containers | Published |
| ANSI MH10.8.8 | Application | RFID for Parcels, packages and Flat Mail | Work Item has been Approved |
| AIAG B-11 | Application | Tire and Wheel Identification Standard | 4th edition (includes RFID) published October 2002 |

Source: Bear, Stearns & Co. Inc. estimates.

## REACHING A UNIVERSAL SET OF STANDARDS FOR RFID

Given that RFID is still in its infancy and the standards process appears to be a dispersed effort (although we do believe the recent agreement between the Auto-ID Center and the UCC is a step in the right direction), we do not expect to see a set of universal RFID standards for many years, if ever. It is our view that the large retailers and CPG firms (which are sponsors of the Auto-ID Center) will continue to support and drive the success of the EPC system given their need to track large numbers of low-cost items, while those not involved with the Auto-ID Center — and those especially interested in international standards — will continue to gravitate toward ISO standards, resulting in co-existing air interface protocols, differentiated by vendor and application.

Because the ISO 18000 series of standards relates only to the air interface protocol of RFID (and not data structure), we believe that tags compliant with ISO 18000-6 should be able to carry unique identifiers in the form of EPCs, which we think would imply compatibility with the Auto-ID Center and its EPC system, aside from its separate air interface. According to ISO, its contributing sponsors and collaborators must make their intellectual property available on a reasonable and equitable basis to anyone who wants to implement the standard, while the same is not true for non-ISO standards (such as those proposed by the Auto-ID Center).

Given this, and assuming that ISO 18000-6 can provide an air interface that can perform at least as well as that proposed by the EPC system, the question becomes why the EPC system needs a separate air interface when a versatile industry standard is currently in the works. In other words, why doesn't the Auto-ID Center or Auto-ID Inc. accept the air interface as proposed by ISO 18000-6, and discontinue the development of its own proprietary air interface, given that its EPC system can function in this environment without sacrificing performance?

There are several likely answers for this, one of which is that a separate air interface might provide an advantage for certain vendors (e.g., Alien Technology or Matrics), which currently sell RFID tags that conform to the Auto-ID Centers Class 1 and Class 0 tags, respectively, given that it provides a way for them to differentiate themselves, or it may allow them to charge royalties to other vendors wishing to utilize an air interface of which they own the intellectual property. This brings up another issue facing the EPC system, which is whether it will infringe on existing RFID patents once it is officially rolled out. We believe that EAN.UCC has been evaluating this possibility, and that so far, it has not found any patents held by third parties that might prevent the implementation of the Auto-ID Center's specifications.

## The Auto-ID Center Explained

Founded in 1999, the Auto-ID Center is a partnership among nearly 100 global companies and five research universities — the Massachusetts Institute of Technology in the U.S.; the University of Cambridge in the U.K.; the University of Adelaide in Australia; Keio University in Japan; and the University of St. Gallen in Switzerland — which collectively aim to create standards for RFID and foster the development of related technologies through a global infrastructure. Specifically, the Auto-ID Center and its sponsors are working to develop flexible, low-cost, RFID tags and readers that will make tracking individual items feasible. The components of the Auto-ID Center's technology (or its "Network") are described below.

### COMPONENTS OF THE AUTO-ID CENTER TECHNOLOGY

- **The Electronic Product Code (EPC).** The Auto-ID Center has proposed the EPC as a new standard for identifying products, and its end goal is to create a migration path from established bar code standards to the EPC. In accordance with this, the Auto-ID Center has adopted the basic structures of the Global Trade Item Number (GTIN), which is a group under which virtually all existing bar codes fall. The EPC proposal has the support of the Uniform Code Council (UCC) as well as European Article Numbering International (EAN), both of which oversee international bar code standards.

  The EPC is a number made up of a header and three sets of data (see Exhibit 14 below), which collectively provide a unique identification for an item. We note that this differs from Universal Product Codes (UPC), which refer to a class of products, because EPC refers to a specific *instance* of a product. The header represents the EPC's version number; the EPC manager typically represents the manufacturer of the product (e.g., "XYZ Computer Company"); the object class represents the type of product, which is most often the stock-keeping unit (e.g., "17-inch black monitor"); and the serial number is unique to the item (for instance, it indicates exactly which 17-inch black monitor from XYZ Computer Company is being referred to).

  The Auto-ID Center has proposed 64- and 96-bit EPCs, and expects the 96-bit EPC to become the most common. The 96-bit EPC provides unique identifiers for 268 million companies, and each manufacturer can have 16 million classes and 68 billion serial numbers in each class. Because there is no need (at this time) for this many serial numbers, the 64-bit EPC was proposed to keep prices down, as less code equates to less cost.

**Exhibit 14. Electronic Product Code (EPC)**


Source: The Auto-ID Center.

- **Savant Systems.** Savant is an enterprise software technology developed by the Auto-ID Center that serves as the "nervous system" of its RFID network. As readers pick up an influx of EPC codes from RFID tags, Savant serves as the technology to manage and move the associated data. Specifically, Savant uses a distributed architecture, and is organized in a hierarchy that manages the flow of data by gathering, storing, and acting on information and interacting with other Savants. Some of the tasks that Savant will handle include data smoothing, reader coordination, data forwarding, data storage, and task management.

- **The Object Name Service (ONS).** The ONS communicates to computer systems where to find information related to an object that carries an EPC. Its role is to match the EPC stored on an RFID tag to information about the item it is attached to. ONS is partially based on the Internet's existing Domain Name System (DNS), which routes computers to sites on the Internet.

- **The Physical Markup Language (PML).** Based on XML (eXtensible Markup Language), PML is a standard language used for describing information about a product, very similar to the way that Hypertext Markup Language (HTML) is used in the creation of most Web pages. Practically any type of information can be contained within the PML description of an object, as it allows manufacturers to determine and modify information tracked on its products.

## HOW IT ALL FITS TOGETHER

### *A Retailer Example — Super-Mart XYZ*

Two dozen boxes of Detergent A, with passive RFID tags attached to them, are displayed on the shelf of Super-Mart XYZ, which is also equipped with an RFID reader. Super-Mart XYZ is trying to ensure that at least a dozen boxes of Detergent A are present on the shelf at all times. Throughout the course of the day, numerous consumers decide to purchase Detergent A. Each time a box is taken off the shelf by a consumer, the RFID tags on the individual boxes send radio waves to the RFID reader on the shelf, which then translates the waves into digital information (Detergent A's EPC code). Detergent A's EPC code is then passed onto a Savant, which will communicate with an ONS to find (either on a local network or on the Internet) where the information for a particular box of Detergent A is stored.

Once found, the ONS directs the Savant to a server where this box's file is located, and then this file is retrieved by the Savant. The Savant can now forward the information about that box of Detergent A to Super-Mart XYZ's inventory/supply chain application. This scenario repeats each time a box of Detergent A is taken off the shelf.

By the time the number of boxes of Detergent A on Super-Mart XYZ's shelf gets close to 12, a store clerk will be alerted by Super-Mart XYZ's inventory/supply chain application, so that he or she can re-stock the shelf accordingly. A similar scenario might take place in Super-Mart XYZ's stock room as well, such that when inventory levels become low, its staff and/or procurement system can be automatically alerted for replenishment.

## SPONSORS OF THE AUTO-ID CENTER

In accordance with its goal of creating a global RFID network based on open standards, the Auto-ID encourages sponsors to join the center, although sponsors do

not receive any intellectual property rights by doing so. Rather, sponsors of the Auto-ID Center get access to the center's research, as well as the ability to participate in the center's activities and meetings. As a result of their membership, sponsors have the chance to influence the development of the global RFID network as proposed by the center. Exhibit 15 below lists the various sponsors of the Auto-ID Center.

The Auto-ID Center divides its sponsors into two different groups: 1) Board of Overseers, and 2) Technology Board. The Center's Board of Overseers represents end-user sponsors — those who will purchase EPC-related technologies — which are required to make a onetime donation of $300,000. The Center's Technology Board represents vendors that plan to sell EPC-related technologies and/or services, and these sponsors are required to make a donation ranging from $50,000 to $150,000— depending upon the annual sales of each. The Auto-ID Center also has EPC Alliance Partners (non-profit trade organizations with at least ten members), which are not required to make a donation and are generally kept informed about the Center's research as well as invited to special partner events.

**Exhibit 15. Auto-ID Center Sponsors**

| Board of Overseers | | Technology Board | |
|---|---|---|---|
| Abbott Laboratories | Ahold IS | Accenture | ACNielsen |
| Best Buy Corporation | Canon Inc. | Alien Technology | Avery Dennison |
| Carrefour | Cheo International | AWID | British Telecommunications (BT) |
| Coca-Cola | CVS | Cash's | Catalina Marketing Corp |
| Dai Nippon Printing Co., Ltd | Department of Defense | Checkpoint Systems, Inc. | ConnecTerra, Inc. |
| Fan International | Eastman Kodak | Ember Corporation | Embrace Networks |
| The Gillette Company | Home Depot | Flexchip AG | Flint Ink |
| International Paper | Johnson & Johnson | GEA Consulting | GlobeRanger |
| Kellogg's Corporation | Kimberely Clark Corporation | IBM Business Consulting Serivces | IDTechEx |
| Kraft | Lowes Companies, Inc. | Impinj, Inc. | Information Resources, Inc. |
| Metro | Mitsui & Co, Ltd | Intel | Intermec |
| Nestle | Pepsi | Invensys PLC | Ishida Co, Ltd |
| PepsiCo | Pfizer | KSW Microtec AG | Manhattan Associates |
| Philip Morris USA | Proctor and Gamble Company | Markem Corp. | Matrics |
| Sara Lee | Smurfit-Stone Container Corp | Morningside Technologies | NCR Corporation |
| Target Corp. | Tesco Stores Ltd. | Nihon Unisys Ltd. | Nippon Telegraph and Telephone Corporation |
| Uniform Code Council | Toppan Printing | NTT Comware | OATSystems |
| United States Postal Service | Unilever | Omron Corporation | Philips Semiconductors |
| Visy Industries | UPS | Rafsec | RF Saw Components |
| Weqmans Food Markets, Inc. | Wal-Mart Stores, Inc. | SAMSYS | SAP |
| Yuen Foong Yu Paper Mfg. Co., LTD. | Westvaco | Savi Technology | Sensitech |
| | | Sensormatic Electronics Corp | Siemens Dematic Corp |
| | | STMicroelectronics | Sun Microsystems |
| | | Symbol Technologies | TAGSYS |
| | | ThingMagic | Toppan Forms |
| | | Toray International, Inc. | Vizional Technologies |
| | | Zebra Technologies Corporation | |

Source: The Auto-ID Center.

## AUTO-ID CENTER FIELD TRIAL

The Auto-ID Center has designed what it refers to as a "field trial" in an effort to evaluate its RFID system by implementing its technology in real-world supply chain applications. The purpose of the field trial is to determine if the Auto-ID Center's RFID system is able to locate an item, case, or pallet anywhere and at anytime in the supply chain among manufacturing facilities, manufacturing distribution centers, retailer distribution centers, retail stores, consumer homes, and eventually disposal/recycling centers. We note that the field trial is not funded by the Auto-ID Center; rather, it is funded by participating sponsors.

The field trial is divided into three phases, as illustrated in Exhibit 16 below, with each of these phases being primarily defined by the type of item being tagged. In addition, each phase has unique objectives as well as requirements. To date, Phase I and II have been completed, and Phase III is under way. However, only details of

Phase I have been disclosed thus far, and thus we take a closer look at Phase I of the field trials below.

**Exhibit 16. Auto-ID Center Field Trial — A Three-Phased Approach**

| | Timeframe | Level of Tracking | Implementation Objectives | Involved Sponsors(1) |
|---|---|---|---|---|
| **Phase I** | October 1, 2001-February 1, 2002 (completed & summary available) | Pallet | • Minimize # of SKUs<br>• Eliminate (if possible) DC's<br>• Minimize # of stores to 1 or 2<br>• Minimize number of participating sponsors<br>• Use existing hardware technology<br>• Auto-ID developed software (incl. ONS, Savant) | CHEP International, International Paper, Johnson & Johnson, Philip Morris Group (Kraft), Proctor & Gamble Company, The Coca Cola Company, The Gillette Company, Uniform Code Council, Unilever, Wal-Mart Stores, Inc., Westvaco, Yeun Foong Yu Paper Mfg., Alien Technology, Checkpoint, Invensys Control, MARKEM Corp., NCR, Philips Semiconductors, Rafsec, Savi Technologies, Sensormatic, SAP Labs Inc., Sun Microsystems |
| **Phase II** | February-02 (completed & summary TBA) | Pallet & Case | • Increase # of SKUs<br>• Increase # of stores<br>• Add distribution center<br>• Increase # of sponsors<br>• Use existing hardware technology<br>• Auto-ID developed software (incl. ONS, Savant) | Unilever, Proctor & Gamble Company, Kraft, The Coca-Cola Company, Wal-Mart Stores, Inc., Johnson & Johnson |
| **Phase III** | 4Q02 (currently taking place) | Pallet, Case & Unit | • Increase # of SKUs<br>• Increase # of sponsors<br>• Use new low-cost technology (incl. tags & readers)<br>• Auto-ID developed software (incl. ONS, Savant) | TBA |

(1) The Uniform Code Council (UCC) is the only non-paying non-voting member of the Field Trial Team. Sponsors listed for Phase II represent only a sample, as full details have not yet been disclosed.

Source: The Auto-ID Center.

### *Field Trial — Phase I: A Closer Look*

Phase I of the field trial, which involved tagging at the pallet level, began on October 1, 2001 and ended in February 1, 2002. During this phase, two commercially available RFID tags were affixed to each pallet (one was placed on opposing corners of each pallet), and the objective of Phase I was to evaluate the effectiveness of the Auto-ID Center's RFID technology (EPC, ONS, and Savant) within a real-world supply chain. Specifically, each RFID tag was written with a unique EPC, and the two EPCs corresponding to the same pallet were recorded in a database, where reading either of the two associated EPCs identified the pallet. RFID readers were installed at many locations within the supply chain to read tags as they entered or exited a location. A single Savant was also installed at each location, with a "top-level" Savant installed at MIT, where the global ONS was also installed.

Phase I of the field trial took place in Tulsa, Oklahoma, and consisted of products from four end-user manufacturer sponsors — CHEP, Procter & Gamble, Gillette, and Unilever. It used the facilities of one end-user retail sponsor, Wal-Mart (see Exhibit 17 below). We note that Wal-Mart's Sam's Club was chosen as a result of the need for high pallet volume for one individual product through a retail environment, which, it was determined, only a Sam's Club could provide.

During Phase I, EPC codes on pallets carrying Bounty paper towels in a Procter & Gamble factory in Cape Girardeau, Missouri, were read remotely in the MIT lab. Soon after that, a shipment of Bounty was shipped to a Sam's Club in Tulsa Oklahoma, and the EPCs were then read as these pallets left the factory. Following this, pallets of other goods, including those from Gillette and Unilever, were added as part of Phase I.

In terms of technology, Savi Technologies' portal application, which uses 915 MHz technology, was selected (Exhibit 18 below illustrates the installation locations and installed systems for Phase I of the field trial). CHEP pallets, which were pre fabricated with 915 MHz RFID tags, were used for the Unilever and P&G facilities. Gillette pallets were equipped with 915 MHz RFID tags that were hand-applied at the distribution center. Because all technology must be tested prior to installation within

a facility, Wal-Mart provided a pilot test facility located in Rogers, Arkansas, which was used to test and debug technologies used in the field trial. We believe the total cost for Phase I totaled $399,136, which includes money spent for readers, tags, Savant, installation, software development, and system maintenance. We understand that $116,000 of the money spent for software development will also benefit Phases II and III.

The Auto-ID Center claims that, based on Phase I, a 97% item identification accuracy was achieved, while a 78% tag identification accuracy was achieved. Presumably, this would imply that the Auto-ID Center system components work as designed, and that attaching multiple tags to an item increases the chance for identification (given that the EPCs on the tags corresponding to a particular item are known in advance). However, Phase I also points out that this type of installation (using existing technology) is not enough to guarantee 100% success relating to item identification.

**Exhibit 17. Phase I — Manufacturer Sponsors and End-User Retail Sponsors**

| End User Sponsor | Product/Facility |
|---|---|
| Chep | Wooden Pallets |
| Proctor & Gamble | Bounty Paper Towels |
| Gillette | Mach 3 Razors, 16 Pack |
| Unilever | Liquid All Detergent Soap |
| Wal-Mart Stores | Sam's Club in Tulsa, Oklahoma |

Source: The Auto-ID Center.

**Exhibit 18. Phase I — Installed Locations and Installed Systems**

| Location of System | Installation Details | |
|---|---|---|
| Procter & Gamble<br>*Cape Girardeau, MO*<br>*Factory* | One Exit Door | Portal installation<br>Dial up modem<br>Two 915 MHz readers<br>Two circular polarized antennas (one on each side of portal)<br>Savi Site Server<br>Savant |
| Sam's Club<br>*Tulsa, OK*<br>*Retail Store* | 5 Entry Doors<br>1 Exit Door | Portal installation<br>Dial up modem<br>One 915MHz reader per door<br>Two circular polarized antennas (one on each side of door)<br>Savit Site Server<br>Savant |
| Sam's Club<br>*Kansas City, MO*<br>*Distribution Center* | 2 Exit Doors | Portal installation<br>Dial up modem<br>Two 915MHz readers<br>Two circular polarized antennas (one on each side)<br>Savi Site Server<br>Savant |
| Gillette<br>*Romeoville, IL*<br>*Distribution Center* | 1 Exit Door | Portal Installation<br>Dial up Modem<br>Two 915MHz readers<br>Two circular polarized antennas, one side of door<br>Savi Site Server<br>Savant |
| Unilever<br>*Baltimore, MD*<br>*Distribution Center* | 1 Exit Door | Portal Installation<br>Dial up Modem<br>Two 915MHz readers<br>Two circular polarized antennas<br>Oatsystem Site Server<br>Savant |
| MIT<br>*Cambridge, MA*<br>*MA Laboratory* | Desk Hook Up | Top level Savant<br>Global ONS |

Source: The Auto-ID Center.

According to the Auto-ID Center, most of the problems experienced during Phase I of the field trial were due to either hardware issues or human error. Some problems highlighted by the Auto-ID Center are illustrated in Exhibit 19 below.

**Exhibit 19. Phase I — Issues Encountered**

| | |
|---|---|
| • Power Outage | • Data Capture Unreliable |
| • Frequency Interference | • Human Error |
| • Loading Dock Issues | • Installation Problems |
| • DSL Line Router Issues | • Read Reliability |
| • Lost Reader | • Poor Quality of Phone Line |
| • Lost Inoperative Tag | • Communication between Technologies |
| • Lost Hard Drive | • Dial-up Failure |
| • Damaged Antennas | |

Source: The Auto-ID Center.

**TRANSPONDER AND READER SYSTEM VENDORS**

### *Alien Technology Corporation*

Alien Technology Corporation is a privately held technology company that develops and manufactures low-cost RFID solutions. The company is a member of the Auto-ID Center and is working to deploy RFID tags that are compliant with the Auto-ID Center's Electronic Product Code (EPC) system. Alien Technology has developed a proprietary manufacturing process which the company believes is capable of manufacturing large volumes of RFID tags at low cost. In this process, called fluidic self assembly (FSA), integrated circuits (ICs) are suspended in liquid and flowed over a flexible film, the surface of which has shaped micro-embossed receptor holes into which the ICs settle. The shape of the devices and the corresponding holes are such that the devices fall into place and self-align.

It is our understanding that Alien has developed a Class 1 ultra-high-frequency 915 MHz tag which, by definition, adheres to the write-once/read-many protocol. Alien received a large purchase order from Gillette for 500 million tags, but so far it has been difficult to determine how many tags have actually been shipped and paid for. Originally, in November 2002, Gillette announced its intention to purchase the 500 million tags from Alien to tag pallets and cases of its razors. Gillette confirmed its plans in January 2003, but qualified the announcement by saying that it was beginning to test technology throughout its supply chain by placing RFID tags in select products for the U.S. market. The company indicated that if tests are successful, it would then purchase up to 500 million tags for placement on Gillette products over the next few years. Alien is also working to develop passive tags with metal or printed conducive antenna at the 2.45 GHz frequency.

Alien also manufactures readers that operate at 915 MHz, according to the Auto-ID Center Class 1 ultra-high-frequency specification. We believe that initially, Alien is producing its readers to be sold to customers along with Alien tags as a complete hardware solution. However, longer term, Alien has indicated that its business plan does not anticipate that reader sales will be a significant component of its revenue and thus we do not believe this will be an area to which the company devotes a great deal of resources upon broader adoption of its tags. Also, Alien is developing a battery tag system, leveraging government funding, that can keep track of its temperature history and subsequently download it to a reader when prompted. We believe that these tags are being developed at 2.45 GHz and are currently priced at well over $1.00.

In addition to internal development, Alien has partnered with Symbol Technologies and NCR to produce readers, and with label makers Avery Denison and Rafsec to convert RFID straps into labels. Alien is also working with Manhattan Associates, which is developing RFID-enabled supply chain execution software solutions.

### *AWID*

AWID has reportedly designed a multi-protocol reader that has the ability to operate at various frequencies. The company primarily designs handheld readers, but is also working to develop a portal reader, which, unlike many of its competitors' portal

readers, consists of two separate readers stacked facing each other. AWID believes that a portal reader with this design provides an advantage in case one of the readers gets knocked down or has a problem, given that the second reader will still be able to read tags in some capacity. AWID's handheld readers are currently priced at roughly $1,200, but the company expects this to come down to about $500 in two to three years and about $150 in four to five years.

AWID is a member of the Auto ID Center and its readers are compatible with the tags of fellow Auto-ID members Alien Technology and Intermec. AWID is also currently working on developing a reader with the capacity to read EM Micro's tags, which are compliant with the strict European standards that regulate power emissions.

AWID is involved in several pilots using its handheld RFID readers and tags and chips from several makers. The company is working with the U.S. Postal Service and the U.S. Customs Agency, both of which are interested in developing a multiple standard reader (MSR). AWID is also involved with a pilot project with the Automotive Industry Action Group, which is seeking to use RFID technology to track tires. After the Firestone/Ford crisis, the group is seeking to use RFID technology to monitor and track all tires so that if another problem occurs with faulty tires, it can immediately be tracked. Intermec is providing the pilot's tags, which are being attached to the tires on the outside tire wall as well as inside the tires. AWID is also involved with pilots related to the supply chain, logistics, fleet management, police evidence tracking, the defense industry, and animal tracking.

### *Checkpoint Systems, Inc.*

Checkpoint Systems is a manufacturer of integrated solutions for retail security, labeling, and merchandising and is best known for its electronic article surveillance (EAS) systems. Checkpoint has past experience with radio frequency (RF) systems, upon which about two-thirds of its installations worldwide are based, and as a consequence we believe the company could potentially have an edge over its close competitor in the EAS systems and tags market space, Tyco Sensormatic. However, we note that Tyco Sensormatic is also well-positioned as the company has roughly 600,000 EAS system installations, giving it a larger customer base to sell RFID systems into. In an effort to integrate RFID technology with its EAS systems, Checkpoint's new Liberty EAS antenna line is designed to allow for a migration path to RFID by switching out boards at the base of the pedestal upon implementation of new standards and applications.

The company is establishing two RFID solutions centers, one in the U.S. and one in Europe. Checkpoint also has a small but growing RFID business in the library and document management markets that it could segue into its core retail vertical over time. The company's Intelligent Library Systems, which serve libraries and document management in enterprise and law firms, was installed in 12 libraries in the recent March 2003 quarter, bringing the installed base to approximately 87. We believe another ten libraries are in the pipeline. Its largest order to date was a $1 million system for the University of Connecticut.

Checkpoint has a strong European presence, which we believe could potentially serve as an advantage in selling its RFID offering, as several European retailers (including Marks & Spencer, Metro AG, Sainsbury, and Tesco) are aggressively pursuing pilot projects with the technology.

Also, whereas Tyco Sensormatic has in the past focused mainly on retail security, Checkpoint has evolved more as a global tagging systems supplier, targeting retailers and consumer goods manufacturers, which could serve as an advantage over its main competitor given the strong interest that consumer product goods companies have expressed in RFID technology.

### *Escort Memory Systems*

Escort Memory Systems (EMS) was founded in 1985 and is a provider of RFID systems for the supply chain. EMS develops and manufactures active RFID tags and passive read/write tags, as well as handheld readers. EMS sells RFID solutions at multiple frequencies, including 125 kHz to 334 kHz and 13.56 MHz. It is our understanding that EMS primarily builds its 13.56 MHz passive tags around Philips' chips. The company also offers installation services and support for its RFID systems. EMS has developed RFID tags that are able to withstand extreme temperatures. They are currently employed in paint oven applications by companies such as Ford and Toyota.

### *Intermec Technologies Corp.*

Intermec Technologies Corp., a division of UNOVA Inc., is a provider of supply chain information products, services, and systems. Intermec is a combination of three companies: Intermec, Norand Corp., and United Barcode Industries. Intermec develops, manufactures, and integrates wired and wireless automated data collection, Intellitag RFID, and mobile computing systems. The company approaches RFID with a total solution, offering tags and readers. Intermec's Intellitag RFID technology incorporates read/write capability.

Intermec's RFID offering is a combination of technology the company purchased from IBM and the acquisition of Amtech Corp.'s high-frequency radio-frequency identification (RFID) business unit, known as the Transportation Systems Group, which Intermec subsequently sold to TransCore in September 2000. Intermec is a member of the Auto-ID Center and is currently involved in RFID pilot projects, including work with other Auto-ID Center sponsors. Intermec is also working closely with the Automotive Industry Action Group (AIAG).

Intermec's RFID tag is well-positioned to potentially become the standard for automobile tire tagging. AIAG's phase one of tire identification involves a paper label on the inside of the tire, but the current accuracy rate is only about 80%. AIAG is working to increase this to 96% using RFID. The AIAG B-11 standard for tire and wheel identification has been published, and tire maker Michelin has stated that it is ready to deploy the standard. One automaker has issued a request to tire makers for proposals of an RFID tag to meet the B-11 specification for a pilot shipment of tires to its various production facilities.

Also, the U.S. government is using Intermec RFID tags in conjunction with an intelligent gate controller and access control software at Fort McPherson Army Base in Atlanta, Georgia, to enhance the vehicle and personnel screening efforts of military policemen at the installation's gates. The package allows controlled access to specific internal areas of the installation without an increase of manpower.

Intermec is also involved in NEXUS smart-card systems that track frequent-driver traffic through border checkpoints between the U.S. and Canada. Intermec created biometric cards that pre-qualified motorists flash in front of RFID scanning devices at the border crossing for faster entry into either country through NEXUS lanes. Inside the border guard stations, the scanned card generates a screen display that includes a photo, fingerprints, and detailed information about each driver and passenger — each person in a vehicle must carry and display his or her personal NEXUS ID card.

Intermec remains focused primarily on passive, low-cost RFID tags that can be employed at the item level. Intermec offers tags at a number of frequencies, including those between 800 MHz and 900 MHz as well as 2.45 GHz. Intermec primarily deploys chips from Philips and Fairchild Semiconductor in its Intellitag RFID tag offering. We believe Intermec's Intellitags are currently priced below $1.00 and possibly as low as $0.50 depending on the quantity that is ordered. The company also offers RFID readers capable of reading multiple forms and protocols.

### *Matrics Inc.*

Matrics is a privately held company that manufactures RFID tags, readers, and system management software. Matrics is a member of the Auto-ID Center and is working to deploy RFID tags that are compliant with the Auto-ID Center's Electronic Product Code (EPC) system. We understand that Matrics has been involved in 15 pilot projects to date, of which five were subsequently converted into full deployments, which is defined as a case where the use of RFID technology becomes central to business operations. We believe that all of these deployments are focused on the back end of the supply chain (i.e., at the distribution center level), involving customers in the CPG, high-tech, automotive, and supply chain verticals. Matrics expects another five of its pilot customers to convert into full deployments by year-end.

Matrics manufactures Class 0 ultra-high-frequency tags that operate between 868 MHz and 928 MHz. These tags, by definition of Class 0 tags, are read-only protocol as their unique identity is programmed very early in the manufacturing process with a special laser process. As part of the tag manufacturing process, Matrics removes the circuit complexity from the integrated circuit in an attempt to make its UHF tags less expensive to produce. We understand that Matrics is in the process of developing an advanced, low-cost tag manufacturing method, comparable to Alien Technologies' FSA method, which we expect to hear more about in the coming months. Matrics' chips require low power, therefore producing longer read ranges. Matrics' tags come in single-dipole and dual-dipole antenna versions. In the case of the dual-dipole antenna tags, the integrated circuit has two ports that allow for perpendicular antenna construction, which leads to a more orientation-insensitive tag (which we note makes

it well-suited for supply chain applications). Matrics' tags can be attached or embedded in products, boxes, pallets, trays, and totes.

In addition to tags, Matrics manufactures a stationary reader as well as a handheld reader. Matrics has said that its stationary reader can read at a rate of about 200 tags per second. The handheld reader also is said to have the capability of reading 200 tags per second, but its read range is in the neighborhood of five feet. Matrics has also designed system management software called *Matrics Visibility Management*. Our channel checks suggest that Matrics' software is both robust and flexible enough to allow integration into host systems without too many complications. The visibility manager solution manages the complexities of collecting data from the RFID tags scanned by readers positioned throughout the customer's supply chain environment.

### *Philips Semiconductors*

Philips Semiconductors provides RFID products across all industry standard frequencies from 125 kHz to 2.45 GHz. Philips is a member of the Auto-ID Center and has been an early provider of RFID technology. We believe that Philips is focused primarily on manufacturing integrated circuits as its I-Code integrated circuits appear in tags of other RFID providers such as Intermec Technologies Corp. and Escort Memory Systems (EMS). We do not believe Philips intends to compete with the customers of its chips. Philips, like Texas Instruments, has been providing RFID solutions for many years and reports numerous successful implementations of its technology.

Most recently, Philips has partnered with systems integrator Lab ID in a project that was to entail the sale of 15 million Philips 13.56 MHz chips to clothing retailer Benetton. The roll-out at Benetton has since been placed on hold after privacy concerns were raised surrounding the tagging of individual pieces of clothing. Philips' RFID chips are also being used for the Metro AG "Future Store" pilot of RFID technology in Germany. In this instance, Intermec has built an 869 MHz ultra-high-frequency tag around the Philips chip, which is being used to track goods throughout Metro AG's supply chain at the case level. It is our sense that upon broader adoption of RFID, Philips will be in a strong position to be a leading provider of RFID chips (and, to a lesser degree, tags) given the company's experience in the space.

### *Psion Teklogix Inc.*

Psion Teklogix is a provider of mobile computing solutions and devices, specializing in wireless solutions for warehousing, distribution and transportation, and logistics. The company's corporate headquarters are in Mississauga, Ontario, Canada. Psion Teklogix was formed in September 2000, a result of the merger between the Psion Enterprise division of Psion PLC and Teklogix Inc., and is the largest operating division of Psion PLC. Psion Teklogix offers integration with SAP R/3, and a choice of radio technologies providing real-time, near-time, and batch capabilities. The company's handheld RFID readers can reportedly read multiple radio frequencies. While Psion Teklogix is not currently associated with the standardizing initiatives under way at the Auto-ID Center in Cambridge, Massachusetts, management keeps abreast of developments there.

Psion Teklogix is currently involved in an RFID initiative with Philips and Lab-ID to bring the technology to Italian retailer Benetton's supply chain. Despite announcements by Philips that Benetton was planning to place RFID tags in its clothing to track it through the supply chain and into the store, concerns about consumer privacy have forced the retailer to put this initiative on hold. However, Psion notes that Benetton still plans to integrate RFID technology into its supply chain for tracking purposes, and this project is under way.

Psion Teklogix is also working on an RFID initiative in the commercial trucking industry. While details of this initiative have not been disclosed (given that the potential project is still in its early stages), it is our understanding that it involves using RFID technology to monitor the life of commercial trucking tires. Trucking tires are re-treaded numerous times during their lifetime and an RFID tag could potentially monitor how many times a tire has been re-treaded for safety purposes, given that multiple re-treads may increase the risk of tire failure. RFID tags could also potentially monitor air pressure in truck tires, as low air pressure can increase the risk of tire failure, and it can lower gas mileage.

### *SAMSys Technologies Inc.*

SAMSys Technologies Inc. was founded in 1995 and is a provider of RFID hardware solutions. SAMSys manufactures RFID reader hardware and sells installation and integration software as well as services. At the time of its inception, SAMSys was equally focused on developing tag and reader technology, but the company has since devoted its efforts to developing RFID readers because of its view that tags will eventually become commoditized. SAMSys is reportedly developing a multi-protocol/multi-frequency reader and currently offers readers that operate at low frequency (125 kHz and 134 kHz), 13.56 MHz, and ultra-high frequency.

### *Savi Technology*

Savi Technology, which was founded in 1989, provides asset management, security, and collaboration software applications utilizing RFID technology. In 1994, the Department of Defense awarded Savi a $70 million contract, followed by a $112 million contract in 1997 to install its RFID hardware and software for item-level tracking of containers shipped to various global military locations.

It is our understanding that the lack of a tracking system during Operation Desert Storm resulted in significant shipping problems and was a catalyst for this RFID undertaking by the U.S. Government. The Department of Defense recently signed a three-year contract with Savi to expand its use of the company's RFID technology. Acquired by Texas Instruments in 1995 and sold to Raytheon Corporation in 1997, Savi became a private company once again in 1999, when management and venture and corporate investors led a buyout of the company from Raytheon. Savi recently launched EchoPoint, which is an RFID technology development platform with a multi-frequency design that various RFID products can be built upon. Savi provides active RFID tags that comply with the ANSI International Committee for Information Technology Standards (INCITS) 256-2001 Standard, which is a minimum requirement for the DoD (see "RFID Implementations and Pilot Programs" section later in this report for additional details on projects outlined in Exhibit 20 below).

**Exhibit 20. Savi Technology — Active RFID Vendor**

| Projects | Frequency | Active/Passive | Type | Units | Estimated Price | Date of Implementation | Current Status |
|---|---|---|---|---|---|---|---|
| Department of Defense — Total Asset Visibility Network | 433 MHz | Active | Read/Write | 500,000 | $60.00-$100.00 | 1994 | Still going |
| Rails/Intermodal | 123 kHz, 433 MHz | Active | Read/Write | 100,000-200,000 | $15.00-$20.00 | Spring 2002 | Still going |
| Shipping/Ports | 123 kHz, 433 MHz | Active | Read/Write | 5,000 | $75.00 | Mid to Late 2002 | Still going |

Source: Bear, Stearns & Co. Inc. estimates.

### *SCS Corporation*

SCS Corporation is a low-cost identification technology vendor based in San Diego, California. The company sells RFID tags, called Dura-Labels, and scanners, called IntraScan, for use in supply chain solutions, security screening and sorting environments such as aviation, and authentication applications. SCS has developed RFID tags and scanners for both 2.45GHz RFID systems and ultra-high-frequency (UHF) RFID systems. SCS's tags and readers operate together in the company's Interactive Identification System, which is a two-way communications protocol that facilitates ongoing interaction between the Dura-Labels and the scanners.

SCS Dura-Labels are made of a laminate material that is able to withstand heat, pressure, bending, and twisting. The Dura-Labels are small in size and can be inserted beneath the seam in a garment. The labels are equipped with flexible antennas, which are affixed to the Dura-Labels' laminate material using a printed process. This multi-step process utilizes high-grade materials that maintain their integrity and stay intact in extreme conditions such as heat, pressure, and bending.

Northwest Airlines is currently using SCS Dura-Label tags and scanners in its baggage screening system at Seattle-Tacoma International Airport (see "RFID Implementations and Pilot Programs" section later in this report for more details). SCS is also involved with an RFID project at San Francisco International Airport, which has installed a sophisticated baggage security and management system using RFID technology. The common use terminal at San Francisco International, with 172 check-in counters, utilizes an RFID system that uses SCS Dura-Labels, placing them on baggage identified by ticket agents for enhanced security screening. The bags with Dura-Labels are identified by a fixed reader placed along the conveyor system and then diverted to an x-ray explosive detection system for screening before then rejoining the main conveyor system.

### *Symbol Technologies*

Founded in 1975 and headquartered in Holtsville, New York, Symbol Technologies is a provider of secure mobile information systems that integrate application-specific handheld computers with wireless networks for data, voice, and bar code data capture. Through its offering of both products and services, Symbol focuses on customers in the retail, warehousing and distribution, transportation, parcel delivery and postal service, health care, education, and government markets. Given its involvement as a provider of bar code technology, Symbol has recently announced its intention of moving into RFID (after its similar announcement in 1998). Accordingly, the company has become a sponsor of the Auto-ID Center and is also collaborating with Manhattan Associates and Alien Technology to develop a supply chain-based RFID solution.

At the National Retail Federation retail IT show in January 2003, Symbol, in conjunction with Manhattan, Alien, and systems integrator Accenture, demonstrated an RFID tracking prototype that the three companies developed together. For this prototype, Manhattan's PKMS warehouse management software (WMS) solution was used, along with low-cost RFID transponders from Alien, RFID readers from Symbol, and middleware and integration work from Accenture. We understand that RFID readers are not yet embedded as standard equipment in any of Symbol's handhelds, but that the company has the capability to offer custom configurations as volumes warrant. In the meantime, Symbol's channel partners are building RFID antennas into the company's handheld readers, enabling them to be used with RFID.

### *TAGSYS*

TAGSYS, based in France, is an independent RFID system provider that focuses on the library and textile rental segments. Currently, TAGSYS offers products that operate at 13.56 MHz, in order to track books in libraries and also to track garments throughout the rental and cleaning industries. TAGSYS works with Philips to produce RFID tags, and also works with several value-added resellers (VARS) to sell its RFID systems. In addition to offering tags, TAGSYS offers RFID readers operating at 13.56 MHz, which, along with services and software, make up approximately 40% of its revenues, with the other 60% coming from tag sales. TAGSYS currently makes use of both "pick-and-place" and "flip-chip" methods for manufacturing its tags, and is working on pilot projects with customers, although details of these pilots have not been publicly disclosed.

### *Texas Instruments*

Texas Instruments is a semiconductor company and designer and supplier of digital signal processing solutions. The company established TIRIS (Texas Instruments Registration and Identification System) in 1991 and at that time became the first multinational semiconductor company to develop and market RFID systems. Texas Instruments changed the name of this business unit to TI-RFid in January 2001. Texas Instruments' RFID strategy looks to combine its foundation in semiconductors, microelectronics packaging, and computer systems with an open-platform design. However, despite the company's pursuit of low-cost RFID solutions, as well as its many existing implementations, Texas Instruments is not a member of the Auto-ID Center.

Texas Instruments currently offers RFID technology at two frequencies: 134 KHz and 13.56 MHz. The company's 134 KHz low-frequency tags are used in such applications as automobile key immobilizer applications. In these systems, an RFID tag is placed in the key and the reader is located in the car's ignition. The reader sends a signal to the automobile's computer system to start the engine if the key placed in the ignition contains the corresponding unique RFID tag. If it is not the correct RFID tag, the reader alerts the computer system and the engine does not start. We understand that Texas Instruments' anti-theft RFID system is currently used by such car manufacturers as Ford, Chrysler, Jeep, Toyota, and Lexus.

These 134 KHz low-frequency tags are also being used to tag and identify livestock such as cows, pigs, and sheep, and in access control products such as identification

cards that are scanned before entry to secure locations. In the case of the livestock tagging, Texas Instruments' RFID tags are being used to track meat and dairy animals, breeding stock, and laboratory animals involved in research projects. With the tags in an electronic ear tag or injected directly into the animals, farm management processes such as feeding, weighing, disease management, and breeding practices can be automated. With respect to access control products, tags are built into the identification cards, and when an individual passes the card in front of a reader, it pulls from the tag information about whether the individual is permitted to enter. If clearance is granted, it opens the door.

Texas Instruments also offers 13.56 MHz high-frequency RFID tags that are used in access control systems to store employee data and information, as well as information on whether or not an individual is permitted to enter a particular area. Texas Instruments' 13.56 MHz tags are also being used in the supply chain for tagging individual product items. The Gap piloted Texas Instruments' RFID at the item level in an Atlanta retail location, tagging blue jeans and denim in the company's closed-loop supply chain (see "RFID Implementations and Pilot Programs" section later in this report). These tags are also functioning in automatic payment mechanisms, such as the Exxon Mobil Speedpass RFID system, whereby an RFID tag is placed in a key chain item or, in some cases, even a watch, and readers are placed at gas station pumps and convenience stores (again, see "RFID Implementations and Pilot Programs" section later in this report). Texas Instruments does not currently offer ultra-high-frequency 915 MHz RFID technology, but we believe that the company is in the process of researching and developing an ultra-high-frequency product. It is also our sense that Texas Instruments did not originally pursue an offering in the UHF band because of the lack of global harmonization in that band.

### *ThingMagic LLC*

Based in Cambridge, Massachusetts, ThingMagic was founded in 2000 by five Massachusetts Institute of Technology (MIT) graduates to provide services including custom product design and prototyping and long-term research and development. RFID is a core technology that ThingMagic focuses on, and it currently has several RFID modules available for licensing. Specifically, ThingMagic focuses on producing intellectual property for RFID technology designs which are licensed by various manufacturers. ThingMagic is a sponsor of the AutoID Center, and has reportedly created technology for an EPC-compliant reader that operates in two frequency bands — UHF and HF — and supports multiple protocols. We understand that while ThingMagic's reader is currently compatible with tags from Alien and Philips, it is not currently complaint with Matrics' tags. However, it expects to be by late summer 2003.

Both Markem and Tyco Sensormatic are using ThingMagic's technology to manufacture RFID readers. The company primarily concentrates on producing fixed readers, but also intends to produce handheld readers as well, although it has not yet set a release date for these devices. It is our understanding that currently, more than 100 fixed readers are utilizing ThingMagic's technology deployed in field trials of the AutoID Center. ThingMagic is also involved in various other pilot projects outside of the AutoID Center as well, although details relating to these projects have not been disclosed publicly.

### *TransCore*

TransCore provides technology-based services and products for managing ground transportation systems, assets, and transactions. The company has installations in 39 countries and its technology operates according to an ISO-9001-certified design. TransCore's Amtech line of wireless technology products (which the company purchased from Intermec) electronically identifies and monitors rail and intermodal equipment. Its systems are also used in automatic train-positioning systems. Tags are attached to trailers, chassis, rail cars, containers, locomotives, and truck cabs, and Amtech readers are positioned by users of the RFID system at chosen locations such as railroad junction points and yards, gates, fuel lanes, and maintenance facilities.

As tagged equipment passes a reader, the RFID reader scans the tag and identifies the car or locomotive or other piece of equipment it is attached to. The reader then relays the time, date, or other programmed information to a host computer which the carrier monitors. As trains, rail cars, and trucks pass readers throughout designated points along their respective routes, the carrier is able to keep track of its trains and trucks and all the cargo they are transporting. We believe that TransCore's tags operate at both 915 MHz and 2.45 GHz.

### *Tyco Sensormatic*

Sensormatic, a unit of Tyco Fire and Security (since Tyco acquired it in 2001), is a provider of electronic security systems focused on the retail vertical. The company designs and manufactures electronic article surveillance (EAS) systems that are used primarily by retailers to deter shoplifting and internal theft. In response to the market opportunity that exists within RFID, Sensormatic has internally formed the SensorID RFID Solutions Team, which is currently made up of roughly 50 engineering and marketing personnel located primarily in the United States. It intends to expand into Europe.

The company has developed an RFID product line comprised of labels, tags, readers, and integration software, and we understand that the company intends to sell its own technology as well as partner with other RFID companies to deliver systems. For example, we believe that Sensormatic recently licensed ThingMagic's RFID reader technology, in order to manufacture a multi-protocol, multi-frequency reader (see section on ThingMagic below). Sensormatic has also developed a smart shelf RFID system that alerts staff when shelves need to be restocked.

The company is developing its own data integration middleware, but we believe it is also considering licensing the software from a third party. Sensormatic's RFID systems are being developed according to the Auto-ID Center's Electronic Product Code system, but we expect the company to also deliver RFID technologies that are based on other specifications if customer demand exists. Specifically, Sensormatic manufactures RFID labels made for tagging at the item level. These RFID labels can be used for inventory counting, reconciliation, and location applications. The label operates at 2.45 GHz, incorporates read/write functionality, and can store up to 100 characters of user-defined data.

The company also offers tags that combine Sensormatic's EAS anti-theft technology with RFID. The RFID element within this tag operates at 2.45 GHz, has read/write capability, and can store more than 100 characters of user-defined information.

Sensormatic manufactures ultra-high-frequency and microwave handheld readers for use primarily in the retail supply chain, and in particular for picking and sorting of inventory or retail store inventory counting. The Sensormatic readers (which are based on ThingMagic's RFID reader technology) are dual-technology data capture-enabled, meaning they can process RFID and bar code data, and can also be integrated with a personal digital assistant (PDA). The handheld readers combine bar code and RFID read/write capabilities, supporting tasks such as tag programming, item tracking, inventory counting, and item location. Sensormatic manufactures readers for use at both 915 MHz and 2.45 GHz. The company also makes stationary RFID readers that operate at low frequency, ultra-high frequency, and microwave frequency and are compliant with EPC, ISO 15693, and ISO 18000 protocols, which support shipping and receiving at dock doors, product routing conveyor systems, picking and sorting configurations, stock room receiving doorways, and smart shelf applications.

### *Zebra Technologies*

Zebra Technologies is a provider of on-demand printing solutions, including thermal bar code label and receipt printers, card printers, RFID smart label printer/encoders, supplies, label design/integration software, and thermal printer connectivity and networking solutions. Zebra products are used in a variety of industries, including consumer goods, manufacturing, automotive, health care, electronics, transportation, telecommunications, chemical, textiles, shipping, warehousing and distribution, military and government, food packaging and distribution, aerospace, education, security, construction, entertainment, hospitality, and retail.

Zebra has entered into the RFID space with its Smart Label printer line, which is capable of turning out tags, tickets, and labels with embedded RFID tags. The company's R-140 printer has an encoding engine that enables it to work with tags from several different manufacturers. An RF antenna under the print head checks whether the RFID tag is working before printing the label. The R402 RFID-encoder printer supports Texas Instruments' and Philips' chips, as well as RFID tags that use the ISO 15693 standard. Both printers operate at the 13.56 MHz frequency, but we think Zebra's long-term capabilities are frequency agnostic. Thus far, Zebra has not reported significant sales of either product.

Zebra, a member of the Auto-ID Center, has partnered with Manhattan Associates, and the two companies are working together to develop a system that prints RFID labels remotely over the Internet. The system combines Manhattan's trading partner management (formerly the company's infolink product) real-time collaborative software and Zebra's R140 printer and R402 RFID label printers, allowing a retailer to use the system to remotely print a label at a supplier's manufacturing facility. The supplier can then put the label on a pallet, case, or item when it is shipped. Also, printing the label triggers an advanced shipping notice, so the retailer's distribution center or store knows the item is coming. When it arrives, the RFID tag can be scanned automatically by a portal reader or manually with a handheld device, and the

information is then transmitted to Manhattan Associates' warehouse management system. The printed label would have a ship-to address, customer purchase order number, and a bar code with the order number, ship date, routing, and contents of the package.

We believe that Zebra's experience in supplying solutions in the supply chain (logistics is its top vertical), combined with its focus on research and development efforts and strong channel and customer relations positions the company for heavy involvement in the proliferation of RFID applications over the next several years.

## SUPPLY-CHAIN SOFTWARE VENDORS

### *Crimson Software*

Based in Washougal, Washington, Crimson Software is a provider of enterprise-level WMS and TMS solutions. Crimson's WMS solution is currently being used by Lionize Logistics, a 3PL, in an RFID initiative in which RFID readers feed data into an RFID module developed by Crimson. We note that RFID SI Xterprise is involved with this initiative, as well.

### *Descartes Systems*

Descartes recently announced its involvement in an RIFD pilot test with Canadian grocer Sobeys and an unnamed consumer goods manufacturer. The pilot is in the early stages and will run through summer 2003, using Descartes' 20/20 Visibility solution to provide Sobeys with the ability to view, monitor, and analyze activity as goods move throughout the supply chain. This is the first we have heard of Descartes' involvement with RFID, but the company has been working to enable its solution to process the track and traceability data that are generated by RFID for some time.

In the initial phase of this pilot, RFID tags are being placed at the pallet level and then monitored as they are shipped from the consumer goods manufacturer to Sobeys. Descartes' 20/20 Visibility solution is providing the "Activity Hub and Management Dashboard" for the pilot, collecting EDI messages, advanced ship notices, and purchase orders, as well as RFID data and GPS location data. It then combines all this information to provide real time data about exactly what is moving through the supply chain and where it is. Before RFID, the Descartes Visibility solution would collect EDI messages, advanced ship notices, and purchase orders to generate status information. With RFID and GPS enablement, the solution would receive, interpret, and provide logistics advice in real time, taking into consideration the additional identification and positioning data that are available with RFID.

Descartes is also tracking the process improvement and cost benefits achieved using RFID and GPS in addition to the traditional EDI, advanced ship notice, and purchase order, comparing these data with previous similar shipments to ascertain whether there is a strong business case for introducing RFID into the supply chain.

Additional phases of this pilot to explore the potential for adding suppliers are planned, as well as monitoring long haul, multimodal, and cross-border shipments. This pilot is using tags and readers from Intermec Technologies Corporation.

Between 500 and 1,000 ultra-high-frequency 915 MHz tags have been purchased for this pilot.

### *EXE Technologies*

EXE Technologies has an RFID pilot project under way with a large transport company that is a user of EXE's warehouse management software. This project is utilizing RFID technology on the pallet level, and the company believes RFID can deliver savings in the form of labor, time, and label costs. EXE is partnered with Intermec Technologies Corp., using its RFID tags and readers, and CHEP, using its pallets. It is our understanding that the price of the tags being used ranges from about $0.50 to $8.00. EXE is currently utilizing about 50,000 pallets from CHEP in this pilot. Under the current pallet-level pilot project, RFID technology results in a more detailed advanced shipment notice with additional information about the shipment, such as specific contents on the pallet.

Previously, there was no way for the distribution center to distinguish one pallet from the other until workers were visually able to identify some of the items on a certain pallet and then connect them with one of the expected pallets, according to the advance shipment notice. After identifying the pallet by eye and matching it with one of the pallets that was detailed in the advanced shipment notice, the employees at the distribution center would then have to create a label and place it on the pallet to identify which one it was and what its contents were. Even after employees identified which pallet was which and placed the label on it, there was the risk that the label would get ripped off or destroyed, and then the pallet would again be unidentifiable until it was matched by eye with one of the expected receivables, according to the advanced shipment notice. The pallet would then be marked as received and the items it contained would be broken up and put away throughout the warehouse.

With RFID technology on the pallet level, according to the way EXE is making use of it, the pallets on the advanced shipment notice would all be identifiable by a distinguishable RFID transponder. As the pallets are unloaded from the truck, they pass through a portal reader on a dock door. The reader interrogates all the pallets and identifies tagged individual pallets, obviating the need for employees to identify contents on the pallet to match them with the advanced shipment notice.

EXE sees the next step for RFID in the warehouse as case-level tagging so that even when the pallets are broken up upon being checked into the warehouse and put away, they can be relocated and then packed back onto a new pallet. Even at the pellet level, though, EXE sees significant cost reductions with RFID, including 1) elimination of the typical 30-minute check-in time when a new delivery arrives at the warehouse and has to be checked in by hand without RFID; 2) savings surrounding not using labels for each pallet that comes into the warehouse (estimated at about $0.04 per label, including ink used to print the label); and 3) elimination of the problems caused when a label is ripped off a pallet. When this happens, the pallet needs to be re-identified by sight, with its contents compared to the advanced shipment notice and then re-labeled.

### *Globe Ranger*

Based in Richardson, Texas, GlobeRanger provides mobile supply chain solutions for transportation and logistics, including a software platform called iMotion that includes RFID capability and is built on Microsoft's .NET framework. GlobeRanger recently demonstrated the RFID extension to its iMotion platform in the context of a retail setting in which tags were attached to items on a store shelf. As items were taken from the shelf, iMotion identified the change in status, created appropriate alerts, and updated databases accordingly.

Customers can configure iMotion to implement business rules, so that, for example, a store clerk can be alerted in the case that more than ten items are taken off a shelf at one time, and inventory replenishment rules can be configured so that iMotion can generate notifications for restocking. We understand that RFID tags from both Matrics and Intermec were used in the demo, and that both fixed and mobile readers were used. GlobeRanger became a sponsor of the Auto-ID Center in 2001.

### *Manhattan Associates*

Manhattan Associates is focused on preparing its inventory management applications for expected broader adoption of RFID technology for supply-chain tracking. Our view is that the company is the best-positioned in the supply-chain software space to take advantage of the anticipated improvements in inventory visibility and supply chain efficiency. The company is at the forefront of software development that will allow integration of data inputs from RFID devices for next-generation inventory management applications. Manhattan recently unveiled newly developed middleware for integrating RFID hardware with its core warehouse management systems solution. Also, Manhattan's next planned release of its new integrated supply chain execution offering, 2003R2 (expected in July 2003), will possess the ability to handle larger volumes of transactions. We see this as a strong indication of the moves the company is making to be prepared for RFID, as the nature of RFID technology will test data processing limits of current software.

Manhattan also recently announced that as part of its plan to support its customers' future roll-out of RFID, the company is configuring an "RFID-in-a-box" solution that will include a limited test license for its trading partner management solution as well as five RFID readers with two antennas each, 100,000 RFID tags, five remote supplier printers, and middleware developed by Manhattan. Tags and readers are to come from Alien Technology. The purpose of the RFID-in-a-box is to permit customers to test the application and better understand it before they are required to start using the technology for pallet and case tracking.

In addition to software developments that will allow integration of RFID technology, Manhattan has been an early mover with respect to partnerships with hardware vendors in the space and demonstrations of RFID in a controlled environment. At the National Retail Federation Retail IT show in January 2003, Manhattan was demonstrating an RFID tracking prototype jointly developed with partners Symbol Technologies, Alien Technology, and Accenture. For this prototype, Manhattan's PKMS warehouse management software (WMS) solution was used, along with low-cost RFID transponders from Alien, RFID readers from Symbol, and middleware and

integration work from Accenture. Manhattan is also working with Zebra Technologies to deliver a joint solution that will allow integration between its trading partner management solution and PkMS and Zebra's RFID printers. Zebra's R-140 and R402 smart label printers/encoders possess the technology to print, program, and verify labels embedded with RFID tags known as smart labels, which can be printed with human readable text, graphics, and bar codes, as well as relevant shipping, product, and tracking information.

The joint solution with Manhattan will allow PkMS to capture, accept, and then execute the smart label information in the distribution center to receive, put away, replenish, pick, pack, and ship the goods with the Zebra smart labels, as well as read and print the smart labels from remote locations using infolink to provide the information to the printers about what information to encode the chip with.

Also, at its user conference in May 2003, Manhattan was demonstrating a distribution center implementation of pallet and case tracking with its own WMS software and newly developed middleware working with RFID tags and readers (operating in the UHF band) from Alien Technology. Manhattan has extended its retail compliance guarantee (the company's proprietary guarantee to meet all of the shipping and labeling requirements of top-100 U.S. retailers and top-100 global retailers) to include any new and emerging RFID standards. We believe this inclusion of RFID technology in its retail compliance guarantee further demonstrates Manhattan's commitment to emerging RFID technology. Given all of Manhattan's early efforts with respect to RFID, we believe that the company will be in a strong position to capitalize on the upgrade cycles for enhanced software that we anticipate will be necessary to successfully utilize RFID.

### *OATSystems*

Based in Watertown, Massachusetts, OATSystems — which was founded by a group of MIT and IIT graduates in April 2001 — is a software company that provides transactional systems as well as RFID systems. As a member of the Auto-ID Center, OATSystems has contributed to the development of the open-source Savant as well as the Object Name Service for MIT, and the company reportedly offers RFID systems that are "hardware vendor-independent" and thus interface with readers and tags offered from multiple vendors. Specifically, OATSystems focuses on developing an infrastructure that facilitates the use of RFID hardware.

Through its Senseware offering, which was developed to generate information from high-volume RFID transactions, assets and inventory that are equipped with tags can be tracked (including returns and special orders), and this information can be integrated into existing SCM, ERP, CRM, and SRM systems. This software also creates status reports related to products, alerts, theft, and hardware that is tracked.

OATSystems is reportedly working with various Fortune 500 companies to implement RFID in their business, and the company collaborated with Yellow Corp. (a transportation services provider based in Overland Park, Kansas, which we rate Underperform in our Market Underweight-rated Trucking sector) to set up an RFID demonstration that consisted of a dock door with portal readers and a basic receiving application.

### *RedPrairie*

Without yet fully embracing it, RedPrairie has begun preparing its software for integration with RFID technology and is also participating in pilots with several existing customers to test functionality of RFID in the supply chain. RedPrairie has also indicated that in addition to the current pilots it is engaged in, it is hearing interest about RFID from about half of its installed base. RedPrairie anticipates that large retailers and CPG firms will drive the broader adoption of RFID, at which point the company plans to offer RFID to enable supply chain execution solutions.

While we are not aware of any one particular pilot RedPrairie is currently running, it is our understanding that the company is involved with pilots with existing customers in its installed base in an attempt to judge the effectiveness of RFID. RedPrairie is focusing on enabling its solutions to provide real-time work management within the warehouse that would allow the software system to actually guide employees through their duties as a result of the real-time status checks that RFID could provide.

New directives would be based on the scans that RFID readers on forklifts make while moving throughout the warehouse. As the readers scan the tag of a particular pallet that the forklift would be assigned to pick, the RFID reader would recognize the tag and inform the system that the employee has reached his or her destination and found the correct pallet. The warehouse management system then, in real time, gives the employee the next directive, detailing, for instance, where to take that pallet. If the driver has picked the wrong pallet, one possessing a different tag than the intended pallet, the system, upon receiving the scanned information from the reader, would update the employee that he has picked the wrong pallet.

RedPrairie defines the time and cost savings from an alert like this as significant — without RFID, the employee might not have discovered he had the wrong pallet. With an RFID-enabled warehouse, the WMS solution would alert the employee to put the pallet down and find the correct one upon learning in real time from the reader that the wrong pallet was picked. With RFID, once the right pallet is loaded on the forklift and the next directive is given, the employee, in real time, knows immediately where to take his load.

Most warehouses and distribution centers have many dock doors, so that even with the intended pallet on the forklift, there is still risk that this pallet will be loaded onto the wrong truck. As the employee goes to carry out his duty and load the pallet onto the truck he believes it is destined for, RFID readers scan the pallet and alert the software system if he is loading it onto the wrong truck.

### *SAP*

About a year ago, SAP hosted its Sapphire users conference in Orlando, Florida, and demonstrated a technology it was creating for Procter & Gamble and Wal-Mart, which takes advantage of item-level tracking utilizing RFID. During the demo, SAP's new technology monitored the movements of bottles with RFID tags taped to their bottoms, so that, for example, the advance planning and optimization software of Wal-Mart and P&G could be alerted when a product was about to become out-of-stock. In that way, adjustments to changes in demand could be made in real time.

Today, SAP is involved in two RFID projects — one with P&G and Wal-Mart and another with Metro AG, a large European retailer based in Germany.

We understand that the P&G and Wal-Mart project is in active mode, past the pilot stage, and it is focused on collecting data at the item level (at 13.56 MHz) and tote level (at 925 MHz). The next phase calls for using RFID to maintain optimal levels of inventory, and the ability to track inventory-related metrics.

Metro AG is working with SAP in a pilot program to track assets moving into its store, at the case and palette levels (both at 13.56 MHz). Specifically, the retailer is using SAP software to capture and manage the data related to the tagged pallets and cases. A primary goal of the pilot is to reduce and/or eliminate the need for human labor (typically associated with bar codes) by automating the process of tracking assets moving into the store. At this point, it does not appear that Metro AG is addressing the issue of shrinkage (versus Gillette and some other CPG firms that are very focused on it), but rather, it is trying to create a more efficient process for checking in goods (for more detail on the MetroAG pilot, see "RFID Implementations and Pilot Programs" section later in this report).

### *V3 Systems*

Based in Charlotte, North Carolina, privately held V3 Systems provides WMS execution solutions to manufacturers and their 3PLs. V3 has been evaluating RFID for a couple of years, starting with active tags, but given that the active tags proved to be technically cumbersome, the company didn't pursue RFID much further. Now it appears to be considerably more interested, prompted by advancements in the technology, such as the introduction of the passive RFID tag. We believe that V3 is currently utilizing RFID technology with some clients.

In addition to the operational efficiencies that can be gained from the use of RFID technology, V3 views visibility and collaboration as a key benefit, as it provides granular visibility into the supply chain, in which case more detailed information can be made available, stored, and managed. We also note that V3 has been working with RFID SI Xterprise, and expect that the two will remain business partners as the company moves forward with its RFID initiatives.

## SYSTEMS INTEGRATORS

### *Accenture*

Through its "Silent Commerce" initiative, which represents a vision for RFID and other broader technologies, Accenture has teamed up with the Auto-ID Center, as well as the retail, consumer goods, and freight transportation industries to promote RFID adoption. In a collaboration with the Auto-ID Center, Accenture has produced a series of white papers related to RFID, aiming to identify opportunities in manufacturing, supply chain, demand planning, transportation, and store operations to help companies realize potential benefits that may be achieved through the use of tagging, tracking, sensing, and actuating technologies.

### *IBM Global Services*

Through its Wireless Services group, IBM Global Services offers RFID solutions for various applications, including asset monitoring, smart card applications, and tagging at the pallet, case, and individual levels. We believe IBM is in the early stages of pilots with many clients that are aimed at determining how well RFID works 1) across trading partners (e.g., between manufacturers and retailers) and 2) inside the four walls, in a closed-loop environment. We also understand that IBM has implemented RFID technology in some gas stations, enabling them to monitor such events as service disruptions, so that these situations can be reacted to quickly, and that it also has pilot efforts under way in the areas of tire tracking and pharmaceutical tracking.

IBM has identified a number of partnerships with RFID vendors that include Intermec Technologies, Symbol Technologies, and USA Technologies, and we believe that it is also having conversations with Matrics and Alien Technology.

IBM is also actively engaged around Auto-ID initiatives with CPG firms and retailers for asset tracking at the pallet and container level, and it is our understanding that the company is also working with one retailer for item-level tracking, outside of the Auto-ID Center.

### *Intellident*

Based in the U.K., Intellident is a British information systems company that offers systems integration services in the area of RFID technology. Prior to delivering RFID systems, Intellident installed bar code labeling and tracking systems. In addition to offering integration services, Intellident offers handheld and fixed-position read/write devices that enable data collection as well as recording onto products and assets; it also offers passive RFID tags.

The company also provides an "Assetrak" software system, which facilitates the movement of electronic data from the point of collection to integration with host applications. We note that Intellident and Manhattan Associates have announced a joint strategy to deliver RFID solutions for supply chain execution. Specifically, Manhattan's supply chain execution solution (PkMS) will capture smart label information which can then be executed against distribution center processes, such as receiving, replenishment, packaging, and shipping. Intellident is also working with Colchester Library in the U.K. to design self-service areas that allow customers to easily check out and check in library items such as books, videos, and CDs, and also offers the use of portable inventory readers for quick inventory checks and book searches.

Marks & Spencer, one of the U.K.'s largest retailers, recently awarded Intellident a contract to supply RFID tracking technology to improve its stock management, following successful implementation of RFID tagging project last year. Intellident designed the technology, in which it tagged 3.5 million produce delivery tags in the retailers food supply chain.

### *Xterprise*

Based in Richardson, Texas, Xterprise is a systems integrator that focuses on warehouse management, transportation management, RFID systems, and mobile enterprise solutions. Xterprise was the SI of choice for 3PL Lionize Logistics' successful RFID pilot, which allowed the company to automate the receiving of goods in one of its two warehouses and distribution centers (we note that Xterprise was instrumental in 3PL provider Beal Solutions' recent RFID initiative as well).

Xterprise designed and implemented Lionize's RFID system, which resulted in a reduction of unloading time from three hours to one. In addition, the error rate at scan was reduced from roughly 20% to 0.01%, and labor costs associated with scanning were reduced by approximately 35%. Currently, Xterprise is working with Alien Technology, given Alien's focus on tags and readers that operate in the UHF band. We understand that Xterprise implemented Lionize's RFID system in approximately 30 days, and that Xterprise is currently working with Lionize to move forward with its RFID initiative.

# RFID Implementations and Pilot Programs

After reviewing all the RFID implementations and pilots that we were able to identify as having occurred beyond just a small scale, we assembled a comprehensive exhibit (see Exhibit 21 below) that examines the manner in which RFID technology was employed, the vendor whose technology was used, as well as the frequency, protocol, quantity, and cost of the tags involved. Because the technology is largely still in the early stages of development and even earlier stages of adoption, many of the suppliers and users that we identify are still under non-disclosure agreements or are reluctant to be forthright with details because of competitive concerns.

**Exhibit 21. RFID Implementations and Pilot Projects**

| User | Vendor (tag) | Vendor (reader) | Frequency | Active/ Passive | Type | Estimated Units | Estimated Price per Tag | Date of Implementation | Current Status |
|---|---|---|---|---|---|---|---|---|---|
| **Automotive** | | | | | | | | | |
| Ford | Escort Memory Systems | Escort Memory Systems | 334 kHz | Active | Read/Write | 10,000-12,000 | $150.00 | 1995 | Still going |
| Harley Davidson | Escort Memory Systems (Philips chips) | Escort Memory Systems | 13.56 MHz | Passive | Read/Write | 15,000 | $22.00 | 1998 | Still going |
| Southeast Toyota (South Africa) | Escort Memory Systems (Philips chips) | Escort Memory Systems | | | Read/Write | | | | |
| Toyota | Escort Memory Systems (Philips chips) | Escort Memory Systems | 13.56 MHz | Passive | Read/Write | 20,000 | $85.00 | 2001 | Still going |
| **Brewing** | | | | | | | | | |
| Scottish Courage Brewery | Philips | Saco | 125-128 MHz | Passive | Read/Write | 2,000,000 | $4.00 installed on keg | Aug-98 | Still going |
| TrenStar | Trendstar (Philips chips) | Trendstar | 125-128 MHz | Passive | Read/Write | 1,000,000 | $1.00 | Jan-03 | Still going |
| **Consumer Packaged Goods** | | | | | | | | | |
| Gillette | Alien Technology | Alien Technology | 915 MHz | Passive | Read only | 500,000,000 | $0.05 | TBA | |
| International Paper | Matrics | Matrics | 915 MHz | Passive | Read only | 10,000,000 | $0.30 | Jan-03 | Still going |
| Revlon and International Paper | Philips | SIRIT | 13.56 MHz | Passive | Read only | 100,000 | $0.30-$0.40 | Summer 2002 | Ran for 4 months |
| **Logistics** | | | | | | | | | |
| Beal Solutions | Alien Technology, Matrics | Alien Technology, Matrics | | | | | | | |
| Lionize Logistics | Alien Technology | Alien Technology | 915 MHz | Passive | | | $0.45 | Feb-03 | Still going |
| Tibbett & Britten | | | | | | | | Summer 02 | |
| **Manufacturing** | | | | | | | | | |
| Boeing | Matrics | Matrics | 915 MHz | Passive | Read only | 15,000-20,000 | $0.78 | Jun-03 | Still going |
| Goldwin Sportswear Europe | Texas Instruments | Texas Instruments | | Passive | Read/Write | | | | |
| Malden Mills | Escort Memory Systems | Escort Memory Systems | 125 KHz | Passive | Read only | 800 | $35.00 | Spring 01 | Still going |
| Michelin | Escort Memory Systems (Philips chips) | Escort Memory Systems | 13.56 MHz | Active | Read/Write | 600 | $125.00 | 1999 | Still going |
| Nestle Company | Escort Memory Systems (Philips chips) | Escort Memory Systems | | | | | | | |
| **Retail** | | | | | | | | | |
| Benetton | Philips | Psion | 13.56 MHz | Passive | | 15,000,000 | $0.25-$0.50 | On Hold | |
| Fig Leaves | Texas Instruments | Texas Instruments | | | | | | | |
| The Gap | Texas Instruments | Symbol | 13.56 MHz | Passive | Read/Write | 3,000 | $1.00 | Summer 01 | 3 months |
| Marks & Spencer | Texas Instruments | Intellident | 13.56 MHz | Passive | Read/Write | 3,500,000 | $1.00 | Spring 02 | Still going |
| Metro AG | Intermec Technologies (Philips chips) | Intermec Technologies | 869 MHz | Passive | Read/Write | 10,000 | $1.00 | Apr-03 | Still going |
| Exxon/Mobil | Texas Instruments | Texas Instruments | 134 kHz | Passive | Read only | 7,000,000 | $2.00 | 1998 | Still going |
| Prada | Texas Instruments | Texas Instruments | 13.56 MHz | Passive | Read/Write | 5,000 | $2.00-$3.00 | Dec-02 | Still going |
| Sainsbury's | Philips | | | | Read/Write | | | | |
| Tesco | Philips | | 13.56 MHz | Passive | | | | Sep-02 | Still going |
| Wal-Mart, International Paper, Procter & Gamble | Philips | SIRIT | 13.56 MHz | Passive | Read only | 100,000 | $0.15-$0.20 | Early 2003 | Still going |
| **Supply Chain/Tracking** | | | | | | | | | |
| CHEP | Intermec Technologies | Intermec Technologies | 915 MHz | Passive | Read/Write | 500,000 | $2.00 or less | Spring 2002 | Still going |
| Colchester Library | Philips | Intellident | 13.56 MHz | | Read/Write | | | | |
| Georgia Pacific | Intermec Technologies | Intermec Technologies | 915 MHz | Passive | Read only | 1,000,000 | $1.00 or less | Nov-00 | Ended April 2001 |
| Northwest Airlines | SCS | SCS | | | | | | 1999 | Still going |
| Raxel | Intermec Technologies | Intermec Technologies | 915 MHz | Passive | Read/Write | 500,000 | $1.00 | 2002 | Still going |

Source: Bear, Stearns & Co. Inc. estimates.

## AUTOMOTIVE

### *Ford*

Ford has been using RFID tags in its Windsor, Ontario, engine manufacturing plant since about 1995. Specifically, the company has opted for Escort Memory System tags and readers that operate at 334 kHz. These are read/write protocol active tags, and we estimate that Ford has purchased between 10,000 and 12,000 tags at about $150.00 per tag. The company has placed RFID tags on carrier bins, which are used in the facility to move engines through the assembly process. At the start of the manufacturing process, an engine is placed into a carrier and the serial number of the engine is written to the tag attached to the carrier. As the engine moves through the various stages of assembly, each manufacturing process that takes place is written to the tag by a reader at each station.

The RFID tags are used to track the time and date that each stage is performed, as well as perform all quality control checks and provide additional information applicable in building out a history of the assembly of a particular engine. Upon completion of the engine manufacturing process, the carrier passes a final reader that

scans the full specification listing of all the procedures involved in assembling the engine and transmits that data to the manufacturing plant's database.

### *Harley Davidson*

Harley Davidson rolled out RFID technology in its York, Pennsylvania, manufacturing facility in 1998, to track custom-made motorcycles as they move across the production floor. Harley Davidson is using Escort Memory System tags and readers. The EMS tags contain Philips chips and operate at 13.56 MHz. The tags are passive read/write protocol, and roughly 15,000 were purchased for the manufacturing facility at about $22.00 each.

At this particular facility, carrier bins run along conveyor belts in the floor, moving motorcycle frames through the various stages of assembly. Because a particular bike is placed in a bin at the start of assembly and remains in the same carrier throughout the production process, Harley Davidson placed read/write protocol RFID tags on the carrier bins. At the start of the production process, the serial number that corresponds to the bike frame and custom order is written to the tag on the carrier that will hold the frame throughout the production process. With the tag now as an identifier of the motorcycle's serial number, the assembly instructions for that particular custom bike are linked to the serial number in the facility's data system.

Readers placed throughout the facility, and particularly under the track at each production stage, scan the tag and recall from the system the instructions for the next assembly process. The instructions appear on a screen at that station for the employee. As each process is completed and the motorcycle proceeds to the next stage, a reader scans the tag on the carrier bin and calls up the subsequent directive for building the bike.

It is our understanding that Harley Davidson has experienced increased efficiency with this RFID system because each manufacturing instruction is automatically displayed for employees at each stage of the assembly process.

### *Toyota*

In 2001, Toyota began installing RFID technology in numerous manufacturing plants for tracking car frames as they move through paint stations. Toyota is employing systems integrator Escort Memory System tags and readers, which contain 13.56 MHz Philips chips. The tags are passive read/write protocol, and it is estimated that roughly 20,000 tags have been purchased from EMS. Each tag Toyota uses for this process costs about $85.00.

A car is typically painted while still in the early stages of assembly; as a result, it is necessary to identify which car is to be which color. Also, because the painting process is performed by robots, the robots need to know not only the correct color, but also the body style of the automobile so as to be aware of the path to trace when painting. If the robot attempts to paint the wrong body style, it risks causing significant damage to both itself and the frame of the car. Thus, Toyota has placed RFID tags on the carriers in its manufacturing facilities. The vehicle number and the corresponding model number, paint color, and body style are all written to the tag.

As the carrier with the automobile frame approaches paint station readers, the readers scan the tag and access all the necessary data about the frame. The reader alerts the painting robots as to the model, body style, and paint color for its next task.

After the paint station, the carriers usher the car frames to the paint oven, where the RFID tags are not scanned or utilized, but are exposed to extreme heat conditions. Because the tags are not removed before entering the paint oven, Toyota had to employ tags with special casings, which increased the price of each tag significantly.

A particular example of Toyota's use of RFID technology is at the company's South African vehicle production facility, which is currently in phase two of an RFID-enabled vehicle tracking system roll-out. Working with EMS and using Philips read/write chips, Toyota has built a system to track cars through numerous vehicle production stages. Phase one of the project has involved re-usable tags to monitor vehicles as they move through the painting process. Phase two has incorporated disposable paper RFID tags using Philips chips and EMS technology. In this instance, RFID is being used to track parts and completed cars throughout the entire assembly line.

In total, Toyota has installed 28 readers from Escort Memory Systems and placed them at fixed locations throughout the South African plant, combined with six additional handheld readers/writers. Toyota is then tracking the RFID-tagged vehicles beyond the plant to the main distribution yards in close proximity to this production facility.

Toyota plans to roll out a third phase with RFID that will extend the use of the technology to the retail sector. In this proposed scenario, the tags will remain on the vehicles and active for the entire life of the automobile, allowing warranty information and customer details to be stored on the tags, in addition to the original production data.

## BREWING

### *Scottish Courage Brewery*

Scottish Courage Brewery is using RFID technology as a means to track and identify the company's beer kegs as they move through the supply chain. Scottish Courage, which tagged its first keg in August 1998, owns about two million beer kegs and has rolled out its RFID initiative in two phases. The first phase was confined to the geographic region of Scotland and involved the fitting of 400,000 containers with read/write RFID tags. Three brewery filling lanes were outfitted with RFID readers and would write data to the tagged beer kegs after they were filled. Because this first phase of the RFID project was successful, Scottish Courage then rolled RFID out to its remaining 1.6 million kegs, at the same time equipping the rest of its filling lanes in the breweries with RFID scanning equipment. It also equipped the keg delivery men with handheld RFID readers.

With its entire fleet of beer kegs RFID-enabled, Scottish Courage now tracks the kegs as they move through the supply chain, writing the type of beer, the date it is brewed, and its destination to the keg each time it is filled. Because the kegs have individual identities, the brewery is able to check each one in and out as it drops them

off and picks them up from customers, alerting the company if it is not receiving the correct kegs back.

This RFID initiative at Scottish Courage Brewery is utilizing passive read/write Philips 125-128 MHz tags and systems integrator Saco's readers. We estimate that Scottish Courage purchased about two million tags from Philips at a cost of roughly $4.00 per tag. The estimated price includes the cost of attaching the tags to the kegs as well as the special casing required because of the harsh environments the kegs are exposed to.

As mentioned the RFID roll-out at Scottish Courage Brewery began in August 1998, and it is still in operation; however, in May 2002, TrenStar purchased Scottish Courage's kegs and now manages them on its own RFID asset-tracking system.

### *TrenStar*

TrenStar is a mobile asset management solutions provider that is using RFID tags as a means for tracking and identifying beer kegs as they move through the supply chain. TrenStar is currently managing more than three million beer kegs in the U.K., and we believe the company is very close to signing a deal to purchase and manage another major brewer's kegs.

The three million kegs TrenStar currently owns include about two million purchased from Scottish Courage Brewers in May 2002 and roughly one million purchased from Carlsberg-Tetley Brewing Company Limited. TrenStar purchases the kegs from brewers, equips them with its 125-128 MHz RFID tags, and services, maintains, and manages them through the supply chain. Readers are placed in the breweries, at the distribution centers, and with the truck drivers that transport the kegs. When a keg is filled with a certain type of beer at the brewery, a reader writes the brewer's name, the type of beer, the date it was brewed, and the destination all to the tag. Then, throughout the supply chain, the keg passes readers that automatically identify which keg it is and update the system as to where that keg is currently located.

Utilizing this visibility into the supply chain, TrenStar's software determines demand forecasts based upon data gathered from the RFID tags. In addition to efficiency and visibility gains, TrenStar's RFID tagged kegs allow brewers to identify black market sale of their beer. In England, some pubs are designated high-volume pubs based on the amount of beer they order and consume. High-volume pubs are able to purchase beer at a discount. In tracking the kegs with RFID and assigning each its own identity, TrenStar is able to track occurrences of these high-volume brew pubs selling the beer they get at a discount to smaller pubs for a premium that still offers the smaller pub a more competitive price than it would get from the brewer.

RFID tracks the kegs that were delivered to the high-volume pub, and the system recognizes when they are picked up from a different location, alerting the operators that a particular keg was supposed to be picked up at the high-volume pub where it was dropped off. Also, if a shipment that is destined for a particular location passes a reader that is not along its route, the operators are alerted so they can stop the process and re-route the kegs.

These misdirected shipments are discovered while the kegs are still moving through the supply chain rather than when they arrive at the wrong pub. We believe that TrenStar is looking to begin pooling its kegs in an effort to centralize the movements of all its containers onto one system. The company believes that by centralizing its assets, the system will be able to identify instances when three different brewers are scheduled to make a delivery to the same pub in the same timeframe. If caught in the supply chain, these three shipments can be consolidated into one, thus leading to significant reductions in transportation costs.

TrenStar is utilizing Philips chips and has developed its own RFID tags working with systems integrator KTP, which TrenStar bought in December 2001. The tags, which we estimate cost about $1.00 apiece, are passive read/write protocol and operate between 125 MHz and 128 MHz. TrenStar uses handheld and stationary readers from Symbol Technologies.

## CONSUMER PACKAGED GOODS

### *Gillette*

Gillette, a founding sponsor of the Auto-ID center and participant in RFID field trials sponsored by the group, announced its intention to purchase 500 million tags from Alien Technology in November 2002 for pallet- and case-level tracking. Gillette confirmed its intention to purchase tags from Alien in January 2003, but qualified the initial announcement with new conditions. The company indicated that initially it will not be purchasing the full 500 million tags, but instead will begin testing RFID technology through its supply chain by placing RFID tags in certain products set to be sold in the U.S. market. Gillette added that if these tests are successful, it will likely place up to half a billion tags on its products over the next few years.

While the exact size of the order and the price Gillette will be paying per tag were not disclosed, we understand that the company still plans to purchase a significant number of tags initially at an estimated cost of less than $0.25 per tag. When the initial announcement was made, there was speculation that the tags would be just $0.05 apiece. However, given that 1) the $0.05 tag is based on certain economies of scale in high volume production, and 2) the purchase order by Gillette is to be more segmented than originally thought, until RFID experiences broader adoption and tag makers begin mass-producing the transponders and the chips, the cost should be higher. The EPC-compliant Alien tags Gillette is purchasing are ultra-high-frequency (UHF) 915 MHz write-once/read-many protocol passive tags.

### *International Paper*

International Paper has been researching RFID and its potential uses within its business since about 1999. The company has run numerous pilot tests and looked at many vendors of the technology, spending an estimated $23.5 million in the process to date, according to the company. International Paper joined the Auto-ID Center in January 2000. In addition to smart shelf pilots with Revlon, Wal-Mart, and Procter & Gamble, International Paper has also worked with Motorola and Accenture in an attempt to develop the ability to print conductive antennas.

More recently, International Paper developed a warehouse RFID system called Intelli-Track that has been running in the company's Texarkana facility since January

2003. In Texarkana, International Paper is using passive read-only Matrics 915 MHz tags and readers. It is also our understanding that International Paper has an arrangement with Matrics to buy roughly ten million chips over the next 18 months, paying about $0.30 per tag.

The company is attaching RFID tags to the cardboard cores of its large paper rolls and then using RFID readers to track the rolls as they move through the facility. International Paper estimates that it was losing $1-$8 million per warehouse each year in lost paper rolls, which were misplaced within the large warehouses, loaded onto the wrong trucks and rail cars, or placed with the wrong grade of paper and sold for reduced prices. The system is designed to alert employees if a roll is being moved to a section of the warehouse where it does not belong. For instance, if a high-grade paper roll is being moved to a section designated for imperfect rolls or if a roll is being loaded on the wrong truck or rail car, the employee is made aware of the error about to take place. It is estimated that International Paper is experiencing roughly a 44% return on investment in its Texarkana facility based on the reduction of lost rolls and rolls loaded onto the wrong rail cars.

Also, as part of its RFID roll-out in the Texarkana facility, International Paper has placed RFID tags in the floor of the warehouse and furnished its forklifts with readers. This system allows International Paper to track its forklifts as they move across the warehouse. The company designed software that cross-checks the location of the RFID tags in the floor with exact coordinates in the warehouse, so that when a forklift passes over a tag and reads it, the system registers the location of the transponder and produces the current location of the forklift. Then, as the forklift moves around the warehouse, it is tracked in a similar manner to a global positioning system (which we believe International Paper tested and found ineffective because of significant metal interference in a typical warehouse facility). While this RFID warehouse tracking system has only been rolled out in one facility, we believe it will likely be employed in additional International Paper facilities, and that other companies could begin to assess the impact it could have on their own warehouses.

### *Revlon and International Paper*

In addition to piloting the technology in its own warehouse facilities, International Paper has worked on some of the first pilots with in-store smart shelf technology. During the summer of 2002, International Paper and Revlon Consumer Products Corporation partnered for a smart shelf initiative that operated for four months and involved RFID tags at the item level on high-end cosmetics. The pilot ran for four months and employed read-only 13.56 MHz passive tags.

For the initiative, International Paper and Revlon purchased about 100,000 chips from Philips at an estimated $0.30-$0.40 each. International Paper worked with systems integrator SIRIT Technologies Inc. to design a smart shelf to read Philips chips embedded on cosmetics. The smart shelf alerted the system if an item, such as a specific cosmetic color or type, was sold out or in the wrong space on the shelf, or if a large number had been taken at once (suggesting theft).

The first two tracking features allowed store clerks to be alerted in real time when items needed to be restocked or repositioned on the shelf. With respect to theft

prevention, the system was designed to alert security if four or more units of a cosmetic were taken off the shelf at once. In these instances, the store's security cameras were triggered to focus on the person at that location, thus allowing employees to determine if it was a case of a potential shoplifter or a legitimate shopper purchasing the product.

## LOGISTICS

### *Beal Solutions*

Beal Solutions, a third-party logistics provider (3PL), recently completed a successful RFID pilot at its operation in Austin, Texas. Beal manages totes (which are reusable containers) to transport and manage electronic components from printed circuit board suppliers. In general, Beal delivers parts to PC manufacturers after picking them up (or receiving them) from distribution partners.

The pilot used tags and readers from multiple vendors including Alien Technology and Matrics, and was designed and implemented by RFID systems integrator Xterprise, which attached RFID labels to individual totes, so that when the shipments were received at Beal's warehouse, the tags were automatically scanned by RFID readers at the dock door. The data that were read from the RFID labels were captured and managed by Beal's proprietary supply chain software, dubbed "the Helm."

It is estimated that RFID technology used during the pilot reduced receiving time by 50% or more.

### *DHL*

DHL Worldwide, an express and logistics company, has partnered with TRI-MEX and Nokia in an RFID pilot project called "CHIEFS" to test RFID technology for tracking individual consignments of phones in the road transit phases of the supply chain and identifying theft or loss in real time. Delivery vehicles were equipped with RFID readers which were then linked with DHL's existing satellite tracking systems, allowing for the phones to be tracked through the supply chain. If a phone is lost or stolen the RFID system alerts the operators in real time, enabling immediate investigation or intervention. The system is also being used to alert law enforcement in instances when the products have been deemed stolen. Because this RFID project has successfully enabled the partners to track phones through the parts of the supply chain in which it was piloted, the companies are planning to move forward and build technology that will track individual consumer items in volume from the point of manufacture to final delivery (in transit and at all fixed locations) by building RFID tags into the individual phones. This project is being sponsored by the British government as part of its "Chipping of Goods" initiative, which also sponsored an RFID pilot involving Tibbett & Britten.

### *Lionize Logistics*

Lionize Logistics, a third-party logistics provider (3PL) that offers warehousing for new and old office supplies and parts, recently completed the deployment of an RFID system at one of its warehouse and distribution centers. The company is using RFID to replace bar codes for tracking inventory, such as printers and copier machines, in a

pilot that began in February 2003. These items are scanned automatically as they come off trucks and enter the warehousing facilities. We believe that the use of RFID has enabled Lionize to cut the time it takes to unload a truck of products from three hours to one, and that inventory checks now take about one day compared to a week when staff receiving goods had to unload palettes and manually scan each box before products were moved into the warehouse.

Currently, Lionize staff are attaching RFID tags to products as they are unloaded, but as the company continues to move forward with its RFID initiative, it has indicated its intention to involve suppliers in the process. We believe that Lionize Logistics' suppliers' responsiveness to that prospect will likely determine how quickly the pilot progresses. The company is considering furnishing its forklifts with RFID readers, as well, in order to reduce the time it takes to perform monthly inventory cycle counts and physical stock counts, which occur twice a year, as inventory would be updated continuously.

Lionize's pilot system was implemented by systems integrator Xterprise and uses labels and readers from Alien Technology. Specifically, the system uses UHF (915 MHz) labels that cost about $0.45 and can be read from nine feet away on finished office products and boxes. The company also uses a warehouse management system developed by Crimson Software to collect and manage data from its RFID readers.

### *Tibbett & Britten*

Tibbett & Britten, an international logistics service provider, tested RFID technology in a pilot with Unilever and Safeway that was sponsored by the British government. As part of this initiative, dubbed the "Chipping of Goods" initiative, Unilever's U.K. home and personal care products company, Lever Faberge, tagged six-packs of Lynx deodorant. These packs of deodorant were then tracked from the factory, through the supply chain, and then to three Safeway stores. The products were passed through both Unilever's national distribution center and Safeway's distribution center, all the while being tracked by the RFID tags embedded in the product packaging.

The pilot tested Tibbett & Britten and Unilever's belief that tracking the products individually and having the ability to identify their exact location would allow for tighter inventory control and reductions in inventory, thus creating a more efficient supply chain. We believe there was value seen in the fact that placing tags on the product was expected to reduce shrinkage and allow the companies to track locations where goods were disappearing in the supply chain.

The Unilever trial was tested in three phases: 1) tracking at the pallet level to Safeway's distribution center; 2) tracking at the product level to Safeway's distribution center; and 3) tracking at the product level to the Safeway stores' shelves. It is our understanding that while this pilot test of RFID was successful in reducing shrinkage as well as counterfeit versions of the Unilever product, there was not a solid business case for using RFID in the logistics setting. The "Chipping of Goods" initiative employed Intermec tags and readers.

### *Boeing*

Boeing is utilizing RFID technology in its Wichita, Kansas, manufacturing facility for tracking work in progress and parts as they move through the building. Boeing has been evaluating RFID since 1999, and in that time period the company has tested numerous RFID vendors and run multiple pilots. The initial roll-out in Kansas encompasses one process line within the greater Wichita operation, which represents about 1/100 of the entire facility. Boeing has chosen Matrics tags and readers for this roll-out of passive RFID. The company has purchased between 15,000 and 20,000 tags thus far at an estimated price of about $0.78 per tag. Boeing is using ultra-high-frequency 915 MHz read-only tags.

When an order is issued for a part, whether the part comes from an external supplier or internally, that part is immediately associated with an RFID tag. The RFID tag is placed on the paperwork that stays with the part for its entire production lifetime and identifies it. At each process station, an employee passes the RFID tag in front of a reader that subsequently calls up the process details that correspond to that workstation, indicating what is to be done next with that particular part. Upon completion of that stage, readers placed at the exit of each work station update the system with information detailing what was done to the part, at what time, and at what exact location. It is our understanding that as each part is combined with others to create a larger piece as part of the manufacturing process, the new part is associated with its own RFID tag and is tracked through the production line.

Boeing pulls the data that its RFID system records and creates a map of each part that went into the final product so that the integrity of every part that goes into it can be traced. Formerly, when this process was done using bar codes, each part first had to be scanned by hand and then the data describing the part and what was being done to it at that particular station had to be entered manually into the data base.

The Boeing facility in Wichita is also using RFID tags to track certified tools as they are used and move through the building. Boeing tracks the tools and has set up alerts that signal if a tool leaves the building or its designated area, thus allowing the company to track the missing tools back to where they were last seen by the RFID system. It is our understanding that Boeing is in the process of rolling out RFID technology in this same capacity to additional production facilities and process lines. We also believe that Boeing's competitor Airbus is looking at RFID and assessing the potential impact the technology could have on its business.

### *Goldwin Sportswear Europe*

Goldwin Sportswear Europe, the European branch of one of the largest branded sportswear companies in Japan, is piloting RFID technology to increase efficiency in its production, shipping, and distribution processes, as well as to eliminate product diversion (which is the sale of Goldwin Sportswear products outside their authorized selling area, implying illegal activity). Working with systems integrator Euro Link SRL, read/write RFID tags from Texas Instruments were sewn into skiwear at the Goldwin factory in Beijing, China.

After the RFID tag is applied during production, each item is scanned by readers at a programming station, at which point data such as the item's unique product code, batch number, color, size, and distribution details are all stored on the tag. The Texas Instruments tags are read/write protocol, so that additional data such as production status can be updated at any stage in the lifecycle of the product.

After production, the products are boxed and shipped to a logistics center, where, upon entering the facility, they pass through an RFID tunnel reader that scans and identifies each shipment, adding the goods to the center's in-stock list. The logistics center's system then compares the in-stock list to customers' orders currently in the system, generating a picking list for each customer order. The final customer shipment is then assembled, using the RFID tags on the items for locating them, and run back through the tunnel reader to verify that the shipment is correct compared to what the customer ordered.

When the goods then arrive at Goldwin Sportswear's distribution center in Italy, they are again scanned through an RFID tunnel reader that checks that the contents arriving are consistent with what was sent from China, thus identifying any shrinkage or error in what was shipped. The products are then sent from the distribution center to customers across Europe.

Throughout the entire Goldwin Sportswear supply chain, the company estimates that its RFID system has reduced the time it takes to check products in and out of the various facilities from several days of manual effort previously to less than an hour. Also, the traceability gained from placing RFID tags in the clothing allowed Goldwin Sportswear to identify products that were being sold illegally outside their authorized area. RFID tags have also made it possible for Goldwin to identify counterfeit products, since clothing being sold under the Goldwin name that lacked a matching RFID tag would be identifiable as fake. This RFID roll-out is utilizing passive read/write Texas Instruments tags and readers.

### *Malden Mills*

Malden Mills, a Massachusetts-based textile company and the inventor of Polartec fabric and clothes, rolled out RFID technology in its factory in the spring of 2001 because of the manner in which the fleece material is manufactured. Malden Mills' RFID roll-out is utilizing Escort Memory Systems tags and readers, which are operating at 125 kHz. The tags are passive and read-only protocol. Malden Mills purchased about 300 tags originally and now purchases roughly 400 new tags per year at an estimated price of $35.00 per tag. The tags are replaced each year, and the price per tag is high because of the harsh conditions the tags are exposed to during the manufacturing process, making heavy-duty cases necessary for the tags and giving them a shelf life of about a year.

The production of Polartec fabric involves 1,700-needle, circular-knit machines that knit fabric strands together at a rate of 25 yards a minute, forming long (roughly 40 yards) pieces of fabric that resemble large stockings. This process often leads to production problems because, if a needle is bent or broken while spinning at high speeds, an imperfection in the material results. After the fabric is dyed, it passes through an inspection station and then into a slitting machine, where it is cut down

the side. Before RFID technology was employed, when imperfections were found during the inspection process, operators tied knots in the sock at those places where the fabric was marred. Knot detectors installed on the slitting machines would detect knots, and operators would manually change the position of the cutting blade or take out the damaged material all together.

This system was proving unreliable and costly. In order for the detector to register the knots, they had to be tied exactly the right way. If a knot was tied incorrectly, the system would miss picking it up and the knot could potentially damage the slitting machine. Also, missing imperfections led to waste of material, and that, coupled with the very high cost of repairing the slitting machines, caused Malden Mills to install an RFID system.

RFID tags are now used in pairs, placed at the location of runs in the material found at the inspection station. When a run is located, inspectors take two tags and attach one tag at the beginning of the run and the other at the end. The tags are actually sewn into small pockets in the material and remain there until they reach the slitting and drying station. RFID readers and antennas were installed at the entrance to the drying and splitting station. As the giant pieces of fabric are being drawn into the splitting station, the antennas read the tags. The presence of tags then alerts the splitter blade to stop. Operators find the initial tag, then rotate the cutting blade so that it is on line with the run. By splitting the sock down the run, no material is wasted and the imperfections are only evident on the very ends of the fabric, which are normally sheared off. Operators then take out the RFID tags and reuse them.

Malden Mills has been able to reduce the amount of material it wastes and determine through reports how many imperfections are being found.

### *Michelin*

Michelin has been utilizing RFID technology since about 1999 to track tires through the manufacturing process at one of its plants in Nova Scotia, Canada. Michelin is utilizing Escort Memory Systems (EMS) RFID readers and tags, which contain Philips chips in the transponders. The Michelin tire plant is employing both 13.56 MHz and 443 KHz tags and has purchased about 600 tags at about $125.00 per tag. These active tags are read/write protocol. We understand that Michelin is currently evaluating EMS's 13.56 MHz passive tags.

RFID tags are fastened to large carrier bins and hooks throughout the plant. The read/write protocol tags store instructions that detail the different stages of the manufacturing process, identifying what needs to be done at each particular point. As the tire moves through the assembly lines, it passes over readers at each stage that scan the tag and identify the next step in the tire manufacturing process. As the tire in the carrier or on the hook passes to the next station, the next reader identifies the subsequent instruction. At the end of the process, the carriers and hooks are rewritten with a new set of instructions depending on the type of tire that is going to be associated with that particular tag for its next manufacturing run. (For additional information on initiatives with RFID technology at Michelin, see TREAD Act section below.)

### *The Nestle Company*

The Nestle Company employs Philips RFID chips to track product trays throughout the production cycle at its Illinois facility. The tags are attached to the reusable trays on which the confectionaries are stored as they pass through various stages of production and packaging. RFID is being used to monitor hygiene, ensuring that the trays are cleaned regularly. Before Nestle began using RFID for tracking the trays, the company had instances where trays were overfilled or missed their regularly scheduled cleaning sessions. Working with Escort Memory Systems and Philips' chips Nestle implemented the system to keep track of trays as they pass through production and packaging and to alert management if a problem arises with any of the trays.

As the trays are filled, information regarding weight and product is written to the tags. When the trays then pass over pre-calibrated scales, the programmed optimal weight is compared to the actual weight of the tray, which reduces the risk of overfill. The system alerts employees if the tray is too heavy. Also, real time tracking with a time and date stamp ensures that trays do not sit around for too long and are cleaned regularly. As the trays travel throughout the facility, they are read at several stations and the information is relayed to Nestle's central operating system, which keeps track of where all the trays are at any given time.

**RETAIL**

### *Benetton*

In March 2003, Philips announced that Benetton was planning to purchase 15 million RFID chips as part of an initiative to tag a complete line of its clothes sold at more than 5,000 stores globally. Following a public outcry from privacy groups, Benetton stated that it had not yet committed to roll out RFID technology and that Philips had prematurely announced the contract. However, the initial release from Philips indicated that clothes produced under Benetton's core brand, Sisley, were to be fitted with RFID labels. The tagged items were then to be placed in shipping boxes, which were also to be tagged, thus allowing Benetton to track its clothes from the time they are produced until the time they are sold.

The company has a closed-loop supply chain, which means Benetton manufactures its own clothing, and thus gets the benefit of the investment in RFID tags from the time of manufacture to the time of purchase; it does not need to be as concerned with the current issues and developments surrounding standards.

The press release by Philips then noted that the chips were to remain active even after the products were sold, so that they could be used to track returns as well. The public outcry surrounding this press release from privacy groups, including CASPIAN (Consumers Against Supermarket Privacy Invasion and Numbering), which immediately called for a worldwide boycott of Benetton, caused the company to quickly announce that it has not yet embedded any of its clothing with RFID tags, including the Sisley brand, which had been the line named as the first to receive the embedded tags. Instead, Benetton said it is still analyzing RFID technology to evaluate its technical characteristics and stated that no feasibility studies had yet been undertaken with a view to the possible industrial introduction of this technology.

The company said that after further analysis of the technology, including analysis of potential implications relating to individual privacy, it may or may not decide to introduce the technology on the individual item level. Based upon the order for 15 million chips that Philips initially announced, it was estimated that the cost of the tags would likely be $0.25-$0.50. However, Philips did not reveal the exact price. The tags were to use Philips chips, which operate at 13.56 MHz, store 512 bits, have a read range of three feet, and are compatible with ISO 15693. Lab ID, a systems integrator was to convert the Philips chip into an RFID tag that would then be sewn into the garments during the manufacturing process. Lab ID was also to provide Benetton with readers that would be placed on store shelves. Psion Teklogix was to provide Benetton with its handheld readers.

Despite Benetton's public announcement following the Philips release, it is our understanding that the company is still looking to move forward with RFID technology at the carton level for tracking products through its supply chain, and we believe the order placed with Philips may still be filled in part in the relatively near term.

### *Exxon Mobil*

In 1998, Exxon Mobil introduced its RFID-enabled Speedpass system, which features a handheld RFID transponder that communicates with readers at gas station pumps and cash registers, acting as a form of payment. When a consumer is purchasing gas or food at a participating Exxon Mobil gas station, the RFID transponder is passed in front of the RFID reader and the amount of the purchase is automatically charged to the linked credit or debit card.

In the case of the Exxon Mobil Speedpass system, Texas Instruments' tags and readers are being used, operating at 134 kHz and more recently 13.56 MHz. These are passive, read-only protocol tags, and it is estimated that Exxon Mobil has purchased about seven million RFID tags at a cost of about $2.00 per tag. The Exxon Mobil Speedpass RFID system has also been tested by Stop & Shop grocery stores and McDonald's restaurants. We believe that Pizza Hut, Taco Bell, and KFC have all looked at and may be considering RFID systems similar to the Exxon Mobil Speedpass.

### *Figleaves*

Figleaves is a U.K.-based an online retailer of underwear that has rolled out an order fulfillment system that incorporates RFID technology. Figleaves was seeking an order fulfillment system that would allow the company to increase efficiencies and the number of sales it was capable of handling via the Internet without expanding its physical warehouse. Systems integrator Microlise Group implemented an order fulfillment solution using Texas Instruments RFID tags and readers. Tote boxes which carry product orders through the processing stages of fulfillment have been furnished with RFID tags. Instructions for particular products that are to be placed in an order are written to the RFID tags, and readers at the picking stations then scan the tags and display instructions for filling the order.

### *The Gap, Inc.*

In 2001, The Gap, Inc. ran a three-month RFID field test at its Atlanta, Georgia, operations using Texas Instruments' 13.56 MHz tags for item-level tracking of denim apparel. The pilot employed Texas Instruments' RFID tags and Symbol RFID readers. The passive tags were read/write protocol. The pilot involved 3,000 RFID tags at an estimated cost of $1.00 per tag; however, we believe Texas Instruments provided the tags for the pilot test at no charge.

At the end of the pilot, The Gap reported both improved customer service and supply chain efficiency as a result of the use of RFID. At a normal Gap store, data accuracy in the neighborhood of 85% is common. The in-store RFID trial increased inventory accuracy levels to 99.9%. The Gap experienced higher sales of RFID-tagged denim apparel compared with stores in the area not using the technology, which was attributed to the RFID-tagged denim's availability and speed with which it was moved through the supply chain and brought to the store shelves. The Gap found sales rose by more than 5% because of this in-store availability improvement.

The Gap employees reported that they were able to better manage inventory and keep items stocked on the shelves because of the added visibility that RFID provided. Also, as a result of keeping items in demand on the shelf, The Gap was able to avoid what is known as "walked sales," which is when a customer leaves the store without purchasing an item he or she was interested in because it couldn't be found on the shelf (but was in store inventory).

RFID technology was also able to limit shrinkage (inventory theft while products are moving through the supply chain), a problem that costs The Gap an estimated $30-$40 million a year. The Gap, like other retailers, has to contend with theft of its clothing in the supply chain — items that are then returned to the store for a refund, meaning the company actually pays for the jeans twice (once for the cost of manufacturing the clothing and again when it buys the product back from the person returning it).

Despite the solid results of the pilot test in 2001, The Gap suspended its use of RFID technology, citing the difficult economic environment that has affected retailers.

### *Marks & Spencer*

Marks & Spencer, a U.K.-based retailer, rolled out RFID to its Food and Logistics division in 2002. As part of this initial roll-out, the company is replacing existing bar codes with RFID technology to create a system to track about 3.5 million reusable trays, dollies, and roll cages used throughout the store's refrigerated food supply chain. We believe Marks & Spencer has purchased about four million RFID tags from Texas Instruments and is employing RFID readers from systems integrator Intellident. The tags are read/write protocol passive tags operating at 13.56 MHz. We estimate that each tag costs roughly $1.00.

More than 70% of Marks & Spencer's food business is in refrigerated fresh foods. The majority of its items are ordered at 6 a.m. and delivered the next day beginning at 7:30 a.m., underscoring the importance of supply chain efficiency. Read/write

protocol tags that are placed on each container acting as a license plate for that specific product load, with the supplier's name, the product, and the sell by date all written to the tag. Thus, as the containers move through the supply chain, into the distribution center, and then on to the store, they are run through portal readers and identified simultaneously, without the need for line-of-sight scanning of each case or tray.

In trials with the technology, RFID tags reduced the time needed to read a stack of multiple trays by approximately 80% when compared with bar coding. We understand that a complete dolly with more than 25 trays can be scanned in a single pass through an RFID-enabled portal in five seconds with high accuracy, while the same task with bar codes takes about 29 seconds. Also, the time needed to unload a truck at the distribution center and check all the goods into the distribution center has been reduced to three minutes with RFID versus 18 minutes previously with bar codes. Finally, because these 3.5 million containers are reusable, the assigned license plate of each item gives it an identity, allowing Marks & Spencer to keep track of these containers and thus reduce shrinkage. In the past, the company has experienced an 8%-10% shrinkage rate on the trays.

### *Metro AG*

In April 2002, Metro AG, a large German retailer, opened what it referred to as a "store of the future," which is a concept store designed to test RFID in the supply chain and on the store floor, as well as at the personal shopping level. One of Metro's stores in Rheinberg, Germany, has been equipped with smart shelves and RFID checkout systems, in addition to other technologies such as kiosks and smart scales. Customers have the option to utilize the new systems or shop in a traditional manner. Several suppliers to the Metro AG store that are participating in this roll-out of RFID technology have employed readers at the dock doors in their manufacturing facilities as well as their distribution centers. With readers in place, RFID is being used to track goods all the way through the supply chain from the supplier to the distribution center to the back of the store and then to store shelves.

The primary goal of the RFID initiative is to determine whether or not the system can reduce stock outages. The resulting shipment and inventory data are captured by Metro's SAP software system. Intermec's RFID tags are being used to track cases and pallets in the back end and individual items (such as DVDs and CDs) are being tagged with Philips' tags that operate at 13.56 MHz, have a read range of up to five feet, and incorporate theft protection. In addition, cosmetics and food products are being tagged to track real-time inventory data and expiration dates. Metro has also equipped shopping carts with RFID tags, and readers at store doors tell the store manager the number of carts that have entered or left the store, so that, for example, if there is an increase in the number of carts entering, more checkout lines can be opened. The project is using tags that are compliant with the Auto-ID Center's EPC infrastructure.

### *Prada*

In December 2002, Prada introduced its Epicenter store in New York City, for which it employed RFID technology in an effort to design an environment that enhances the

customer experience. A British systems integrator called KTP (now owned TrenStar) handled the implementation of RFID technology at Prada. The roll-out is utilizing RFID readers and tags made by Texas Instruments that are operating at 13.56 MHz. The tags are passive and are read/write protocol. We estimate that Prada purchased roughly 5,000 tags at an estimated cost of $2.00-$3.00 per tag. We actually believe the actual cost of the tags alone was closer to $1.00, but we think that the price of every tag was boosted by $1.00-$2.00 because Prada wanted the tags to be customized with its brand name and a particular look.

RFID is not being used to inventory products or keep track of what is on the shelf or to prevent theft. Instead, RFID readers from Texas Instruments have been placed in numerous locations throughout the store to identify products, devices, and staff, while RFID tags have been placed on all the products in the store. Every item in the store is tagged upon entering. All shoes, handbags and clothes possess a clear RFID tag with the antenna and chip clearly visible. Staff carry handheld readers and can scan products and bring video clips up on various television monitors throughout the store to show samples of the very same article of clothing on the fashion runway or in a collection of photographs and designer sketches.

Also, there are RFID readers placed in the dressing rooms so in instances when a customer tries on an article of clothing, the readers in the dressing room (there are two in each room, one that is small and square and is used for shoes and smaller items and another that is long and narrow for reading hanging clothes) scan the RFID tag and display information about the clothing on a television with a touch-screen. The customer can then view accessories or see the same item in different colors. Also, the handheld sales tools are tied to a real-time inventory system on the back end, permitting sales associates to show only colors and sizes that are in stock.

The Epicenter Prada store offers regular shoppers a customer card that can be presented to a sales associate upon entering. The RFID chip in the card identifies the customer and calls up his or her shopping preferences. But this customer card that stores a personal profile is an option — customers may still shop anonymously in the store.

### *Sainsbury's*

Sainsbury's ran an RFID pilot several years ago that set out to test the degree to which labor associated with stock counting and spoilage of perishables in the supply chain could be reduced. In the Sainsbury's RFID pilot, tracking was done only for perishable goods and in the initial phase it involved just one supplier, one distribution center, and one store. During the second phase of this test, all the perishable products arriving at the single Sainsbury's store were tagged. We believe Philips read/write RFID tags were used for this pilot and were attached to reusable plastic containers.

In phase one, a reader at the end of the production line programmed all crates containing perishable goods with the description and quantity of products in the crate, the use-by date of the products, and the container's own identification number. The containers were then transported to the distribution center where they were rolled through portal readers upon entering. When the goods were ready to go to the Sainsbury's store, they were again loaded and transported, this time to the retail

location, where they were passed through a portal reader to check the goods into the store.

Besides the efficiency gained from the increased speed with which the goods were able to be checked into and out of the distribution center as well as the store, the RFID system alerted employees about the perishables that were closest to their spoil date, allowing them to be moved out to the store front to be sold first. This test was scaled up in phase two, and all perishables from all suppliers going to the same Sainsbury's store were tagged with RFID transponders.

Sainsbury's calculated that the RFID system, if rolled out to all its stores and distribution centers, would pay for itself in two to three years. However, it should be noted that in order for the RFID system to reach maximum potential, Sainsbury's suppliers also would have had to install readers at their production facilities and at other locations along their piece of the supply chain, which, at the time of this pilot, they were not prepared to do.

Because of a lack of supplier confidence in rolling RFID out full scale, combined with the fact that we believe Sainsbury's had additional business priorities of higher importance that it needed to address, the RFID system was not rolled out to all stores despite the efficiency gains seen in the pilot. Additional details about the frequency, price, and number of tags used in this pilot were not available.

### *Target*

Target is a member of the Auto-ID Center and is participating in pilot projects that seek to replace bar codes on merchandise with RFID tags that are small enough to be embedded invisibly into all of the products in the store. Target anticipates that eventually this technology will allow its products to communicate directly with computers throughout the entire supply chain process, resulting in cashier-less checkouts, increased efficiency and accuracy of guest service, and improved visibility into store activity.

While noting that it believes RFID technology could potentially serve as a replacement for bar coding in the future, Target views improved data integrity and supply chain intelligence as the key objectives of RFID going forward. However, Target has indicated that we are likely five or more years away from RFID tracking individual items on a broad scale.

While Target has not been as vocal as Wal-Mart about its RFID plans, the retailer has been involved in Auto-ID Center pilot projects and is expected to require its suppliers to become RFID-compliant in the intermediate term as well.

### *Tesco*

Tesco is involved in a pilot test of RFID technology with Gillette in Europe. The pilot, which was originally supposed to be performed with Alien Technology tags, is now using Philips tags. While additional details about the pilot are not readily available, we understand that Philips tags are being used to test the case for communication in the store and tracking out-of-stocks and replenishment rates. We

believe that smart shelves are being tested, with item-level RFID tags on high-shrinkage goods like razor blades and batteries, as well as tags being placed on cases and pallets of these products.

Alien tags were originally chosen for the pilot test by Gillette, but we believe they did not conform to European standards and thus could not be used. Tesco is extending its trial of RFID tags to DVDs at a Tesco Extra store in Sandhurst, Berkshire, United Kingdom. At that location, we believe Tesco is using tags supplied by packaging company MeadWestvaco, a Checkpoint partner. In this pilot, each DVD will feature a unique tag on the packaging, which is activated by a shelf reader. When the product is removed from the shelf, or from the back room of the store, the reader will immediately send a message to a central system accessed by Tesco and its distribution partner, Entertainment U.K., so the item can be replenished.

### *Wal-Mart, International Paper, and Procter & Gamble*

At the beginning of 2003, International Paper, working with systems integrator SIRIT Technologies Inc., rolled out a retail smart shelf pilot at a Wal-Mart store in Broken Arrow, Oklahoma. Working with Procter & Gamble and the company's Lipfinity cosmetics product in particular, individual items are being tagged with RFID transponders. This pilot is still running at the Broken Arrow store and employs 13.56 MHz passive Philips tags that are "read-only" protocol. For this pilot, we estimate International Paper, Wal-Mart, and Procter & Gamble purchased fewer than 100,000 tags at roughly $0.15-$0.20 per tag. We believe the price per tag in this pilot is so low compared to many of the other pilots we outline because of the project's recent start date, further evidencing how new RFID technology and manufacturing processes are lowering costs.

Like International Paper's smart shelf pilot with Revlon, this application of RFID alerts store employees about inventory of the item on the shelf as well as possible situations where probability suggests that a theft may be occurring. The smart shelf at the Wal-Mart store also records the speed that items leave the shelf. These data are then being applied to fulfillment algorithms to calculate how much product needs to be ordered to prevent outages but at the same time avoid building too much inventory.

Also, in the case where individual items are not where they are supposed to be on the shelf, possibly implying that they are sold out, the system alerts employees in real time of this potential stock outage so they can put more on display. Finally, this smart shelf application is wired into the store's security system, and if four or more of the cosmetic product are removed from the product shelf at once, the store's cameras focus on the shelf and security personnel are alerted.

## SUPPLY CHAIN/TRACKING

### *CHEP*

CHEP, a pallet and container pooling services provider, manages the daily movements of more than 200 million pallets and containers worldwide. Because the company has so many reusable containers, CHEP is affected when its units are damaged, lost, or leased out for extended periods of time. RFID tags provide CHEP

with the ability to assign each individual pallet and container an identity, giving the company the ability to identify a particular user that might have lost, stolen, or damaged a unit.

CHEP tested bar codes on its pallets, but found that they tended to fall off and were thus deemed unreliable. Also, CHEP found that in tests with roughly 550 pallets loaded onto a truck, unloading and scanning all the pallets took about three hours when line of sight was necessary using bar codes, but with RFID technology the unload time was reduced to about ten minutes.

In spring 2002, CHEP began a pilot with RFID technology in which the company tagged about 250,000 pallets throughout six service centers in Florida. CHEP found that with RFID tags on its pallets 1) traceability was increased; 2) the ability to dispatch and receive pallets loads was more efficient; and 3) the typical three to four hours of waiting time during the unloading of trucks was reduced. CHEP found that it could move pallets through the supply chain more efficiently and keep track of its pallets as they moved. However, demand did not yet exist among its suppliers to support a full-scale roll-out of RFID.

CHEP is now seeking corporate approval to roll RFID technology out to an additional percentage of its pallet fleet for its own internal observation, tracking, and statistical analysis, but we believe that the company is prepared to offer RFID-enabled pallets to its customers for a premium fee when demand exists.

The pilot in Florida is utilizing passive Intermec tags and readers. The tags are operating between 905 MHz and 928 MHz and are of the read/write protocol. CHEP originally purchased about 500,000 tags from Intermec, as the company placed two tags on each pallet to ensure reader accuracy, at an estimated price of less than $2.00 each. In more recent tests of newer RFID technology, it is now necessary to equip each pallet with only one tag.

### *Colchester Library*

Intellident, a systems integrator based in the U.K., has signed a contact with a Colchester Library to tag all of the books contained within its system. Read/write RFID tags are being placed in each book and written with the name of the book and a security profile that alerts the central library system when the book is leaving without being properly checked out. When the book is checked out, it is scanned by a reader at an automated checkout that associates the book title with the person checking it out, records the information to the library database, and alerts the RFID tag within the book to deactivate its security alert, allowing the individual to leave without setting off alarms. Also, this system reduces the time it takes to find a mis-shelved book, as someone on the library staff can locate the book in question using an RFID reader.

Intellident is utilizing read/write protocol tags by Philips and its own readers for this project. The tags operate at 13.56 MHz.

### *Georgia-Pacific*

After taking a first look at RFID technology in mid-1999, Georgia-Pacific Corp. introduced new reusable plastic containers (RPCs) for holding perishables equipped with RFID tags in November 2000. Each of the collapsible containers were harnessed with two Intermec Intellitags, which were ultra-high-frequency RFID tags that operated at 915 MHz and had a read distance of ten to 12 feet. Readers, also from Intermec, were tested at different stages along the supply chain to track the RPCs as they moved from the grower all the way through the distribution center and finally to the retailer.

Because Georgia-Pacific was introducing these reusable plastic containers, it had a new-found interest in tracking them, in part solely to be sure that they were being returned by the customers who used them. Also, the company saw value in the efficiency gains RFID made possible. These collapsible containers are stacked on top of each other when empty, with roughly 160 RPCs to a pallet, and scanning a bar code on each RPC, which required line of sight, was neither plausible nor efficient. However, Georgia-Pacific instead installed two RFID tags on each RPC and was able to read large quantities of the RPCs as they moved through portal readers at a rate that was 25 times faster than the estimated time it would take to complete the same task with bar codes.

We estimate that Georgia-Pacific initially purchased more than a million of these Intermec 915 MHz tags at a cost of about $1.00 or less. Working with Intermec, Georgia-Pacific also developed software to track and process the data that was captured by readers placed throughout the supply chain. Despite the success of the project in using the technology to trace the RPCs, in April 2001, Georgia-Pacific shelved its RFID initiative because it decided that at the time, the efficiency gains did not yet justify the cost of capital, largely, we believe, because the rest of the supply chain was not ready for it.

We believe that Georgia-Pacific, having proved that the technology would work to track at the case level through the supply chain with efficiency and accuracy, is still in a position to offer RFID-enabled containers when it deems that its customers are ready to leverage the technology. We also believe that Georgia-Pacific may be in the early stages of exploring how RFID technology could be incorporated with its corrugated boxes at a price point that still makes the value proposition compelling.

While we were not able to gather definitive information about this initiative, given the volume of disposable boxes Georgia Pacific distributes annually, we believe that the prospect of tagging these boxes with low-cost RFID tags could offer a compelling value proposition for shipping more expensive perishables, like meats.

### *Northwest Airlines*

Northwest Airlines is currently using SCS Corporation RFID tags and readers in its baggage screening system at Seattle-Tacoma International Airport. Working with Northwest Airlines, the Federal Aviation Administration (FAA), Lockheed Martin (the general contractor for the baggage screening system), and URS Greiner (the designer of Northwest Airlines' security subsystem), the RFID-controlled baggage

screening system was installed at the end of 1999. The system has served to automate the baggage screening process, which previously was done manually. Under this new RFID-enabled system, airline personnel affix RFID tags to luggage that has been identified as requiring additional screening at check-in. Those bags are then automatically identified by an RFID reader along the conveyor belt and diverted for further screening.

### *Raxel*

Raxel, a South African company that handles the tracking and disposal of biohazardous waste, implemented RFID in 2002 in order to track its reusable plastic containers as well as to comply with a government mandate that called for better tracking and disposal of hazardous waste. Raxel is utilizing passive read/write Intermec tags and readers operating between 905 MHz and 928 MHz. It is our understanding that Raxel purchased about 500,000 tags from Intermec at an estimated price of $1.00 each.

Because the containers are carrying potentially hazardous waste, the government has strict rules and regulations that must be abided by for picking up, transporting, and disposing of the waste. It is also necessary to be entirely sure that containers have been cleaned properly after the waste is disposed of and before they are reused. RFID readers throughout this disposal chain write information to the tags detailing what is being picked up, how to dispose of it, and when the containers were last cleaned. With RFID readers, employees can scan containers that are in various stages of the disposal chain and immediately be alerted as to what is in each container and how it should be handled at that stage.

RFID tags also have made it possible to be sure that a container has been properly cleaned because an employee can scan the tag and find out if it is clean before handling it and risking contamination. Also, government inspectors who monitor the disposal of biohazardous waste can scan storage locations to check that all the containers in a designated clean and ready station have in fact been sterilized. The RFID readers also update the Raxel system with information about where different containers are and what jobs they are handling.

## ADDITIONAL RFID IMPLEMENTATIONS AND PILOT PROGRAMS

### *Commercial Trucking*

Commercial trucking is currently piloting projects with RFID that seek to utilize the technology to monitor commercial grade truck tires. While we believe this initiative is in the early stages, RFID is being used to monitor both air pressure and current conditions of tires. The integrity of a tire can be compromised if it has been re-treaded too many times. This can be a safety concern because it increases the chances of a blowout, which could lead to an accident. Information detailing how many re-treading procedures and other maintenance procedures a tire has had is being written to RFID tags, and each time the tire is scanned by a reader, those data become readily available. Thus, if the tire has been re-treaded too many times, a technician servicing it will know to replace the tire rather than perform the refurbishing procedure again.

Also, RFID tags are monitoring the air pressure in tires and sending alerts to the driver if the air pressure is low. Low pressure hampers both performance and gas mileage.

### *Napoleon Gate Entry Management System*

In the shipping port initiative equivalent to the Metro AG Future Store, a New Orleans port is being outfitted with RFID technology as part of a new system being implemented called Napoleon Gate Entry Management System. The project, which has been in development for two and a half years, is expected to be operational by the summer of 2003. With RFID technology and additional technological advancements to automate the load process, the port expects to increase its loading capacity from 130 trucks an hour to 240. Each truck utilizing the port will be tagged with a TransCore tag, and only trucks with RFID tags will be permitted to enter for pickups.

To track the trucks as they move through the port, more than 20 RFID readers are being installed throughout the facility. When a truck approaches the terminal, its tag is read by an RFID reader. The driver receives an automated message over AM radio instructing him whether to proceed to the portal. Upon gaining clearance, the driver is allowed to proceed through the portal, which contains optical recognition technology that identifies the equipment the truck is pulling and updates the terminal operation system with that data. The driver then pulls up to a pedestal with a display screen and a telephone.

The clerk no longer has to type information about the truck into the system or receive any paperwork from the driver, as it was entered into the system automatically upon being read off the RFID tag. Provided the truck is on time and had an appointment and there are no other issues, it is permitted to enter the port. The readers located throughout the port then continue to scan the driver's RFID tag and keep the system updated as to where the truck is inside the facility. After the driver picks up his load, the truck passes through an exit portal similar to the one it originally entered through. The driver receives a receipt and is allowed to exit provided there are no abnormalities.

The physical structure being built in New Orleans for this technologically advanced port is expected to be done by the end of April 2003, at which point the Napoleon Gate Entry Management system will be implemented and tested. Formerly a 61-acre terminal, this new advanced port will operate in a space of 21 acres because of the new efficiencies afforded by the automation of processes.

### *Savi Technology*

- **Department of Defense: Total Asset Visibility Network (TAV).** The U.S. Department of Defense became interested in using RFID technology to track items shipped between military locations shortly after Operation Desert Storm. During that first Gulf war, problems and confusion in tracking military shipments made it necessary to open roughly 25,000 out of 40,000 containers sent to the Persian Gulf in order to verify the contents upon arrival overseas. Many containers had to be re-shipped because they were lost and never reached the correct destination. As a result, the Department of Defense began utilizing RFID

technology to create what it refers to as its Total Asset Visibility (TAV) network. In 1994, the Department of Defense awarded Savi Technology a $70 million contract to use its RFID technology, which was followed by a $112 million contract in 1997.

Then, in 2000, the Department of Defense signed a two-year contract with Savi to extend its use of the company's RFID technology. Even more recently, it signed a three-year contract with Savi worth up to $90 million for RFID hardware and related logistics software and services. The Department of Defense's Total Asset Visibility Network employs Savi Technology RFID tags and readers that operate at 433 MHz. The tags are active read/write protocol, and we understand that the DOD has purchased about 500,000 tags at a price of $60.00-$100.00 per tag, depending on casing and memory capabilities.

The Department of Defense's TAV network now tracks approximately 270,000 containers transporting military supplies between 400 locations in more than 40 countries. The tags that the military is using throughout its Total Asset Visibility Network are built to withstand extreme conditions and also have considerable data memory capacity. The tags are written with the full manifest and searchable database detailing current contents of the container it is attached to. The searchable database allows items to be quickly located, as the user does not have to scroll through the entire manifest to find something inside the large container, but instead can do a search on the tag database and immediately find out if the item or items are contained within. The use of RFID tags on these military containers has reduced the time it takes to locate a particular item from roughly two days to about 20 minutes.

The TAV network is also integrated with software that tracks the containers through the entire supply chain, allowing for the dynamic order management of shipments even while in transit. That is, if there is a more urgent need for certain goods at a location different than the container's original destination during a wartime scenario, it can be re-routed to a new location. Savi's active RFID tags comply with the ANSI International Committee for Information Technology Standards (INCITS) 256-2001 Standard, which is a minimum requirement for the Department of Defense.

- **Intermodal/Railroads.** A large rail carrier outside of North America, whose identity has not yet been disclosed, has been using RFID technology for about a year to track its rail cars. Because rail cars can cost in the neighborhood of $100,000 and this rail carrier owns roughly 100,000 cars, the company reportedly has found RFID to be an effective tool for locating and keeping track of its fleet. With so many cars, the company formerly had instances when a particular car would sit "missing" in a rail yard because there was effectively no way of identifying it or distinguishing it from other cars in the yard. Sitting cars are sometimes recorded as lost, causing management to think its fleet is smaller than it is, which then leads to increased capital expenditure as the carrier adds new rail cars to meet demand when in reality the carrier isn't fully utilizing its current fleet.

This large carrier outside North America is now tracking its cars with RFID, allowing it to keep track of the cars along their routes. This real-time tracking capability allows the carrier to efficiently delegate new routes to cars as they complete previous tasks, which has led to better utilization of the fleet. The carrier has installed readers along its routes, and as the cars pass the readers, they are scanned. The readers update the system with the car's position, which is then cross-checked with where it is supposed to be. RFID readers have also allowed the carrier to more efficiently manage the order by which it lines up its cars, taking into consideration early on which cars will be unloaded or detached at different stages. This saves time as well as resources required to reposition rail cars, which was often necessary before RFID tags alerted the system about the order of the cars.

Also, RFID tags allow the carrier to identify what is being shipped and how many cars may be involved in a certain run, making it possible to match the convoy with the appropriate size locomotive so that the train convoy is not overloaded or underpowered. The orientation of the rail car can also be determined by the RFID tag attached to it, as it will alert the carrier's system if it is facing the wrong direction. Before RFID tagging, rail cars facing the wrong direction in the caravan often had to back track to a certain location in order to be turned around, thus wasting time and resources in the process of repositioning itself.

Lastly, the Savi Technology RFID system being used by the large rail carrier outside North America tracks the planned routes of its rail cars. The readers alongside the tracks alert the system if a car has deviated from its set route and destination. This precautionary alert allows for correction of the misdirected rail car in the early stages of discovery, which cuts down on lost time and the additional expense incurred when a rail car arrives at the wrong destination. For this project, the large rail carrier is using Savi tags and readers that operate at two frequencies, receiving signals at 123 KHz and transmitting signals at 433 MHz. This dual-frequency system allows for greater accuracy in pinpointing the location of the passing rail car. The 433 MHz transmission has a greater read distance and thus picks up the tag and alerts the system when the rail car is within about 300 feet. The 123 KHz signal has a much shorter read range, and when this signal is read, the system recognizes that the tag is now within just a few feet of the reader picking it up.

The tags are active read/write protocol, and we understand that the rail carrier has purchased 100,000-200,000 tags priced at $15.00-$20.00 per tag.

- **Shipping/Ports.** Because more than 17,000 containers, carrying roughly 80% of U.S. imports, arrive daily at U.S. seaports, the increased threat of terrorism has been a cause for greater focus on ways to secure U.S. ports. The Strategic Council on Security Technology, an international assembly of executives from the world's largest port operators and major logistics technology providers, four-star generals, former public officials, and representatives of transportation consultancies, was instrumental in the launch of Smart and Secure Tradelanes (SST) during the summer of 2002. In an effort to create an RFID system to track oceangoing containers, the SST is working with Savi Technology to build out an

RFID infrastructure similar to the one currently employed by the U.S. Department of Defense for its Total Asset Visibility Network (which was created by Savi Technology). Thus far, several large seaport terminal operators, including Hutchison-Whampoa, PSA Corp., and P&O Ports, among others, have agreed to and are in the process of deploying Savi's RFID tracking technology in their respective terminals.

The first ports to be outfitted with the technology were Hong Kong, Rotterdam, Singapore, and Seattle-Tacoma. At the terminals where RFID has been employed, there are readers strategically placed throughout the grounds of the facility. RFID tags have been placed on containers at these ports and all the contents placed in the individual containers are written to its tag, which is also equipped with an electronic seal mechanism. After the containers are loaded with the goods, they are sealed by an authorized employee. An electronic seal is created after additional information detailing when the container was sealed and under whose supervision it was done is written to the tag. The safety of the contents of these containers can then be verified by the port from which they originated, and the receiving port can scan the tags and determine if the seal has been broken or tampered with while in transit across the ocean. The RFID tags also identify ahead of time what is coming into the port, which should help to expedite the unloading process.

However, at this time, the serious concerns surrounding terrorism, as well as government mandates such as the 24-Hour Rule (which mandates that cargo be filed with U.S. Customs 24 hours before it is loaded on a ship headed to the U.S.), are the drivers behind adoption of RFID technology by seaport terminal operators, rather than efficiency gains alone. Further down the road, though, we believe that the employment of RFID in ports should help to create a more efficient load/unload process at the terminals, thus creating a more efficient supply chain.

### *The TREAD Act*

The TREAD (Transportation Recall Enhancement Accountability and Documentation) Act was enacted on November 1, 2000, as a direct consequence of hearings before the Committee on Energy and Commerce on the safety of Firestone tires and related matters. In the course of the hearings, the Committee determined that the U.S. National Highway Traffic Safety Administration (NHTSA) could have detected the problems with the tires sooner if it had obtained reports about the tires' problems in a timely manner. In addition to the safety concerns raised by the instances involving Firestone tires, ensuring that tires were properly inflated was also a major concern, as an under-inflated tire can compromise vehicle stability, handling, and braking, and reduce fuel economy, performance, and tire life.

In order to comply with enhanced federal record-keeping standards, including those set by the TREAD Act, RFID tags can be used (attached to or manufactured inside the tire) to store tire identification information, including when and where the tire was made, maximum inflation pressure, and tire size. Michelin and Intermec Technologies have designed an ultra-high-frequency RFID tag, using chips from

Philips Semiconductor and Fairchild Semiconductor that can be embedded in tires to store the aforementioned information.

The tag has a larger data capacity than a bar code and can be encoded and decoded with a handheld reader. Also, unlike a bar code, the RFID tag remains unaffected by soil or deterioration over time. New information can also be written to the tag, such as the vehicle identification number of the vehicle on which it is mounted. The data stored on the tags can also be stored in a database for retrieval purposes. The Michelin RFID tag has a read range of about 24 inches. In addition to complying with new federal record-keeping standards, the Michelin RFID tag is also compliant with Automotive Industry Action Group's B-11 standard for North America, which calls for an identification solution that is embedded inside the tire.

RFID is also being investigated as a solution to comply with TREAD Act's 2004 deadline that all cars produced after 2004 be fitted with tire pressure monitoring systems. Currently, TPMS solutions fall into one of two categories: using either a direct or an indirect measuring method. Indirect measurement systems work by using the vehicle's existing ABS system to measure the difference in wheel speed caused by under-inflation of the tires. These systems can be implemented at very low cost, as they only require the addition of new software to the existing ABS system. However, they can only detect a minimum pressure difference of around 30%, and do not work when the vehicle is stationary.

In order to meet the TPMS standards set by the NHTSA, more accurate direct measurement systems are required, and that is where RFID enters the picture. RFID can be applied in direct systems that use pressure and temperature sensors housed in the tires to send data back to a central receiver, where the tire status is monitored. Philips has designed an RFID chip that has the ability to directly measure vehicle tire pressure. The Philips chip broadcasts at regular intervals the temperature and pressure of each tire, which can be displayed on a dashboard, either through a warning light or digital readout. The system is designed to work with the receivers used for remote keyless entry. Antennas are installed in each wheel well. The keyless remote entry receiver is modified so that it can send out a low-frequency signal through the wheel well antennas, reading the active RFID tag located either in the tire valve or inside the rim of the tire.

The 315 MHz or 434 MHz active tag transmits its ID number, which identifies the tire's location on the car and data on the temperature and pressure of that tire. It is our understanding that Philips does not make the entire RFID-enabled system, but instead just produces the RFID chip. System integrators combine the chip with a pressure and heat sensor, although it is unclear at this point which SIs will be used.

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# Universe Tables

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## Exhibit 22. Bear Stearns Supply-Chain Technology/Application Software Universe — EPS and Revenue Multiples, 2000-04E

| SUPPLY-CHAIN TECHNOLOGY<br>Sector Rating:<br>Market Weight | Price ($)<br>6/2/03 | 52-Week<br>High | <br>Low | Share Count (MM) [3] | Market Cap (MM) | BSC Rating | Target Price | Float (MM) | Trading Volume (MM) [4] | Short Interest % [5] |
|---|---|---|---|---|---|---|---|---|---|---|
| Agile Software (AGIL) [7] | $9.03 | $10.27 | $4.97 | 49 | $441 | Underperform | | 39 | 0.36 | 1.5% |
| Aspen Technology (AZPN)[7] | $4.12 | $11.63 | $0.59 | 41 | $169 | Underperform | | 32 | 0.45 | 13.5% |
| Descartes Systems (DSGX) [7] | $2.29 | $3.96 | $2.03 | 52 | $120 | Underperform | | 48 | 0.02 | 0.7% |
| EXE Technologies (EXEE) | $3.00 | $11.48 | $2.25 | 7 | $20 | Peer Perform | | 43 | 0.01 | 0.0% |
| FreeMarkets, Inc. (FMKT) | $7.23 | $16.41 | $3.50 | 42 | $304 | Outperform | $8 | 40 | 0.81 | 3.1% |
| i2 Technologies (ITWO) | $1.03 | $3.98 | $0.41 | 431 | $444 | Peer Perform | | 307 | 6.92 | 4.6% |
| JDA Software (JDAS) | $12.73 | $29.78 | $5.10 | 28 | $362 | Outperform | UR | 23 | 0.64 | 6.0% |
| Manhattan Associates (MANH) | $27.90 | $33.95 | $12.16 | 30 | $849 | Outperform | $33 | 24 | 0.66 | 27.3% |
| Manugistics (MANU) [7] [10] | $4.85 | $9.00 | $1.54 | 70 | $339 | Underperform | | 59 | 1.22 | 21.2% |
| MatrixOne, Inc. (MONE) [7] | $5.07 | $7.43 | $1.80 | 48 | $242 | Peer Perform | | 41 | 0.45 | 1.6% |
| PTC (PMTC) [7] | $3.41 | $4.00 | $1.64 | 262 | $894 | Peer Perform | | 234 | 1.54 | 1.4% |
| Retek, Inc. (RETK) | $6.92 | $25.38 | $1.50 | 53 | $368 | Peer Perform | | 53 | 1.28 | 4.4% |
| Vastera (VAST) | $5.01 | $6.41 | $1.61 | 41 | $203 | Peer Perform | | 17 | 0.13 | 6.4% |
| **SCT Group Average** | | | | | $359 | | | 74 | 1.11 | 7.1% |
| **SCT Group Median** | | | | | $321 | | | 41 | 0.64 | 4.4% |
| **Nasdaq Composite** | 1,591 | 1,651 | 1,108 | | | | | | | |

| | Revenue (MM) [8] | | | | | Market Cap / Revenue | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000-2004E | 2000 | 2001 | 2002 | 2003E | 2004E | 2000 Range | 2001 Range | 2002 | 2003E | 2004E |
| Agile Software (AGIL) [7] | $66 | $91 | $67 | $77 | $95 | 67.8x-14.4x | 26.4x-4.0x | 6.6x | 5.7x | 4.6x |
| Aspen Technology (AZPN)[7] | 311 | 321 | 328 | 323 | 350 | 4.7x-1.6x | 3.8x-0.9x | 0.5x | 0.5x | 0.5x |
| Descartes Systems (DSGX) [7] | 65 | 78 | 71 | 59 | 61 | 56.5x-12.2x | 17.6x-2.6x | 1.7x | 2.0x | 2.0x |
| EXE Technologies (EXEE) | 116 | 99 | 74 | 70 | 79 | 6.8x-1.2x | 7.0x-0.9x | 0.3x | 0.3x | 0.3x |
| FreeMarkets, Inc. (FMKT) | 98 | 167 | 182 | 155 | 180 | 122.1x-6.5x | 6.2x-1.5x | 1.7x | 2.0x | 1.7x |
| i2 Technologies (ITWOE) | 1,150 | 1,013 | 523 | 435 | 469 | 32.7x-10.4x | 24.2x-1.2x | 0.8x | 1.0x | 0.9x |
| JDA Software (JDAS) | 172 | 214 | 219 | 183 | 216 | 3.4x-1.4x | 2.9x-1.0x | 1.7x | 2.0x | 1.7x |
| Manhattan Associates (MANH) | 139 | 161 | 173 | 202 | 252 | 13.2x-1.3x | 7.1x-1.8x | 4.9x | 4.2x | 3.4x |
| Manugistics (MANU)[7] | 249 | 307 | 279 | 261 | 269 | 15.0x-2.7x | 10.8x-1.1x | 1.2x | 1.3x | 1.3x |
| MatrixOne, Inc. (MONE) [7] | 109 | 138 | 124 | 106 | 138 | 18.8x-2.4x | 11.0x-1.6x | 2.0x | 2.3x | 1.7x |
| PTC (PMTC) [7] | 917 | 898 | 719 | 690 | 752 | 9.6x-2.4x | 4.9x-1.3x | 1.2x | 1.3x | 1.2x |
| Retek, Inc. (RETK) | 92 | 179 | 192 | 161 | 166 | 39.1x-8.2x | 13.5x-3.3x | 1.9x | 2.3x | 2.2x |
| Vastera (VAST) | 34 | 66 | 76 | 86 | 97 | 16.9x-3.3x | 10.8x-4.2x | 2.7x | 2.4x | 2.1x |
| **SCT Group Average** | **$271** | **$287** | **$233** | **$216** | **$240** | **31.3x-5.2x** | **11.3x-2.0x** | **1.7x** | **1.8x** | **1.6x** |
| **SCT Group Median** | **$116** | **$167** | **$182** | **$161** | **$180** | **16.9x-2.7x** | **10.8x-1.5x** | **1.7x** | **2.0x** | **1.7x** |

| | Adjusted EPS [1, 8, 9] | | | | | PE [2] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000-2004E | 2000 | 2001 | 2002 | 2003E | 2004E | 2000 [6] | 2001 [6] | 2002 [6] | 2003E | 2004E |
| Agile Software (AGIL) [7] | ($0.07) | ($0.32) | ($0.66) | ($0.15) | $0.11 | NM | NM | NM | NM | 78.6x |
| Aspen Technology (AZPN)[7] | 0.38 | (0.62) | (0.51) | 0.03 | 0.23 | 10.8x | NM | NM | 132.7x | 17.8x |
| Descartes Systems (DSGX) [7] | (0.01) | (0.06) | (0.12) | (0.09) | 0.04 | NM | NM | NM | NM | 63.9x |
| EXE Technologies (EXEE) | 0.72 | (2.00) | (1.78) | (0.48) | 0.26 | 4.2x | NM | NM | NM | 11.5x |
| FreeMarkets, Inc. (FMKT) | (1.18) | (0.34) | 0.26 | 0.02 | 0.34 | NM | NM | 27.4x | 447.6x | 21.1x |
| i2 Technologies (ITWOE) | 0.28 | (0.31) | (0.35) | (0.01) | 0.06 | 3.7x | NM | NM | NM | 17.9x |
| JDA Software (JDAS) | 0.53 | 0.67 | 0.55 | 0.19 | 0.65 | 24.0x | 19.0x | 23.3x | 68.2x | 19.7x |
| Manhattan Associates (MANH) | 0.61 | 0.72 | 0.85 | 0.90 | 1.25 | 45.7x | 38.6x | 32.9x | 31.2x | 22.3x |
| Manugistics (MANU)[7] | 0.08 | (0.19) | (0.66) | (0.24) | 0.08 | 64.4x | NM | NM | NM | 64.2x |
| MatrixOne, Inc. (MONE) [7] | 0.07 | (0.20) | (0.34) | (0.23) | 0.13 | 74.7x | NM | NM | NM | 38.8x |
| PTC (PMTC) [7] | 0.12 | 0.15 | (0.10) | (0.07) | 0.18 | 28.3x | 22.3x | NM | NM | 18.9x |
| Retek, Inc. (RETK) | (0.55) | 0.08 | 0.05 | (0.08) | 0.15 | NM | 84.0x | 148.9x | NM | 47.7x |
| Vastera (VAST) | (0.78) | (0.29) | (0.07) | 0.06 | 0.15 | NM | NM | NM | 81.0x | 32.5x |
| **SCT Group Average** | **$0.02** | **($0.21)** | **($0.22)** | **($0.01)** | **$0.28** | **32.0x** | **41.0x** | **58.1x** | **152.1x** | **35.0x** |
| **SCT Group Median** | **$0.08** | **($0.20)** | **($0.12)** | **($0.07)** | **$0.15** | **26.1x** | **30.4x** | **30.2x** | **81.0x** | **22.3x** |

| | EBITDA / Share [8] | | | | | Enterprise Value / EBITDA | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000-2004E | 2000 | 2001 | 2002 | 2003E | 2004E | 2000 Range | 2001 Range | 2002 | 2003E | 2004E |
| Agile Software (AGIL) [7] | ($0.35) | ($0.50) | ($0.45) | ($0.20) | ($0.04) | 1,201.8x-165.3x | NM | NM | NM | 70.5x |
| Aspen Technology (AZPN)[7] | $0.96 | ($0.22) | $0.25 | $0.86 | $0.93 | 55.5x-20.4x | NM | 20.1x | 5.6x | 5.2x |
| Descartes Systems (DSGX) [7] | (0.05) | (0.13) | (0.22) | (0.04) | 0.11 | NM | NM | NM | NM | 1.5x |
| EXE Technologies (EXEE) | 2.37 | (0.36) | (1.18) | (0.14) | 0.35 | 56.6x-20.0x | NM | 1.7x | 13.9x | NM |
| FreeMarkets, Inc. (FMKT) | (1.15) | 0.07 | 0.64 | 0.49 | 0.81 | NM | 335.2x-59.0x | 6.4x | 9.6x | 5.6x |
| i2 Technologies (ITWOE) | 0.41 | (0.47) | (0.26) | 0.09 | 0.14 | 268.3x-88.1x | NM | NM | 8.1x | 5.2x |
| JDA Software (JDAS) | 1.02 | 1.23 | 1.07 | 0.50 | 1.11 | 20.8x-6.8x | 16.8x-5.2x | 8.8x | 19.0x | 7.7x |
| Manhattan Associates (MANH) | 1.06 | 1.28 | 1.46 | 1.54 | 2.08 | 65.1x-5.0x | 31.0x-6.0x | 16.2x | 15.3x | 10.8x |
| Manugistics (MANU)[7] | 0.47 | (0.20) | (0.39) | 0.09 | 0.28 | 136.6x-23.9x | NM | NM | 68.7x | 19.5x |
| MatrixOne, Inc. (MONE) [7] | 0.01 | (0.15) | (0.38) | (0.14) | 0.17 | NM | NM | NM | NM | 9.9x |
| PTC (PMTC) [7] | 0.32 | 0.35 | 0.09 | 0.15 | 0.31 | 99.5x-19.4x | 42.4x-8.2x | 54.8x | 15.9x | 6.7x |
| Retek, Inc. (RETK) | (1.02) | 0.28 | 0.27 | 0.14 | 0.45 | NM | 166.5x-36.3x | 20.1x | 36.3x | 11.2x |
| Vastera (VAST) | (0.72) | (0.27) | 0.03 | 0.17 | 0.26 | NM | NM | 134.4x | 21.1x | 13.1x |
| **SCT Group Average** | **$0.26** | **$0.07** | **$0.07** | **$0.27** | **$0.54** | **NM** | **NM** | **32.8x** | **21.3x** | **13.9x** |
| **SCT Group Median** | **$0.32** | **($0.15)** | **$0.03** | **$0.14** | **$0.31** | **55.5x-6.8x** | **NM** | **18.1x** | **15.6x** | **8.8x** |

| | Price / Adjusted Earnings / Earnings Growth | | | | | Book Value / Share | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000-2004E | 2000 | 2001 | 2002 | 2003E | 2004E | 2000 | 2001 | 2002 | 2003E | 2004E |
| Agile Software (AGIL) [7] | NM | NM | NM | NM | NM | $7.7 | $6.3 | $5.5 | $5.0 | $4.9 |
| Aspen Technology (AZPN)[7] | NM | NM | NM | NM | 1.8x | 6.1 | 7.1 | 4.9 | 2.6 | 1.3 |
| Descartes Systems (DSGX) [7] | NM | NM | NM | NM | NM | 6.5 | 5.9 | 3.3 | 2.5 | 2.2 |
| EXE Technologies (EXEE) | NM | NM | NM | NM | NM | 15.4 | 8.2 | 4.6 | 4.2 | 4.1 |
| FreeMarkets, Inc. (FMKT) | NM | NM | NM | 22.4x | 1.1x | 11.2 | 3.8 | 3.5 | 2.7 | 2.5 |
| i2 Technologies (ITWOE) | 0.3x | NM | NM | NM | NM | 20.0 | 2.2 | (0.2) | (0.2) | (0.1) |
| JDA Software (JDAS) | 1.3x | 1.0x | 1.2x | 3.4x | 1.0x | 7.3 | 8.6 | 8.8 | 9.8 | 10.1 |
| Manhattan Associates (MANH) | 1.6x | 1.5x | 1.3x | 1.2x | 0.9x | 3.6 | 4.6 | 6.1 | 7.2 | 8.4 |
| Manugistics (MANU)[7] | NM | NM | NM | NM | NM | 6.3 | 5.6 | 2.9 | 1.9 | 1.3 |
| MatrixOne, Inc. (MONE) [7] | NM | NM | NM | NM | NM | 4.0 | 3.3 | 2.9 | 2.5 | 2.5 |
| PTC (PMTC) [7] | 1.4x | 1.1x | NM | NM | NM | 1.8 | 1.4 | 1.1 | 1.1 | 1.4 |
| Retek, Inc. (RETK) | NM | NM | 9.9x | NM | NM | 2.6 | 4.1 | 1.9 | 1.9 | 2.0 |
| Vastera (VAST) | NM | NM | NM | NM | 2.2x | 6.5 | 3.7 | 3.4 | 2.6 | 2.6 |
| **SCT Group Average** | **1.1x** | **1.2x** | **4.1x** | **9.0x** | **1.4x** | **$7.6** | **$5.0** | **$3.7** | **$3.4** | **$3.3** |
| **SCT Group Median** | **1.3x** | **1.1x** | **1.3x** | **3.4x** | **1.1x** | **$6.5** | **$4.6** | **$3.4** | **$2.6** | **$2.5** |

**Footnotes:**
(1) Adjusted EPS exclude effects of nonrecurring events and D&A expense.
(2) Excludes impacts of nonrecurring events and D&A expense.
(3) Estimated average diluted share count for the current quarter.
(4) Average daily trading volume over past 52 weeks.
(5) Shares short as a percent of float.
(6) Based on current market price and historical earnings for the period and estimated average diluted share counts for the current quarter; based on First Call adjusted EPS estimates.
(7) DSGX reports fiscal January, MANU fiscal February, AGIL fiscal April, MONE fiscal June, AZPN fiscal June, PMTC fiscal September.
(8) Values calendarized for DSGX, MANU, AGIL, MONE, AZPN and PMTC.
(9) Adjustments to net income include amortization of intangibles, amortization of stock-based compensation, in-process R&D, net gains (losses) on investments, and restructuring charges.
(10) With forward projections of operating losses and a net debt position, we do not have a target price for MANU.

Note: All price targets are for calendar year-end 2003.

Source: Bear, Stearns & Co. Inc. estimates.

## Exhibit 23. Bear Stearns Supply-Chain Technology/Application Software Universe — Comparative Financial Metrics, 2000-04E

**COMPOUND ANNUAL GROWTH RATES 2000-2004E [2]**

| | Revenue | EBITDA | EPS [8] |
|---|---|---|---|
| Agile Software (AGIL) [4] | 9.5% | -10.0% | NM |
| Aspen Technology (AZPN) [4] | 3.0% | 9.0% | NM |
| Descartes Systems (DSGX) [4] | NM | NM | NM |
| EXE Technologies (EXEE) | NM | NM | NM |
| FreeMarkets, Inc. (FMKT) | 16.3% | NM | NM |
| i2 Technologies (ITWOE) | NM | NM | NM |
| JDA Software (JDAS) | 5.9% | 8.3% | 6.8% |
| Manhattan Associates (MANH) | 16.1% | 19.9% | 26.9% |
| Manugistics (MANU) [8] | 2.0% | NM | 0.1% |
| MatrixOne, Inc. (MONE) [4] | 6.3% | NM | 24.5% |
| PTC (PMTC) [8] | NM | 6.0% | 14.4% |
| Retek, Inc. (RETK) | 15.8% | NM | NM |
| Vastera (VAST) | 29.6% | NM | NM |
| **SCT Group Average** | **11.6%** | **6.7%** | **14.5%** |

**GROSS MARGIN**

| 2001-2004E | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|
| Agile Software (AGIL) [4] | 80.3% | 71.0% | 72.6% | 74.4% |
| Aspen Technology (AZPN) [4] | 58.8% | 61.1% | 64.1% | 63.3% |
| Descartes Systems (DSGX) [8] | 65.3% | 62.4% | 65.5% | 69.0% |
| EXE Technologies (EXEE) | 46.4% | 40.1% | 41.2% | 41.5% |
| FreeMarkets, Inc. (FMKT) | 52.8% | 58.1% | 54.5% | 59.8% |
| i2 Technologies (ITWOE) | 61.3% | 54.5% | 61.3% | 62.5% |
| JDA Software (JDAS) | 57.7% | 60.0% | 56.1% | 59.8% |
| Manhattan Associates (MANH) | 58.4% | 61.0% | 60.8% | 62.5% |
| Manugistics (MANU) [4] | 63.7% | 54.7% | 55.7% | 57.7% |
| MatrixOne, Inc. (MONE) [8] | 54.9% | 54.0% | 53.6% | 58.3% |
| PTC (PMTC) [4] | 71.5% | 70.5% | 70.6% | 72.6% |
| Retek, Inc. (RETK) | 61.8% | 59.1% | 51.5% | 60.3% |
| Vastera (VAST) | 47.5% | 47.0% | 45.7% | 49.7% |
| **SCT Group Average** | **60%** | **58%** | **58%** | **61%** |

**RETURN ON AVERAGE EQUITY**

| 2000-2004E | 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|
| Agile Software (AGIL) [4] | -1.9% | -6.3% | -8.3% | -3.7% | 1.8% |
| Aspen Technology (AZPN) [4] | 1.1% | -7.3% | -7.7% | 2.7% | 8.5% |
| Descartes Systems (DSGX) [4] | -1.8% | -1.0% | -2.6% | -3.4% | 1.6% |
| EXE Technologies (EXEE) | 7.5% | -18.5% | -28.1% | -11.0% | 6.5% |
| FreeMarkets, Inc. (FMKT) | -13.8% | -4.8% | 7.7% | 0.5% | 13.2% |
| i2 Technologies (ITWOE) | 2.7% | -2.8% | -37.9% | 4.7% | -41.1% |
| JDA Software (JDAS) | 7.5% | 8.5% | 9.2% | 2.5% | 6.8% |
| Manhattan Associates (MANH) | 22.1% | 17.7% | 15.8% | 13.5% | 16.4% |
| Manugistics (MANU) [8] | 0.8% | -2.9% | -16.5% | -8.7% | 6.2% |
| MatrixOne, Inc. (MONE) [4] | 1.9% | -3.0% | -13.6% | -7.3% | 3.7% |
| PTC (PMTC) [8] | 7.3% | 8.2% | -6.3% | -7.1% | 14.5% |
| Retek, Inc. (RETK) | -21.0% | 2.5% | 1.6% | -4.1% | 7.6% |
| Vastera (VAST) | -24.5% | -7.4% | -1.9% | 2.1% | 6.0% |
| **SCT Group Average** | **-0.9%** | **-1.3%** | **-6.8%** | **-1.5%** | **4.0%** |

**ADJUSTED OPERATING MARGIN [6]**

| 2001-2004E | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|
| Agile Software (AGIL) [4] | -30.7% | -55.9% | -15.3% | -6.2% |
| Aspen Technology (AZPN) [4] | -9.9% | -8.2% | 3.1% | 2.3% |
| Descartes Systems (DSGX) [8] | -16.4% | -20.1% | -5.5% | 7.7% |
| EXE Technologies (EXEE) | -14.7% | -18.2% | -5.5% | 1.2% |
| FreeMarkets, Inc. (FMKT) | -9.3% | 5.1% | -1.1% | 6.1% |
| i2 Technologies (ITWOE) | -24.0% | -29.3% | 3.8% | 8.5% |
| JDA Software (JDAS) | 11.2% | 10.4% | 3.5% | 12.8% |
| Manhattan Associates (MANH) | 20.7% | 21.8% | 19.6% | 23.0% |
| Manugistics (MANU) [4] | -6.2% | -14.0% | -2.1% | 4.3% |
| MatrixOne, Inc. (MONE) [8] | -9.9% | -14.7% | -12.1% | 3.0% |
| PTC (PMTC) [4] | 6.1% | -3.4% | 0.8% | 8.7% |
| Retek, Inc. (RETK) | 2.6% | 0.9% | -5.8% | 5.1% |
| Vastera (VAST) | -20.4% | -4.6% | 2.0% | 5.6% |
| **SCT Group Average** | **-7.8%** | **-10.0%** | **-1.1%** | **6.3%** |

**RETURN ON AVERAGE TOTAL CAPITAL**

| 2000-2004E | 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|
| Agile Software (AGIL) [4] | -1.9% | -6.3% | -8.3% | -3.7% | 1.8% |
| Aspen Technology (AZPN) [4] | 0.7% | -5.1% | -5.4% | 1.3% | 4.7% |
| Descartes Systems (DSGX) [4] | -4.1% | -2.4% | -2.7% | -1.2% | 2.4% |
| EXE Technologies (EXEE) | 10.8% | -17.6% | -17.5% | -1.4% | 3.7% |
| FreeMarkets, Inc. (FMKT) | -13.6% | -4.7% | 7.5% | 0.5% | 12.9% |
| i2 Technologies (ITWOE) | 2.5% | -2.5% | -18.7% | -1.6% | 11.0% |
| JDA Software (JDAS) | 7.5% | 8.5% | 9.2% | 2.5% | 6.8% |
| Manhattan Associates (MANH) | 19.2% | 15.9% | 14.4% | 12.5% | 15.0% |
| Manugistics (MANU) [8] | 0.2% | -1.8% | -8.7% | -3.7% | 1.9% |
| MatrixOne, Inc. (MONE) [4] | 1.9% | -3.0% | -13.6% | -7.3% | 3.7% |
| PTC (PMTC) [8] | 7.3% | 8.2% | -6.3% | -7.1% | 14.5% |
| Retek, Inc. (RETK) | -20.5% | 1.8% | 0.7% | -5.7% | 5.0% |
| Vastera (VAST) | -16.0% | -2.5% | -2.0% | -0.1% | 1.0% |
| **SCT Group Average** | **-0.5%** | **-0.9%** | **-3.9%** | **-1.2%** | **6.5%** |

**LICENSE REVENUE AS A PERCENTAGE OF TOTAL REVENUE**

| 2001-2004E | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|
| Agile Software (AGIL) [4] | 67.4% | 43.2% | 44.4% | 47.0% |
| Aspen Technology (AZPN) [4] | 41.5% | 43.1% | 43.8% | 42.3% |
| Descartes Systems (DSGX) [4] [7] | 84.0% | 84.3% | 79.0% | 79.2% |
| EXE Technologies (EXEE) | 24.8% | 17.1% | 19.4% | 20.0% |
| FreeMarkets, Inc. (FMKT) [9] | NM | NM | NM | NM |
| i2 Technologies (ITWOE) | 45.2% | 29.0% | 29.4% | 31.4% |
| JDA Software (JDAS) | 33.3% | 30.4% | 24.7% | 30.1% |
| Manhattan Associates (MANH) | 22.1% | 23.2% | 23.3% | 24.9% |
| Manugistics (MANU) [4] | 43.0% | 30.1% | 30.5% | 34.4% |
| MatrixOne, Inc. (MONE) [8] | 46.8% | 42.0% | 36.1% | 45.6% |
| PTC (PMTC) [4] | 38.4% | 32.0% | 32.1% | 32.7% |
| Retek, Inc. (RETK) [10] | 73.4% | 69.1% | 57.5% | 72.5% |
| Vastera (VAST) | 20.7% | 16.4% | 13.6% | 13.9% |
| **SCT Group Average** | **45.0%** | **38.3%** | **36.2%** | **39.5%** |

**FREE CASH FLOW RETURN ON AVG. TOTAL CAPITAL [3]**

| 2000-2004E | 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|
| Agile Software (AGIL) [4] | -16.5% | -14.3% | -11.4% | -5.3% | 1.1% |
| Aspen Technology (AZPN) [4] | -7.7% | -27.2% | -18.6% | 3.7% | 9.7% |
| Descartes Systems (DSGX) [4] | -4.5% | -3.2% | 27.2% | -1.3% | -1.0% |
| EXE Technologies (EXEE) | 10.8% | -17.6% | -17.5% | -1.4% | 3.7% |
| FreeMarkets, Inc. (FMKT) | -24.7% | -7.6% | 16.9% | 9.9% | 23.3% |
| i2 Technologies (ITWOE) | 2.5% | -2.3% | -38.6% | -23.0% | 13.6% |
| JDA Software (JDAS) | 9.3% | 10.1% | 4.1% | 2.4% | 6.7% |
| Manhattan Associates (MANH) | 19.5% | 16.1% | -6.5% | 13.5% | 16.5% |
| Manugistics (MANU) [8] | -1.4% | -10.4% | -29.6% | -10.5% | 0.6% |
| MatrixOne, Inc. (MONE) [4] | -5.3% | -9.4% | -20.2% | -12.5% | 0.8% |
| PTC (PMTC) [8] | 4.1% | -3.0% | -16.3% | -10.8% | 15.9% |
| Retek, Inc. (RETK) | -56.5% | -17.1% | -17.2% | 15.2% | 22.5% |
| Vastera (VAST) | -16.0% | -2.5% | -2.0% | -0.1% | 1.0% |
| **SCT Group Average** | **-6.6%** | **-6.8%** | **-10.0%** | **-1.5%** | **8.8%** |

**LICENSE REVENUE / SALES AND MARKETING EXPENSE**

| 2001-2004E | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|
| Agile Software (AGIL) [4] | 1.01x | 0.61x | 0.89x | 1.07x |
| Aspen Technology (AZPN) [4] | 1.15x | 1.21x | 1.42x | 1.35x |
| Descartes Systems (DSGX) [4] [7] | 2.27x | 2.01x | 1.98x | 2.27x |
| EXE Technologies (EXEE) | 0.89x | 0.66x | 0.94x | 1.13x |
| FreeMarkets, Inc. (FMKT) [10] | NM | NM | NM | NM |
| i2 Technologies (ITWOE) | 0.98x | 0.80x | 1.30x | 1.43x |
| JDA Software (JDAS) | 1.87x | 1.67x | 1.36x | 1.83x |
| Manhattan Associates (MANH) | 1.59x | 1.52x | 1.50x | 1.66x |
| Manugistics (MANU) [4] | 1.10x | 0.84x | 1.05x | 1.27x |
| MatrixOne, Inc. (MONE) [8] | 1.20x | 1.13x | 1.07x | 1.57x |
| PTC (PMTC) [4] | 0.92x | 0.70x | 0.72x | 0.79x |
| Retek, Inc. (RETK) | 2.52x | 2.60x | 2.34x | 2.99x |
| Vastera (VAST) | 0.76x | 1.05x | 1.20x | 1.03x |
| **SCT Group Average** | **1.36x** | **1.23x** | **1.31x** | **1.53x** |

**CASH FLOW FROM OPERATIONS (MM)**

| 2000-2004E | 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|
| Agile Software (AGIL) [4] | ($6.0) | ($10.6) | ($20.1) | ($4.1) | $10.4 |
| Aspen Technology (AZPN) [4] | 7.3 | (10.8) | 4.2 | 31.2 | 46.2 |
| Descartes Systems (DSGX) [4] | (7.8) | (15.1) | (16.7) | (18.6) | (6.2) |
| EXE Technologies (EXEE) | 0.5 | (9.7) | (6.1) | 6.3 | 10.0 |
| FreeMarkets, Inc. (FMKT) | (40.2) | (14.7) | 21.3 | 9.2 | 22.3 |
| i2 Technologies (ITWOE) | 192.0 | (48.0) | (297.4) | (34.8) | 56.0 |
| JDA Software (JDAS) | 8.9 | 29.4 | 41.5 | 19.0 | 27.2 |
| Manhattan Associates (MANH) | 36.4 | 39.4 | 46.0 | 46.6 | 54.5 |
| Manugistics (MANU) [8] | 15.0 | (10.7) | (126.8) | (28.1) | 12.7 |
| MatrixOne, Inc. (MONE) [4] | 8.5 | (1.7) | (14.2) | (3.2) | 14.1 |
| PTC (PMTC) [8] | 51.7 | 32.7 | (21.6) | 5.2 | 79.3 |
| Retek, Inc. (RETK) | 6.4 | 23.6 | (2.3) | 20.2 | 26.8 |
| Vastera (VAST) | (19.7) | (18.3) | (4.7) | 8.5 | 12.2 |
| **SCT Group Average** | **$19.5** | **($1.1)** | **($30.5)** | **$4.4** | **$28.1** |

**TOTAL REVENUE/ SALES AND MARKETING EXPENSE**

| 2001-2004E | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|
| Agile Software (AGIL) [4] | 1.51x | 1.41x | 2.00x | 2.27x |
| Aspen Technology (AZPN) [4] | 2.77x | 2.82x | 3.24x | 3.20x |
| Descartes Systems (DSGX) [4] [7] | 2.66x | 2.38x | 2.56x | 2.86x |
| EXE Technologies (EXEE) | 3.57x | 3.87x | 4.85x | 5.63x |
| FreeMarkets, Inc. (FMKT) [10] | 3.25x | 3.98x | 4.09x | 4.13x |
| i2 Technologies (ITWOE) | 2.17x | 2.76x | 4.43x | 4.55x |
| JDA Software (JDAS) | 5.63x | 5.51x | 5.50x | 6.06x |
| Manhattan Associates (MANH) | 7.20x | 6.57x | 6.43x | 6.67x |
| Manugistics (MANU) [4] | 2.55x | 2.80x | 3.43x | 3.69x |
| MatrixOne, Inc. (MONE) [8] | 2.58x | 2.69x | 2.98x | 3.45x |
| PTC (PMTC) [4] | 2.41x | 2.18x | 2.25x | 2.43x |
| Retek, Inc. (RETK) | 3.43x | 3.77x | 4.08x | 4.12x |
| Vastera (VAST) | 3.65x | 6.38x | 8.83x | 7.46x |
| **SCT Group Average** | **3.34x** | **3.62x** | **4.20x** | **4.35x** |

**EBITDA (MM)**

| 2000-2004E | 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|
| Agile Software (AGIL) [4] | 3.8 | (18.9) | (29.7) | (8.2) | 2.5 |
| Aspen Technology(AZPN) | 29.6 | (6.9) | 10.8 | 38.5 | 41.9 |
| Descartes Systems (DSGX) [4] | (1.8) | (6.6) | (11.4) | (1.9) | 6.2 |
| EXE Technologies (EXEE) | 13.3 | (2.3) | (7.8) | (0.9) | 2.5 |
| FreeMarkets, Inc. (FMKT) | (42.6) | 2.9 | 28.7 | 19.3 | 33.1 |
| i2 Technologies (ITWOE) | 171.8 | (194.7) | (111.0) | 40.6 | 63.1 |
| JDA Software (JDAS) | 25.8 | 32.0 | 31.0 | 14.4 | 35.6 |
| Manhattan Associates (MANH) | 32.4 | 39.3 | 44.5 | 47.2 | 66.9 |
| Manugistics (MANU) [8] | 28.5 | (14.3) | (27.5) | 6.6 | 23.4 |
| MatrixOne, Inc. (MONE) [4] | (1.4) | (10.3) | (13.4) | (7.4) | 10.6 |
| PTC (PMTC) [8] | 81.7 | 92.8 | 12.6 | 43.4 | 103.3 |
| Retek, Inc. (RETK) | (48.0) | 13.9 | 14.0 | 7.7 | 25.1 |
| Vastera (VAST) | (17.7) | (10.3) | 1.1 | 7.0 | 11.3 |
| **SCT Group Average** | **21.2** | **(6.4)** | **(4.5)** | **15.9** | **32.7** |

**DEBT RATIO [2]**

| 2001-2004E | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|
| Agile Software (AGIL) [4] | 0.0% | 0.0% | 0.0% | 0.0% |
| Aspen Technology (AZPN) [4] | 29.4% | 37.2% | 45.7% | 43.6% |
| Descartes Systems (DSGX) [8] | 19.9% | 30.3% | 35.4% | 37.5% |
| EXE Technologies (EXEE) | 2.6% | 3.0% | 3.2% | 3.2% |
| FreeMarkets, Inc. (FMKT) | 2.9% | 1.8% | 2.6% | 2.7% |
| i2 Technologies (ITWOE) | 31.5% | 131.0% | 139.8% | 116.1% |
| JDA Software (JDAS) | 0.0% | 0.0% | 0.0% | 0.0% |
| Manhattan Associates (MANH) | 4.0% | 0.2% | 0.1% | 0.1% |
| Manugistics (MANU) [4] | 39.3% | 56.1% | 65.2% | 70.3% |
| MatrixOne, Inc. (MONE) [8] | 0.0% | 0.0% | 0.0% | 0.0% |
| PTC (PMTC) [4] | 0.0% | 0.0% | 0.0% | 0.0% |
| Retek, Inc. (RETK) | 0.1% | 0.2% | 0.2% | 0.1% |
| Vastera (VAST) | 3.2% | 2.3% | 2.9% | 2.8% |
| **SCT Group Average** | **10.2%** | **20.2%** | **22.7%** | **21.3%** |

**Footnotes:**
(1) Adjusted EPS, which exclude noncash, nonrecurring items.
(2) Debt ratio defined as total debt/total debt + equity (%).
(3) Gross cash flow - capex/average total debt and equity. Gross CF = net income + depreciation + amortization + deferred income taxes.
(4) DSGX reports fiscal January, MANU fiscal February, AGIL fiscal April, MONE fiscal June, AZPN fiscal June, PMTC fiscal September.
(5) Based on calendarized values.
(6) Adjusted operating margin excludes amortization expenses and other nonrecurring charges.
(7) Includes license and network revenues.
(8) RETK reports a combined software license and maintenance figure.
(9) Currently, software license revenue is not broken out from total revenue at FMKT.
(10) FMKT does not break out license revenue.

Source: Bear, Stearns & Co. Inc. estimates.

## Exhibit 24. Bear Stearns Airfreight Universe — EPS and Book Value Multiples, 2000-04E

| SECTOR RATING: Market Overweight | Price ($) 6/2/03 | 52-Week High | 52-Week Low | Share Count (MM) [9] | Market Cap (MM) | BSC Stock Rating | Rating Since (U/D) [6] | Target Price | Annual Dividend | Dividend Yield (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Non-Asset Based** | | | | | | | | | | |
| C.H. Robinson Worldwide (CHRW) | $37.05 | $38.76 | $25.83 | 85.6 | $3,172 | Peer Perform | 10/2/00 (D) | $34 | $0.32 | 0.9% |
| EGL Inc. (EAGL) | $15.39 | $17.31 | $9.18 | 53.0 | 816 | NR | 9/20/01 (S) | -- | Nil | Nil |
| Expeditors International (EXPD) | $34.87 | $38.00 | $24.94 | 109.7 | 3,824 | Underperform | 10/16/02 (D) | 32 | 0.16 | 0.5% |
| Forward Air Corp. (FWRD) | $24.95 | $32.88 | $16.40 | 21.7 | 543 | Outperform | 4/25/03 (U) | 27 | Nil | Nil |
| Pacer International (PACR) | $18.55 | $19.00 | $9.11 | 37.4 | 694 | Outperform | 7/8/02 | 21 | Nil | Nil |
| UTi (UTIW) | $33.08 | $32.07 | $15.70 | 30.5 | 1,008 | Outperform | 9/5/2002 (U) | 37 | 0.10 | 0.3% |
| **Asset-Based** | | | | | | | | | | |
| Airborne Freight Corp. (ABF) | $20.41 | $23.20 | $10.29 | 48.5 | $990 | Peer Perform | 3/24/03 (U) | $20 | 0.16 | 0.8% |
| Atlas Air Inc. (CGO) | $1.55 | $9.25 | $0.50 | 38.2 | 59 | Underperform | 11/19/01 (D) | -- | --- | Nil |
| FedEx Corp. (FDX) | $64.61 | $64.35 | $42.75 | 302.8 | 19,562 | Peer Perform | 11/3/00 (D) | 59 | 0.20 | 0.3% |
| TPG N.V. (TP) [1] | $17.32 | $22.72 | $13.10 | 475.0 | 8,227 | Outperform | 1/16/02 (U) | 28 | 0.54 | 3.1% |
| United Parcel Service (UPS) | $62.96 | $67.10 | $53.00 | 1,137.5 | 71,617 | Outperform | 5/31/02 (U) | 78 | 0.84 | 1.3% |
| **S&P 500** | **967.00** | **1,079.83** | **768.67** | **-** | **-** | **-** | **-** | **950.0** | **17.50** | **1.8%** |

| Absolute Estimates 1999-2003E | Earnings / Share 2000 | 2001 | 2002 | 2003E | 2004E | Book Value / Share 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|---|---|---|---|---|
| **Non-Asset Based** | | | | | | | | | | |
| C.H. Robinson Worldwide (CHRW) | $0.83 | $0.98 | $1.15 | $1.35 | $1.51 | $3.47 | $4.15 | $4.97 | $5.92 | $6.89 |
| EGL Inc. (EAGL) [2] | 1.23 | (0.62) | 0.24 | 0.65 | 0.86 | 8.47 | 7.64 | 7.88 | 7.57 | 8.38 |
| Expeditors International (EXPD) | 0.76 | 0.92 | 1.02 | 1.19 | 1.35 | 3.30 | 3.78 | 4.80 | 5.55 | 6.57 |
| Forward Air Corp. (FWRD) | 1.05 | 0.89 | 0.92 | 1.07 | 1.25 | 3.75 | 4.79 | 5.36 | 6.52 | 7.74 |
| Pacer International (PACR) | 0.75 | 0.40 | 0.75 | 0.96 | 1.15 | NM | 0.11 | 5.38 | 5.60 | 6.75 |
| UTi (UTIW) [8] | 0.88 | 0.75 | 1.11 | 1.29 | 1.48 | 8.91 | 7.07 | 12.23 | 11.47 | 12.43 |
| **Asset-Based** | | | | | | | | | | |
| Airborne, Inc. (ABF) | $0.27 | ($0.57) | $0.37 | $0.35 | $0.89 | $17.70 | $17.34 | $17.30 | $17.88 | $18.53 |
| Atlas Air Inc. (CGO) | 2.31 | 0.56 | (1.07) | 0.00 | 0.32 | 14.95 | 12.81 | 11.56 | 11.56 | 11.88 |
| FedEx Corp. (FDX) [3] | 2.43 | 1.94 | 2.50 | 2.91 | 3.73 | 20.12 | 21.60 | 24.12 | 26.65 | 30.30 |
| TPG N.V. (TP) | 0.89 | 1.05 | 1.19 | 1.31 | 1.49 | 4.36 | 4.66 | 5.80 | 7.34 | 8.55 |
| United Parcel Service (UPS) | 2.38 | 2.10 | 2.14 | 2.42 | 2.90 | 8.29 | 8.96 | 10.99 | 12.44 | 14.48 |
| **S&P 500** | **55.12** | **45.16** | **47.94** | **50.00** | **54.00** | **264.30** | **301.92** | **329.58** | **360.02** | **392.52** |

| Price / Earnings 2000-2003E | Absolute P/E Multiples [7] 2000 Range | 2001 Range | 2002 Range | 2003E | 2004E | Relative P/E Multiples [4] 2000 Range | 2001 Range | 2002 Range | 2003E | 2004E |
|---|---|---|---|---|---|---|---|---|---|---|
| **Non-Asset Based** | | | | | | | | | | |
| C.H. Robinson Worldwide (CHRW) | 33.5x-23.7x | 31.5x-23.0x | 30.2x-21.7x | 27.5x | 24.5x | 1.2x-1.0x | 1.1x-1.1x | 1.0x-1.2x | 1.42x | 1.37x |
| EGL Inc. (EAGL) [5] | NM | 56.2x-13.2x | 32.2x-14.8x | 23.7x | 17.8x | NM | 1.9x-0.6x | 1.1x-0.8x | NM | 0.99x |
| Expeditors International (EXPD) | 33.1x-24.8x | 31.4x-21.9x | 31.1x-23.8x | 29.4x | 25.9x | 1.2x-1.1x | 1.0x-1.1x | 1.1x-1.3x | 1.52x | 1.44x |
| Forward Air Corp. (FWRD) | 35.0x-19.4x | 31.0x-18.9x | 31.3x-15.4x | 23.2x | 20.0x | 1.3x-0.9x | 1.0x-0.9x | 1.1x-0.8x | 1.20x | 1.12x |
| Pacer International (PACR) | NA | NA | 21.2x-12.9x | 19.4x | 16.2x | NA | NA | 0.7x-0.7x | 1.00x | 0.90x |
| UTi (UTIW) [8] | NA | 20.3x-13.0x | 23.4x-15.4x | 25.7x | 22.4x | NA | 0.7x-0.6x | 0.8x-0.8x | 1.33x | 1.25x |
| **Group Average** | **33.9x-22.6x** | **34.1x-18.0x** | **28.2x-17.3x** | **24.8x** | **21.1x** | **1.2x-1.0x** | **1.1x-0.9x** | **1.0x-0.9x** | **1.30x** | **1.18x** |
| **Asset-Based** | | | | **8.4%** | **2.5%** | | | | | |
| Airborne Freight Corp. (ABF) | 15.5x-8.6x | NM | 25.7x-15.9x | NM | NM | 0.6x-0.4x | NM | NM | NM | NM |
| Atlas Air Inc. (CGO) | 18.4x-10.6x | 17.0x-8.1x | NM | NM | NM | 0.7x-0.5x | 0.6x-0.4x | NM | NM | NM |
| FedEx Corp. (FDX) | 21.2x-12.1x | 19.7x-14.3x | 24.8x-14.7x | 22.2x | 17.3x | 0.8x-0.5x | 0.7x-0.7x | 0.9x-0.8x | 1.15x | 0.97x |
| TPG N.V. (TP) | 28.8x-19.1x | 21.7x-13.4x | 17.6x-11.1x | 13.3x | 11.6x | 1.0x-0.8x | 0.7x-0.7x | 0.6x-0.6x | 0.69x | 0.65x |
| United Parcel Service (UPS) | 29.5x-20.4x | 24.7x-20.5x | 27.4x-24.4x | 26.1x | 21.7x | 1.1x-0.9x | 0.8x-1.0x | 0.9x-1.3x | 1.35x | 1.21x |
| **Group Average** | **22.7x-14.2x** | **20.8x-14.1x** | **23.9x-16.5x** | **20.5x** | **16.9x** | **0.8x-0.6x** | **0.7x-0.7x** | **0.8x-0.9x** | **1.06x** | **0.94x** |
| **Universe Average** | **26.9x-17.3x** | **28.2x-16.3x** | **26.5x-17.0x** | **23.4x** | **19.7x** | **1.0x-0.8x** | **0.9x-0.8x** | **0.9x-0.9x** | **1.21x** | **1.10x** |
| **S&P 500** | **28.0x-22.7x** | **29.9x-20.5x** | **29.1x-18.6x** | **19.3x** | **17.9x** | **NM** | **NM** | **NM** | **NM** | **NM** |

| 2000-2003E | Enterprise Value/EBITDA [10, 11] 2000 Range | 2001 Range | 2002E Range | 2003E | 2004E | Price / Book Value 2000 Range | 2001 Range | 2002 Range | 2003E | 2004E |
|---|---|---|---|---|---|---|---|---|---|---|
| **Non-Asset Based** | | | | | | | | | | |
| C.H. Robinson Worldwide (CHRW) | 20.1x-10.6x | 17.1x-12.4x | 16.4x-12.0x | 15.1x | 13.4x | 9.4x-5.1x | 7.7x-5.7x | 7.1x-5.3x | 6.3x | 5.4x |
| EGL Inc. (EAGL) [9] | 18.4x-8.1x | NM | 15.7x-7.7x | 8.3x | 7.0x | 5.5x-2.4x | 4.0x-1.1x | 2.4x-1.2x | 2.0x | 1.8x |
| Expeditors International (EXPD) | 20.4x-10.8x | 19.4x-12.5x | 18.2x-13.2x | 16.4x | 14.1x | 8.9x-4.9x | 8.6x-5.7x | 7.1x-5.3x | 6.3x | 5.3x |
| Forward Air Corp. (FWRD) | 24.5x-10.0x | 23.6x-11.4x | 19.0x-8.5x | 11.5x | 10.1x | 12.8x-5.3x | 9.0x-4.4x | 6.6x-3.1x | 3.8x | 3.2x |
| Pacer International (PACR) | NA | NA | 10.3x-7.7x | 10.4x | 9.5x | NA | NM | NM | 3.3x | 2.7x |
| UTi (UTIW) [8] | NA | 10.6x-5.9x | 13.9x-8.0x | 12.1x | 10.5x | NA | 2.8x-1.6x | 2.1x-1.3x | 2.9x | 2.7x |
| **Group Average** | **20.9x-9.9x** | **17.7x-10.5x** | **15.6x-9.5x** | **12.3x** | **10.8x** | **9.1x-4.4x** | **6.4x-3.7x** | **4.7x-3.0x** | **4.1x** | **3.5x** |
| **Asset-Based** | | | | | | | | | | |
| Airborne Freight Corp. (ABF) | 7.3x-4.0x | 6.1x-4.3x | 5.7x-3.3x | 4.1x | 3.4x | 1.4x-0.5x | 0.9x-0.5x | 1.3x-0.6x | 1.1x | 1.1x |
| Atlas Air Inc. (CGO) | 11.2x-8.6x | 20.9x-14.6x | 34.1x-27.3x | nm | nm | 3.1x-1.5x | 2.9x-0.7x | 1.5x-0.1x | 0.1x | 0.1x |
| FedEx Corp. (FDX) | 10.2x-7.9x | 11.3x-8.9x | 10.7x-8.6x | 10.5x | 9.5x | 2.5x-1.5x | 2.5x-1.6x | 2.5x-1.8x | 2.4x | 2.1x |
| TPG N.V. (TP) | 35.3x-25.8x | 27.6x-21.3x | 7.9x-5.3x | 6.2x | 5.9x | 7.1x-4.5x | 5.7x-3.6x | 3.9x-2.7x | 2.4x | 2.0x |
| United Parcel Service (UPS) | 15.1x-11.2x | 14.4x-11.4x | 14.5x-11.9x | 12.6x | 11.1x | 8.3x-6.1x | 6.9x-5.4x | 6.1x-5.0x | 5.1x | 4.3x |
| **Group Average** | **15.8x-11.5x** | **16.0x-12.1x** | **14.6x-11.3x** | **8.3x** | **7.4x** | **4.5x-2.8x** | **3.8x-2.3x** | **3.1x-2.0x** | **2.2x** | **1.9x** |
| **Universe Average** | **18.1x-10.8x** | **16.8x-11.4x** | **15.1x-10.3x** | **10.7x** | **9.4x** | **6.6x-3.5x** | **5.1x-3.0x** | **4.0x-2.6x** | **3.2x** | **2.8x** |

**Footnotes:**
(1) TP price and EPS based on NYSE ADR's in US dollars. Price target in $US based on Euro 30 price target converted at current exchange rate.
(2) EGL Inc. earnings model numbers are calendarized from 1999 forward.
(3) FedEx Corp earnings model numbers are calendarized.
(4) Multiples are relative to S&P 500 Average.
(5) Most recently reported (quarterly basis) fully diluted share count.
(6) Date of last rating change along with direction of change (U=upgrade, D=downgrade, S=suspended coverage).
(7) Historical P/E multiples represent blended forward P/E estimates.
(8) Continuing U.S. GAAP estimates include eff. tax rates for F00-F02 of 8.4%, 22.9% and 28.0%. Assuming a 30% eff. tax rate, pro forma EPS would be $0.69, $0.83 and $0.96 for the same time period.
(9) For EAGL, 2000 Hi/Lo stock prices based on 10/2/00 - 12/31/00 date range (post Circle merger close) as multiple calculations are based on pro forma C00 EPS of $1.23.
(10) Enterprise Value defined as market cap plus net debt minus cash and cash equivalents.
(11) Balance Sheet and Cash Flow figures for FedEx and UTi are FYE numbers.

Note: All price targets are for calendar year-end 2003.

Source: Company reports; Bear, Stearns & Co. Inc. estimates.

## Exhibit 25. Bear Stearns Airfreight Universe — Comparative Financial Returns, 2000-04E

**COMPOUND ANNUAL GROWTH RATES 2001-2004E**

| | Gross Revenue | Op. Inc. | EPS |
|---|---|---|---|
| **Non-Asset Based** | | | |
| C.H. Robinson Worldwide | 10.3% | 15.9% | 15.5% |
| EGL Inc. | NM | NM | NM |
| Expeditors International | 17.5% | 15.2% | 13.6% |
| Forward Air Corp. | 5.1% | 9.9% | 11.8% |
| Pacer International | 3.8% | 15.4% | 42.6% |
| UTi [8,9] | 23.0% | 29.7% | 25.1% |
| **Group Average** | **11.9%** | **17.2%** | **21.7%** |
| **Asset-Based** | | | |
| Airborne Freight Corp. | 5.5% | NM | NM |
| Atlas Air Inc. (CGO) | 18.6% | 2.3% | NM |
| FedEx Corp. [4] | 6.7% | 21.0% | 24.4% |
| TPG N.V. | 9.6% | 11.2% | 10.1% |
| United Parcel Service | 6.5% | 9.4% | 11.3% |
| **Group Average** | **9.4%** | **11.0%** | **15.3%** |
| **Universe Average** | **10.7%** | **14.4%** | **19.3%** |

**PRETAX RETURN ON ASSETS**

| | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|
| **Non-Asset Based** | | | | |
| C.H. Robinson Worldwide | 19.6% | 20.7% | 20.9% | 20.1% |
| EGL Inc. | -4.6% | 3.1% | 7.3% | 8.6% |
| Expeditors International | 22.2% | 21.8% | 20.6% | 20.5% |
| Forward Air Corp. | 25.0% | 22.5% | 23.2% | 23.0% |
| Pacer International | 2.6% | 6.8% | 9.7% | 11.7% |
| UTi [8] | 7.0% | 8.8% | 8.7% | 8.8% |
| **Group Average** | **12.0%** | **14.0%** | **15.1%** | **15.5%** |
| **Asset-Based** | | | | |
| Airborne Freight Corp. | -1.3% | 3.5% | 5.0% | 5.7% |
| Atlas Air Inc. (CGO) | 8.9% | 0.6% | 8.5% | 11.2% |
| FedEx Corp. [4] | 9.6% | 8.7% | 10.0% | 11.4% |
| TPG N.V. | 12.7% | 12.7% | 12.4% | 13.1% |
| United Parcel Service | 17.0% | 15.7% | 16.3% | 18.2% |
| **Group Average** | **9.4%** | **8.2%** | **10.4%** | **11.9%** |
| **Universe Average** | **10.8%** | **11.4%** | **13.0%** | **13.9%** |

**RETURN ON AVERAGE EQUITY**

| | 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|
| **Non-Asset Based** | | | | | |
| C.H. Robinson Worldwide | 24.0% | 23.6% | 23.2% | 22.7% | 21.9% |
| EGL Inc. | 14.2% | -7.7% | 3.2% | 8.9% | 10.7% |
| Expeditors International | 25.8% | 26.0% | 23.7% | 23.0% | 22.2% |
| Forward Air Corp. | 33.9% | 20.9% | 18.2% | 18.0% | 17.6% |
| Pacer International | NM | NM | 24.2% | 18.3% | 18.6% |
| UTi [8,110] | 12.6% | 10.4% | 11.6% | 11.6% | 12.4% |
| **Group Average** | **22.1%** | **14.6%** | **17.3%** | **17.1%** | **17.2%** |
| **Asset-Based** | | | | | |
| Airborne Freight Corp. | 3.3% | -2.3% | 1.8% | 4.0% | 4.8% |
| Atlas Air Inc. (CGO) | 18.7% | 4.1% | -8.8% | 0.0% | 2.7% |
| FedEx Corp. [4] | 14.3% | 12.2% | 10.3% | 11.7% | 13.0% |
| TPG N.V. | 22.2% | 25.5% | 22.4% | 19.2% | 18.6% |
| United Parcel Service | 25.2% | 24.0% | 21.3% | 20.7% | 21.4% |
| **Group Average** | **16.7%** | **12.7%** | **9.4%** | **11.1%** | **12.1%** |
| **Universe Average** | **19.4%** | **13.7%** | **13.7%** | **14.4%** | **14.9%** |

**OPERATING RATIOS**

| | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|
| **NET OPERATING MARGIN [5]** | | | | |
| **Non-Asset Based** | | | | |
| C.H. Robinson Worldwide | 29.4% | 33.2% | 34.2% | 33.6% |
| EGL Inc. | -6.1% | 3.9% | 8.4% | 8.8% |
| Expeditors International | 24.7% | 25.1% | 24.9% | 25.4% |
| Forward Air Corp. | 13.9% | 14.0% | 15.0% | 15.9% |
| Pacer International | 24.6% | 17.1% | 21.2% | 21.1% |
| UTi [8] | 9.7% | 11.2% | 10.1% | 10.1% |
| **Group Average** | **16.0%** | **17.4%** | **19.0%** | **19.2%** |
| **OPERATING RATIO** | | | | |
| Airborne Freight Corp. | 100.7% | 98.1% | 97.5% | 97.2% |
| Atlas Air Inc. (CGO) | 87.9% | 99.4% | 93.6% | 92.2% |
| FedEx Corp. [4] | 94.6% | 93.7% | 93.3% | 92.1% |
| TPG N.V. | 88.8% | 90.2% | 89.9% | 89.8% |
| United Parcel Service | 86.9% | 87.2% | 87.0% | 86.0% |
| **Group Average** | **91.8%** | **93.7%** | **92.3%** | **91.5%** |

**RETURN ON AVERAGE TOTAL CAPITAL [1]**

| | 2000 | 2001 | 2002E | 2003E | 2004E |
|---|---|---|---|---|---|
| **Non-Asset Based** | | | | | |
| C.H. Robinson Worldwide | 24.0% | 23.9% | 22.6% | 22.7% | 21.9% |
| EGL Inc. | 12.0% | -6.1% | 2.5% | 7.0% | 8.7% |
| Expeditors International | 25.9% | 22.5% | 23.7% | 23.0% | 22.3% |
| Forward Air Corp. | 25.6% | 17.8% | 18.3% | 16.4% | 16.1% |
| Pacer International | NM | -1.9% | 0.9% | 3.4% | 4.8% |
| UTi [8,11] | 10.5% | 8.6% | 9.9% | 10.2% | 11.1% |
| **Group Average** | **19.6%** | **10.8%** | **13.0%** | **13.8%** | **14.2%** |
| **Asset-Based** | | | | | |
| Airborne Freight Corp. | 3.0% | -0.5% | 2.5% | 4.1% | 4.7% |
| Atlas Air Inc. (CGO) | 8.6% | 0.4% | -0.1% | 3.7% | 5.1% |
| FedEx Corp [4] | 5.3% | 4.3% | 4.0% | 4.4% | 5.0% |
| TPG N.V. [7] | 9.4% | 9.8% | 9.3% | 8.7% | 9.4% |
| United Parcel Service | 14.2% | 12.1% | 11.5% | 12.1% | 13.4% |
| **Group Average** | **8.1%** | **5.2%** | **5.4%** | **6.6%** | **7.5%** |
| **Universe Average** | **13.9%** | **8.3%** | **9.6%** | **10.5%** | **11.1%** |

**FREE CASH FLOW RETURN ON AVG. TOTAL CAPITAL [3]**

| | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|
| **Non-Asset Based** | | | | |
| C.H. Robinson Worldwide | 13.7% | 21.4% | 16.5% | 16.2% |
| EGL Inc. | -11.3% | 6.0% | 14.0% | 13.4% |
| Expeditors International | 30.6% | 2.6% | 15.9% | 11.6% |
| Forward Air Corp. | 28.0% | 19.8% | 17.4% | 17.9% |
| Pacer International | 0.5% | 3.0% | 5.6% | 6.5% |
| UTi [8] | 14.6% | 12.3% | 7.9% | 9.5% |
| **Group Average** | **12.7%** | **10.9%** | **12.9%** | **12.5%** |
| **Asset-Based** | | | | |
| Airborne Freight Corp. | 13.3% | 4.3% | 4.2% | 5.1% |
| Atlas Air Inc. (CGO) | -1.5% | 0.5% | 0.8% | 3.1% |
| FedEx Corp. [4] | 2.1% | 4.3% | 3.0% | 2.6% |
| TPG N.V. [7] | 8.1% | 7.6% | 7.9% | 8.8% |
| United Parcel Service | 9.5% | 13.1% | 9.1% | 9.2% |
| **Group Average** | **6.3%** | **6.0%** | **5.0%** | **5.7%** |
| **Universe Average** | **9.8%** | **8.6%** | **9.3%** | **9.4%** |

**DEBT RATIO [2]**

| | 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|
| **Non-Asset Based** | | | | | |
| C.H. Robinson Worldwide | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| EGL Inc. | 19.0% | 23.4% | 22.5% | 21.2% | 19.1% |
| Expeditors International | 1.3% | 0.4% | 0.3% | 0.2% | 0.2% |
| Forward Air Corp. | 9.0% | 4.8% | 1.2% | 0.6% | 0.3% |
| Pacer International | 94.8% | 93.3% | 58.7% | 50.7% | 39.9% |
| UTi [8] | 23.7% | 18.7% | 13.9% | 10.9% | 7.8% |
| **Group Average** | **24.6%** | **23.4%** | **16.1%** | **13.9%** | **11.2%** |
| **Asset-Based** | | | | | |
| Airborne Freight Corp. | 42.1% | 42.2% | 43.4% | 41.4% | 37.9% |
| Atlas Air Inc. (CGO) | 66.4% | 67.7% | 68.0% | 65.1% | 61.1% |
| FedEx Corp. [4,6] | 68.5% | 64.7% | 62.5% | 60.3% | 57.0% |
| TPG N.V. [7] | 76.9% | 76.5% | 76.8% | 67.1% | 58.0% |
| United Parcel Service [6] | 32.6% | 38.8% | 31.8% | 23.2% | 18.4% |
| **Group Average** | **57.3%** | **58.0%** | **56.5%** | **51.4%** | **46.5%** |
| **Universe Average** | **39.5%** | **39.1%** | **34.5%** | **31.0%** | **27.2%** |

**Footnotes:**

(1) Total Capital defined as total debt plus total equity, return on average total capital defined as net income + tax affected interest / total debt + total capital leases + total equity

(2) Debt ratio defined as total debt / total debt + equity (%).

(3) Gross Cash Flow - dividend payouts - maintenance capital expenditures / total debt + total capital leases + total equity.

(4) Balance Sheet and Cash Flow figures for FedEx are FYE numbers.

(5) Total costs including purchased transportation/net revenue.

(6) Includes off balance sheet debt in total capital formulation.

(7) TPG debt includes provisions and off-balance-sheet debt.

(8) Fiscal year ending January data for UTi (e.g. 1998 data based on fiscal 1999 results).

(9) Based on pro forma EPS assuming flat 30% tax rate.

(10) Excludes onetime charges in F00/01 related to stock option compensation costs.

Source: Company reports; Bear, Stearns & Co. Inc. estimates.

## Exhibit 26. Bear Stearns Ground Transport Rail Universe — EPS and Book Value Multiples, 2000-04E

| SECTOR RATING: Market Weight | Price ($) 6/2/03 | 52-Week High | 52-Week Low | Share Count (MM)[2] | Market Cap (MM) | BSC Rating | Rating Since (U/D)[3] | Target Price | Annual Dividend | Dividend Yield (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Large-Cap Railroads** | | | | | | | | | | |
| Burlington Northern Santa Fe (BNI) | $29.80 | $30.93 | $23.18 | 376.1 | $11,208 | Outperform | 3/24/03 | $32 | $0.48 | 1.6% |
| Canadian National (CNI) | $51.28 | $53.06 | $35.96 | 202.0 | $10,359 | Outperform | 9/9/02 | 54 | 0.68 | 1.3% |
| Canadian Pacific (CP) | $23.98 | $24.99 | $16.99 | 158.5 | $3,801 | Peer Perform | 10/16/02 | 25 | 0.33 | 1.4% |
| CSX Corp. (CSX) | $32.64 | $36.80 | $25.09 | 213.7 | $6,975 | Peer Perform | 9/9/02 | 36 | 0.40 | 1.2% |
| Norfolk Southern Corp. (NSC) | $21.88 | $23.90 | $17.20 | 389.0 | $8,511 | Outperform | 9/9/02 | 25 | 0.28 | 1.3% |
| Union Pacific (UNP) | $61.17 | $64.97 | $50.90 | 277.8 | $16,993 | Peer Perform | 12/6/02 | 65 | 0.80 | 1.3% |
| **Small-Cap Railroads** | | | | | | | | | | |
| Genesee and Wyoming (GWR) | $20.98 | $24.50 | $12.70 | 17.7 | $371 | Peer Perform | 9/9/02 | 23 | --- | --- |
| Kansas City Southern (KSU) | $12.49 | $17.50 | $10.65 | 62.6 | $782 | Peer Perform | 10/16/02 | 13 | --- | --- |
| RailAmerica (RRA) | $7.65 | $11.30 | $4.44 | 32.1 | $246 | Peer Perform | 9/9/02 | 9 | --- | --- |
| TMM (TMM) | $2.00 | $11.05 | $1.45 | 57.0 | $114 | NR | 5/22/03 (S) | --- | --- | --- |
| **S&P 500** | **967.00** | **1,079.83** | **768.67** | - | - | - | - | **950.0** | **17.50** | **1.8%** |

| Absolute Estimates 1999-2003E | Earnings / Share 2000 | 2001 | 2002 | 2003E | 2004E | Book Value / Share 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|---|---|---|---|---|
| **Large-Cap Railroads** | | | | | | | | | | |
| Burlington Northern Santa Fe (BNI) | $2.45 | $1.97 | $2.00 | $2.10 | $2.45 | $18.02 | $20.09 | $20.83 | $22.29 | $23.89 |
| Canadian National (CNI) | 2.96 | 3.19 | 3.33 | 3.48 | 3.90 | 23.07 | 24.09 | 25.53 | 31.46 | 35.18 |
| Canadian Pacific (CP) | 1.74 | 1.55 | 1.64 | 1.60 | 2.00 | 14.61 | 12.13 | 13.61 | 15.97 | 17.57 |
| CSX Corp. (CSX) | 0.88 | 1.56 | 2.16 | 2.28 | 2.80 | 28.45 | 28.81 | 29.23 | 32.84 | 35.24 |
| Norfolk Southern Corp. (NSC) | 0.59 | 0.94 | 1.18 | 1.34 | 1.65 | 15.16 | 15.84 | 16.74 | 18.36 | 20.03 |
| Union Pacific (UNP) | 3.61 | 3.77 | 4.78 | 4.20 | 5.00 | 32.14 | 35.22 | 38.47 | 44.14 | 47.77 |
| **Small-Cap Railroads** | | | | | | | | | | |
| Genesee and Wyoming (GWR) | 1.29 | 1.50 | 1.50 | 1.61 | 1.90 | 9.39 | 14.41 | 11.92 | 13.43 | 15.23 |
| Kansas City Southern (KSU) | 0.43 | 0.36 | 0.91 | 0.73 | 0.85 | 11.01 | 11.16 | 12.08 | 13.00 | 14.05 |
| RailAmerica (RRA) | 0.49 | 0.55 | 0.75 | 0.82 | 1.02 | 6.76 | 8.72 | 8.55 | 8.88 | 9.87 |
| TMM (TMM) (6) | 0.33 | 0.05 | (0.68) | 0.13 | 0.27 | 2.73 | 2.92 | 5.77 | 5.20 | 4.66 |
| **S&P 500** | **55.12** | **45.16** | **47.94** | **50.00** | **54.00** | **268.30** | **305.92** | **333.58** | **364.02** | **414.00** |

| Price / Earnings 2000-2003E | Price / Earnings (Absolute) [5] 2001 High | 2001 Low | 2002 Range | 2003E | 2004 | Price / Earnings (Relative) [1] 2001 High | 2001 Low | 2002 Range | 2003E | 2004E |
|---|---|---|---|---|---|---|---|---|---|---|
| **Large-Cap Railroads** | | | | | | | | | | |
| Burlington Northern Santa Fe (BNI) | 12.8x | 9.8x | 13.0x-10.6 | 14.2x | 12.2x | 0.43x | 0.48x | 0.84x-1.01 | 0.73x | 0.68x |
| Canadian National (CNI) | 14.3x | 9.7x | 14.2x-10.5 | 14.7x | 13.1x | 0.48x | 0.47x | 0.92x-1.00 | 0.76x | 0.73x |
| Canadian Pacific (CP) | NA | NA | 14.3x-9.8 | 15.0x | 12.0x | NA | NA | 0.93x-0.93 | 0.77x | 0.67x |
| CSX Corp. (CSX) | 20.5x | 11.9x | 16.3x-10.4 | 14.3x | 11.7x | 0.68x | 0.58x | 1.06x-0.99 | 0.74x | 0.65x |
| Norfolk Southern Corp. (NSC) | 21.6x | 12.5x | 20.0x-13.6 | 16.3x | 13.3x | 0.72x | 0.61x | 1.30x-1.30 | 0.84x | 0.74x |
| Union Pacific (UNP) | 13.8x | 10.4x | 14.2x-11.9 | 14.6x | 12.2x | 0.46x | 0.51x | 0.92x-1.13 | 0.75x | 0.68x |
| **Group Average** | **16.0x** | **10.4x** | **15.3x-11.1** | **14.8x** | **12.4x** | **0.54x** | **0.51x** | **1.00x-1.06** | **0.77x** | **0.69x** |
| **Small-Cap Railroads** | | | | | | | | | | |
| Genesee and Wyoming (GWR) | 12.9x | 6.0x | 14.3x-9.8 | 13.0x | 11.0x | 0.43x | 0.29x | 0.93x-0.93 | 0.67x | 0.62x |
| Kansas City Southern (KSU) | 25.8x | 13.2x | 19.1x-13.0 | 17.1x | 14.6x | 0.86x | 0.64x | 1.24x-1.24 | 0.88x | 0.82x |
| RailAmerica (RRA) | 11.5x | 7.5x | 10.6x-7.5 | 9.3x | 7.5x | 0.38x | 0.37x | 0.69x-0.71 | 0.48x | 0.42x |
| TMM (TMM) | NA | NA | NA | 15.4x | 7.4x | NA | NA | NA | 0.80x | 0.41x |
| **Group Average** | **16.7x** | **8.9x** | **14.7x-10.1** | **13.9x** | **9.9x** | **0.56x** | **0.43x** | **0.95x-0.96** | **0.7x** | **0.6x** |
| **Railroad Average** | **16.3x** | **9.9x** | **15.1x-10.8** | **14.5x** | **11.6x** | **0.5x** | **0.5x** | **0.98x-1.03** | **0.8x** | **0.6x** |
| **S&P 500** | **29.9x** | **20.5x** | **15.4x-10.5** | **19.3x** | **17.9x** | **NM** | **NM** | **NM** | **NM** | **NM** |

| | ENTERPRISE VALUE / EBITDA [4] 2001 | | | | | Price / Book Value (Absolute) 2001 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000-2003E | High | Low | 2002 Range | 2003E | 2004E | High | Low | 2002 Range | 2003E | 2004E |
| **Large-Cap Railroads** | | | | | | | | | | |
| Burlington Northern Santa Fe (BNI) | 6.9x | 6.3x | 8.4x-6.9 | 6.9x | 6.4x | 1.6x | 1.3x | 1.7x-1.2 | 1.3x | 1.2x |
| Canadian National (CNI) | 6.9x | 5.6x | 9.5x-6.4 | 8.7x | 8.1x | 1.4x | 1.0x | 2.0x-1.2 | 1.6x | 1.5x |
| Canadian Pacific (CP) | na | na | 6.7x-5.2 | 7.2x | 6.5x | NA | NA | 1.1x-1.8 | 1.5x | 1.4x |
| CSX Corp. (CSX) | 9.5x | 7.5x | 9.7x-7.8 | 7.4x | 6.5x | 1.1x | 0.7x | 1.4x-0.9 | 1.0x | 0.9x |
| Norfolk Southern Corp. (NSC) | 12.6x | 9.7x | 11.2x-8.5 | 9.2x | 8.3x | 1.4x | 0.8x | 1.5x-0.8 | 1.2x | 1.1x |
| Union Pacific (UNP) | 7.8x | 6.3x | 8.1x-6.8 | 7.0x | 6.5x | 1.6x | 1.1x | 1.7x-1.3 | 1.4x | 1.3x |
| **Group Average** | **8.7x** | **7.1x** | **8.9x-6.9** | **7.7x** | **7.0x** | **1.4x** | **1.0x** | **1.6x-1.2** | **1.3x** | **1.2x** |
| **Small-Cap Railroads** | | | | | | | | | | |
| Genesee and Wyoming (GWR) | 7.7x | 4.6x | 12.7x-6.2 | 6.8x | 6.6x | 2.2x | 0.9x | 2.3x-1.0 | 1.6x | 1.4x |
| Kansas City Southern (KSU) | 10.4x | 13.2x | 13.5x-10.1 | 7.8x | 6.9x | 0.9x | 0.3x | 1.5x-0.9 | 1.0x | 0.9x |
| RailAmerica (RRA) | 5.6x | 4.9x | 7.0x-5.2 | 6.1x | 5.4x | 1.3x | 0.7x | 1.7x-0.9 | 0.9x | 0.8x |
| TMM (TMM) | 7.2x | 6.1x | 7.9x-6.2 | 7.0x | 5.9x | 3.7x | 1.6x | 4.6x-1.5 | 0.4x | 0.4x |
| **Group Average** | **7.8x** | **7.2x** | **10.3x-6.9** | **6.9x** | **6.2x** | **2.0x** | **0.9x** | **2.6x-1.1** | **0.9x** | **0.9x** |
| **Railroad Average** | **8.3x** | **7.1x** | **9.5x-6.9** | **7.4x** | **6.7x** | **1.7x** | **0.9x** | **2.0x-1.1** | **1.2x** | **1.1x** |

**Footnotes:**
(1) Multiples are relative to S&P 500 Average.
(2) Most recently reported (quarterly basis) fully diluted share count.
(3) Date of last rating change along with direction of change (U=upgrade, D=downgrade).
(4) Railroad debt includes off balance sheet debt in EV/EBITDA calculation.
(5) Historical P/E multiples represent blended forward P/E estimates.
(6) EPS estimates represent First Call consensus.

Note: All price targets are for calendar year-end 2003.

Source: Company reports; Bear, Stearns & Co. Inc. estimates.

## Exhibit 27. Bear Stearns Ground Transport Rail Universe — Comparative Financial Returns, 2000-04E

**COMPOUND ANNUAL GROWTH RATES 2001-2004E[4]**

| | Gross Revenue | Op. Inc. | EPS |
|---|---|---|---|
| **Large-Cap Railroads** | | | |
| Burlington Northern Santa Fe (BNI) | 1.4% | 1.9% | 7.5% |
| Canadian National (CNI) | 3.8% | 4.3% | 7.0% |
| Canadian Pacific (CP) | 1.6% | 2.6% | 8.8% |
| CSX Corp. (CSX) | -0.3% | 9.7% | 21.6% |
| Norfolk Southern Corp. (NSC) | 2.9% | 11.2% | 20.6% |
| Union Pacific (UNP) | 3.8% | 7.1% | 9.9% |
| **Group Average** | **2.2%** | **6.1%** | **12.6%** |
| **Small-Cap Railroads** | | | |
| Genesee and Wyoming (GWR) | 12.8% | 18.2% | 8.1% |
| Kansas City Southern (KSU) | 0.1% | 3.4% | 33.8% |
| RailAmerica (RRA) | 7.8% | 12.2% | 22.5% |
| TMM (TMM) | 6.1% | 6.4% | -238.1% |
| **Group Average** | **6.7%** | **10.1%** | **-43.4%** |
| **Railroad Average** | **4.2%** | **7.9%** | **-12.9%** |

**OPERATING RATIOS [5]**

| | 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|
| **Large-Cap Railroads** | | | | | |
| Burlington Northern Santa Fe (BNI) | 76.6% | 80.6% | 81.6% | 81.7% | 80.3% |
| Canadian National (CNI) | 69.6% | 68.5% | 69.4% | 70.9% | 69.5% |
| Canadian Pacific (CP) | 76.9% | 77.3% | 76.6% | 78.5% | 76.6% |
| CSX Corp. (CSX) | 90.2% | 87.4% | 86.3% | 85.7% | 83.6% |
| Norfolk Southern Corp. (NSC) | 87.0% | 83.7% | 81.5% | 81.6% | 79.4% |
| Union Pacific (UNP) | 81.8% | 81.4% | 79.8% | 81.0% | 79.3% |
| **Group Average** | **80.4%** | **79.8%** | **79.2%** | **79.9%** | **78.1%** |
| **Small-Cap Railroads** | | | | | |
| Genesee and Wyoming (GWR) | 86.5% | 86.6% | 86.2% | 84.5% | 84.5% |
| Kansas City Southern (KSU) | 89.9% | 90.4% | 91.5% | 91.3% | 89.4% |
| RailAmerica (RRA) | 82.2% | 82.0% | 82.6% | 82.4% | 79.7% |
| TMM (TMM) | 80.0% | 81.0% | 81.8% | 82.3% | 80.8% |
| **Group Average** | **84.6%** | **85.0%** | **85.5%** | **85.1%** | **83.6%** |
| **Railroad Average** | **82.3%** | **82.2%** | **82.1%** | **82.3%** | **80.6%** |

**RETURN ON AVERAGE EQUITY**

| | 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|
| **Large-Cap Railroads** | | | | | |
| Burlington Northern Santa Fe (BNI) | 13.0% | 10.0% | 9.6% | 9.6% | 10.5% |
| Canadian National (CNI) | 13.1% | 13.6% | 13.5% | 11.6% | 11.6% |
| Canadian Pacific (CP) | 12.5% | 14.4% | 19.7% | 15.2% | 16.5% |
| CSX Corp. (CSX) | 3.2% | 5.4% | 7.4% | 7.3% | 8.2% |
| Norfolk Southern Corp. (NSC) | 3.9% | 6.1% | 7.3% | 7.6% | 8.6% |
| Union Pacific (UNP) | 11.0% | 10.6% | 12.5% | 9.7% | 10.7% |
| **Group Average** | **9.4%** | **10.0%** | **11.7%** | **10.2%** | **11.0%** |
| **Small-Cap Railroads** | | | | | |
| Genesee and Wyoming (GWR) | 14.6% | 13.1% | 12.7% | 12.2% | 12.8% |
| Kansas City Southern (KSU) | 39.5% | 4.6% | 8.0% | 7.0% | 7.4% |
| RailAmerica (RRA) | 10.0% | 7.5% | 9.3% | 8.9% | 10.5% |
| TMM (TMM) | 6.1% | 7.0% | 0.1% | 0.0% | 3.7% |
| **Group Average** | **17.6%** | **8.1%** | **7.5%** | **7.0%** | **8.6%** |
| **Railroad Average** | **12.7%** | **9.2%** | **10.0%** | **8.9%** | **10.1%** |

**PRETAX RETURN ON ASSETS**

| | 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|
| **Large-Cap Railroads** | | | | | |
| Burlington Northern Santa Fe (BNI) | 8.9% | 7.3% | 6.6% | 6.5% | 7.0% |
| Canadian National (CNI) | 9.8% | 9.2% | 8.8% | 8.0% | 8.3% |
| Canadian Pacific (CP) | 9.9% | 9.2% | 8.9% | 8.1% | 8.9% |
| CSX Corp. (CSX) | 3.9% | 4.9% | 5.3% | 5.5% | 6.2% |
| Norfolk Southern Corp. (NSC) | 4.2% | 5.2% | 5.9% | 6.0% | 6.7% |
| Union Pacific (UNP) | 6.7% | 6.7% | 7.2% | 6.8% | 7.4% |
| **Group Average** | **7.2%** | **7.1%** | **7.1%** | **6.8%** | **7.4%** |
| **Small-Cap Railroads** | | | | | |
| Genesee and Wyoming (GWR) | 8.9% | 10.6% | 9.8% | 9.9% | 9.6% |
| Kansas City Southern (KSU) | 0.1% | 2.1% | 8.2% | 5.3% | 13.5% |
| RailAmerica (RRA) | 9.9% | 7.7% | 7.8% | 7.2% | 8.8% |
| TMM (TMM) | 7.1% | 7.0% | 6.5% | 6.6% | 8.4% |
| **Group Average** | **6.5%** | **6.8%** | **8.1%** | **7.2%** | **10.1%** |
| **Railroad Average** | **6.9%** | **7.0%** | **7.5%** | **7.0%** | **8.5%** |

**RETURN ON AVERAGE TOTAL CAPITAL [1]**

| | 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|
| **Large-Cap Railroads** | | | | | |
| Burlington Northern Santa Fe (BNI) | 9.4% | 7.8% | 7.1% | 7.1% | 7.7% |
| Canadian National (CNI) | 9.5% | 9.4% | 9.2% | 8.5% | 8.7% |
| Canadian Pacific (CP) | 10.2% | 9.0% | 9.4% | 8.5% | 9.3% |
| CSX Corp. (CSX) | 4.5% | 5.3% | 5.5% | 5.6% | 6.3% |
| Norfolk Southern Corp. (NSC) | 3.9% | 4.8% | 5.5% | 5.8% | 6.3% |
| Union Pacific (UNP) | 7.8% | 7.6% | 8.2% | 7.8% | 8.4% |
| **Group Average** | **7.5%** | **7.3%** | **7.5%** | **7.2%** | **7.8%** |
| **Small-Cap Railroads** | | | | | |
| Genesee and Wyoming (GWR) | 9.1% | 10.6% | 9.5% | 9.2% | 10.2% |
| Kansas City Southern (KSU) | 6.3% | 3.5% | 5.7% | 5.2% | 5.6% |
| RailAmerica (RRA) | 10.2% | 6.7% | 7.4% | 6.2% | 7.5% |
| TMM (TMM) | 9.4% | 8.3% | 6.2% | 0.3% | 8.7% |
| **Group Average** | **8.8%** | **7.3%** | **7.2%** | **5.2%** | **8.0%** |
| **Railroad Average** | **8.1%** | **7.3%** | **7.3%** | **6.3%** | **7.9%** |

**FREE CASH FLOW RETURN ON AVG. TOTAL CAPITAL [3]**

| | 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|
| **Large-Cap Railroads** | | | | | |
| Burlington Northern Santa Fe (BNI) | 4.5% | 4.4% | 4.0% | 3.2% | 3.6% |
| Canadian National (CNI) | 4.9% | 5.0% | 5.0% | 4.5% | 4.4% |
| Canadian Pacific (CP) | 3.4% | 3.7% | 6.4% | 4.5% | 5.9% |
| CSX Corp. (CSX) | 3.7% | -0.8% | 1.3% | 2.0% | 2.5% |
| Norfolk Southern Corp. (NSC) | 5.4% | 0.5% | 1.0% | 3.4% | 3.3% |
| Union Pacific (UNP) | 2.5% | 2.6% | 4.0% | 3.6% | 2.8% |
| **Group Average** | **4.1%** | **2.5%** | **3.6%** | **3.5%** | **3.8%** |
| **Small-Cap Railroads** | | | | | |
| Genesee and Wyoming (GNWR) | -1.3% | 9.0% | 3.2% | 5.0% | 4.8% |
| Kansas City Southern (KSU) | -1.7% | 2.1% | 2.9% | 2.6% | 2.4% |
| RailAmerica (RRA) | 16.4% | 1.9% | -2.5% | 1.9% | 1.5% |
| TMM (TMM) | 10.6% | 8.7% | 14.0% | 13.4% | 17.2% |
| **Group Average** | **6.0%** | **5.4%** | **4.4%** | **5.8%** | **6.5%** |
| **Railroad Average** | **4.8%** | **3.7%** | **3.9%** | **4.4%** | **4.9%** |

**DEBT RATIO [2][6]**

| | 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|
| **Large-Cap Railroads** | | | | | |
| Burlington Northern Santa Fe (BNI) | 55.5% | 54.7% | 55.4% | 54.8% | 54.1% |
| Canadian National (CNI) | 41.6% | 47.5% | 44.0% | 42.3% | 39.6% |
| Canadian Pacific (CP) | 43.6% | 58.1% | 51.4% | 47.9% | 44.5% |
| CSX Corp. (CSX) | 54.3% | 56.3% | 55.8% | 51.7% | 48.8% |
| Norfolk Southern Corp. (NSC) | 58.4% | 57.3% | 54.9% | 51.6% | 47.8% |
| Union Pacific (UNP) | 54.6% | 51.3% | 51.4% | 43.6% | 40.8% |
| **Group Average** | **51.3%** | **54.2%** | **52.1%** | **48.7%** | **45.9%** |
| **Small-Cap Railroads** | | | | | |
| Genesee and Wyoming (GWR) | 55.0% | 26.7% | 58.6% | 33.6% | 26.5% |
| Kansas City Southern (KSU) | 59.3% | 58.0% | 53.6% | 50.8% | 47.6% |
| RailAmerica (RRA) | 81.6% | 70.3% | 69.5% | 67.5% | 65.1% |
| TMM (TMM) | 57.8% | 57.0% | 56.0% | 55.6% | 53.5% |
| **Group Average** | **63.4%** | **53.0%** | **59.4%** | **51.9%** | **48.2%** |
| **Railroad Average** | **56.2%** | **53.7%** | **55.1%** | **49.9%** | **46.8%** |

**FREE CASH PER SHARE (3)**

| | 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|
| **Large-Cap Railroads** | | | | | |
| Burlington Northern Santa Fe (BNI) | $1.54 | $1.62 | $1.55 | $1.28 | $1.52 |
| Canadian National (CNI) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Canadian Pacific (CP) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CSX Corp. (CSX) | 2.12 | (0.48) | 0.79 | 1.27 | 1.60 |
| Norfolk Southern Corp. (NSC) | 1.95 | 0.17 | 0.37 | 1.21 | 1.23 |
| Union Pacific (UNP) | 1.55 | 1.65 | 2.63 | 2.48 | 2.01 |
| **Group Average** | **1.19** | **0.49** | **0.89** | **1.04** | **1.06** |
| **Small-Cap Railroads** | | | | | |
| Genesee and Wyoming (GWR) | (0.25) | 1.56 | 0.53 | 0.98 | 0.96 |
| Kansas City Southern (KSU) | (0.37) | 0.47 | 0.62 | 0.58 | 0.54 |
| RailAmerica (RRA) | 4.30 | 0.47 | (0.55) | 0.45 | 0.35 |
| TMM (TMM) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Group Average** | **0.92** | **0.62** | **0.15** | **0.50** | **0.46** |
| **Railroad Average** | **1.08** | **0.54** | **0.60** | **0.83** | **0.82** |

**Footnotes:**
(1) Total Capital defined as total debt plus total equity, return on average total capital defined as net income + tax affected interest / total debt + total capital leases + total equity.
(2) Debt ratio defined as total debt / total debt + equity (%).
(3) Free Cash Flow defined as Cash from Operating activities - Net Capex.
(4) Reported revenue and operating expenses include fuel surcharge revenue and gross fuel expense, respectively.
(5) Total operating expenses as a percentage of total revenue.
(6) Debt ratio for Railroads includes off-balance-sheet debt.

Source: Company reports; Bear, Stearns & Co. Inc. estimates.

## Exhibit 28. Bear Stearns Ground Transport Truck Universe — EPS and Book Value Multiples, 2000-04E

| SECTOR RATING: Market Underweight | Price ($) 6/2/03 | 52-Week High | 52-Week Low | Share Count (MM)[5] | Market Cap (MM) | BSC Rating | Rating Since (U/D)[6] | Target Price | Annual Dividend | Dividend Yield (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Truckload (TL)** | | | | | | | | | | |
| Covenant Transportation (CVTI) [1] | $19.01 | $23.00 | $14.79 | 14.7 | $279 | Peer Perform | (D) 2/24/2003 | NA | --- | --- |
| Heartland Express (HTLD) [2] | $24.00 | $24.20 | $16.77 | 50.0 | $1,200 | Peer Perform | (D) 2/24/2003 | NA | --- | --- |
| J.B. Hunt Transport (JBHT) [2] | $37.39 | $37.28 | $21.25 | 40.3 | $1,506 | Outperform | (U) 4/15/2003 | $40 | --- | --- |
| Knight Transportation (KNGT) [3] | $25.72 | $25.65 | $14.67 | 38.1 | $980 | Peer Perform | (D) 2/24/2003 | NA | --- | --- |
| Swift Transportation (SWFT) [2, 3] | $20.69 | $23.90 | $14.76 | 84.7 | $1,753 | Peer Perform | (D) 2/24/2003 | NA | --- | --- |
| Werner Enterprises (WERN) [2] | $23.12 | $23.64 | $17.25 | 65.1 | $1,506 | Peer Perform | (D) 2/24/2003 | NA | 0.08 | 0.3% |
| U.S. Xpress (XPRSA) [2] | $12.15 | $14.55 | $6.70 | 14.0 | $171 | Underperform | 9/9/2002 | $10 | --- | --- |
| **Less-than-truckload (LTL) / Other** | | | | | | | | | | |
| Arkansas Best Corp. (ABFS) | $26.92 | $32.19 | $17.83 | 24.9 | $670 | Underperform | (D) 5/15/2003 | $21 | $0.32 | 1.2% |
| CNF Inc. (CNF) | $30.87 | $38.28 | $27.19 | 53.7 | $1,656 | Peer Perform | (D) 5/15/2003 | NA | 0.40 | 1.3% |
| Roadway Corp. (ROAD) | $37.10 | $41.27 | $20.58 | 19.1 | $708 | Underperform | (D) 5/15/2003 | $31 | 0.20 | 0.5% |
| Ryder System Inc. (R) | $26.64 | $29.99 | $20.00 | 62.8 | $1,673 | Peer Perform | (U) 4/24/2002 | NA | 0.60 | 2.3% |
| USF Corporation (USFC) | $30.75 | $39.32 | $22.27 | 27.1 | $834 | Peer Perform | (U) 10/21/2002 | $25 | 0.37 | 1.2% |
| Yellow Corp. (YELL) | $26.00 | $32.48 | $18.28 | 29.8 | $775 | Underperform | (D) 5/15/2003 | $19 | --- | --- |
| **S&P 500** | **967.00** | **1,079.83** | **768.67** | **-** | **-** | **-** | **-** | **950.0** | **17.50** | **1.8%** |

| Absolute Estimates 2000-2004E | Earnings / Share 2000 | 2001 | 2002 | 2003E | 2004E | Book Value / Share 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|---|---|---|---|---|
| **Truckload (TL)** | | | | | | | | | | |
| Covenant Transportation (CVTI) [1] | $0.82 | $0.24 | $0.77 | $1.00 | $1.40 | $11.65 | $11.55 | $12.09 | $12.77 | $13.83 |
| Heartland Express (HTLD) [2] | 0.68 | 0.75 | 0.86 | 0.99 | 1.15 | 3.88 | 4.66 | 5.52 | 6.49 | 7.60 |
| J.B. Hunt Transport (JBHT) [2] | 1.02 | 0.63 | 1.34 | 1.96 | 2.55 | 11.80 | 12.66 | 15.12 | 16.56 | 18.91 |
| Knight Transportation (KNGT) [3] | 0.53 | 0.64 | 0.73 | 0.92 | 1.10 | 3.11 | 4.77 | 5.25 | 6.19 | 7.29 |
| Swift Transportation (SWFT) [2, 3] | 0.82 | 0.45 | 0.78 | 0.96 | 1.25 | 7.83 | 8.58 | 8.81 | 9.42 | 10.62 |
| Werner Enterprises (WERN) [2] | 0.76 | 0.74 | 0.94 | 1.14 | 1.38 | 8.51 | 9.20 | 9.93 | 11.06 | 12.38 |
| U.S. Xpress (XPRSA) [2] | 0.25 | (0.05) | 0.22 | 0.48 | 0.79 | 11.09 | 11.31 | 11.28 | 11.65 | 12.28 |
| **Less-than-truckload (LTL) / Other** | | | | | | | | | | |
| Arkansas Best Corp. (ABFS) | 3.17 | 1.47 | 1.42 | 2.00 | 2.60 | 12.16 | 13.53 | 14.02 | 15.88 | 17.97 |
| CNF Inc. (CNF) | 2.77 | 0.42 | 1.28 | 1.90 | 2.55 | 21.13 | 14.50 | 14.88 | 17.07 | 19.03 |
| Roadway Corp. (ROAD) | 2.98 | 1.81 | 1.94 | 3.24 | 3.72 | 17.91 | 19.00 | 20.42 | 23.45 | 27.21 |
| Ryder System Inc. (R) | 1.93 | 1.54 | 1.84 | 2.01 | 2.04 | 20.96 | 20.38 | 17.71 | 19.16 | 20.63 |
| USF Corporation (USFC) | 3.65 | 1.62 | 1.57 | 1.86 | 2.50 | 23.70 | 25.64 | 22.65 | 24.10 | 25.85 |
| Yellow Corp. (YELL) | 2.51 | 0.57 | 1.04 | 2.05 | 2.33 | 18.55 | 19.90 | 12.73 | 14.12 | 16.45 |
| **S&P 500** | **55.12** | **45.16** | **47.94** | **50.00** | **54.00** | **264.30** | **301.92** | **329.58** | **360.02** | **392.52** |

| Price / Earnings 2000-2004E | Price / Earnings (Absolute)[7] 2000 Range | 2001 Range | 2002 Range | 2003E | 2004E | Price / Earnings (Relative)[8] 2000 Range | 2001 Range | 2002 Range | 2003E | 2004E |
|---|---|---|---|---|---|---|---|---|---|---|
| **Truckload (TL)** | | | | | | | | | | |
| Covenant Transportation (CVTI) [1] | 10.4x-5.4x | 27.1x-11.7x | 26.1x-14.3x | 19.1x | 13.6x | 0.4x-0.2x | 0.9x-0.6x | 0.9x-0.8x | 1.0x | 0.8x |
| Heartland Express (HTLD) [2] | 16.0x-10.4x | 23.5x-15.6x | 27.5x-18.7x | 24.2x | 20.9x | 0.6x-0.5x | 0.8x-0.8x | 0.9x-1.0x | 1.3x | 1.2x |
| J.B. Hunt Transport (JBHT) [2] | 14.6x-9.8x | 25.6x-13.1x | 27.9x-13.6x | 19.1x | 14.7x | 0.5x-0.4x | 0.9x-0.6x | 1.0x-0.7x | 1.0x | 0.8x |
| Knight Transportation (KNGT) [3] | 14.3x-10.1x | 27.5x-13.2x | 30.2x-17.5x | 27.8x | 23.3x | 0.5x-0.4x | 0.9x-0.6x | 1.0x-0.9x | 1.4x | 1.3x |
| Swift Transportation (SWFT) [2, 3] | 19.5x-11.1x | 27.6x-16.8x | 29.4x-13.5x | 21.5x | 16.6x | 0.7x-0.5x | 0.9x-0.8x | 1.0x-0.7x | 1.1x | 0.9x |
| Werner Enterprises (WERN) [2] | 14.5x-9.0x | 20.9x-12.9x | 21.7x-15.4x | 20.2x | 16.7x | 0.5x-0.4x | 0.7x-0.6x | 0.7x-0.8x | 1.0x | 0.9x |
| U.S. Xpress (XPRSA) [2] | 10.7x-6.0x | 32.7x-11.4x | 35.7x-12.1x | 25.5x | 15.3x | 0.4x-0.3x | 1.1x-0.6x | 1.2x-0.7x | 1.3x | 0.9x |
| **Group Average** | **14.3x-8.8x** | **26.4x-13.5x** | **28.4x-15.0x** | **22.5x** | **17.3x** | **0.5x-0.4x** | **0.9x-0.7x** | **1.0x-0.8x** | **1.2x** | **1.0x** |
| **Less-than-truckload (LTL) / Other** | | | | | | | | | | |
| Arkansas Best Corp. (ABFS) | 6.3x-3.7x | 14.3x-5.3x | 15.4x-10.2x | 13.5x | 10.4x | 0.2x-0.2x | 0.5x-0.3x | 0.5x-0.5x | 0.7x | 0.6x |
| CNF Inc. (CNF) | 11.1x-6.5x | 22.6x-10.4x | 22.5x-13.7x | 16.3x | 12.1x | 0.4x-0.3x | 0.8x-0.5x | 0.8x-0.7x | 0.8x | 0.7x |
| Roadway Corp. (ROAD) | 10.1x-5.6x | 14.1x-6.5x | 16.2x-10.0x | 11.4x | 10.0x | 0.4x-0.2x | 0.5x-0.3x | 0.6x-0.5x | 0.6x | 0.6x |
| Ryder System Inc. (R) | 11.6x-6.9x | 14.3x-8.6x | 17.8x-11.0x | 13.3x | 13.1x | 0.4x-0.3x | 0.5x-0.4x | 0.6x-0.6x | 0.7x | 0.7x |
| USF Corporation (USFC) | 10.6x-5.2x | 17.6x-7.8x | 17.7x-12.2x | 16.5x | 12.3x | 0.4x-0.2x | 0.6x-0.4x | 0.6x-0.7x | 0.9x | 0.7x |
| Yellow Corp. (YELL) | 14.6x-6.2x | 8.0x-5.5x | 14.5x-10.0x | 12.7x | 11.1x | 0.5x-0.3x | 0.3x-0.3x | 0.5x-0.5x | 0.7x | 0.6x |
| **Group Average** | **10.7x-5.7x** | **15.2x-7.4x** | **17.4x-11.2x** | **13.9x** | **11.5x** | **0.4x-0.3x** | **0.5x-0.4x** | **0.6x-0.6x** | **0.7x** | **0.6x** |
| **Trucking Average** | **12.6x-7.4x** | **21.2x-10.7x** | **23.3x-13.2x** | **18.5x** | **14.6x** | **0.5x-0.3x** | **0.7x-0.5x** | **0.8x-0.7x** | **1.0x** | **0.8x** |
| **S&P 500** | **28.0x-22.7x** | **29.9x-20.5x** | **29.1x-18.6x** | **19.3x** | **17.9x** | **NM** | **NM** | **NM** | **NM** | **NM** |

| 2000-2004E | ENTERPRISE VALUE / EBITDA [9] 2000 Range | 2001 Range | 2002 Range | 2003E | 2004E | Price / Book Value (Absolute) 2000 Range | 2001 Range | 2002 Range | 2003E | 2004E |
|---|---|---|---|---|---|---|---|---|---|---|
| **Truckload (TL)** | | | | | | | | | | |
| Covenant Transportation (CVTI) [1] | 5.9x-3.7 | 4.8x-3.2 | 5.3x-3.5 | 4.5x | 3.7x | 1.5x-0.7 | 1.5x-0.8 | 1.8x-1.2 | 1.5x | 1.4x |
| Heartland Express (HTLD) [2] | 7.3x-3.1 | 11.1x-5.6 | 13.2x-8.3 | 10.6x | 9.6x | 3.0x-1.7 | 4.1x-2.4 | 4.5x-3.1 | 3.7x | 3.2x |
| J.B. Hunt Transport (JBHT) [2] | 5.1x-3.9 | 6.3x-4.0 | 6.1x-4.5 | 5.8x | 4.8x | 1.5x-0.9 | 2.0x-1.0 | 2.1x-1.4 | 2.3x | 2.0x |
| Knight Transportation (KNGT) [3] | 6.7x-5.1 | 12.0x-4.9 | 12.6x-7.9 | 10.9x | 9.0x | 2.8x-2.0 | 4.2x-1.7 | 4.5x-2.9 | 4.2x | 3.5x |
| Swift Transportation (SWFT) [2, 3] | 7.7x-4.6 | 9.5x-6.1 | 8.3x-5.1 | 7.1x | 5.8x | 2.8x-1.5 | 2.8x-1.7 | 2.8x-1.7 | 2.2x | 1.9x |
| Werner Enterprises (WERN) [2] | 5.0x-2.9 | 6.5x-3.7 | 6.6x-5.0 | 6.0x | 5.2x | 1.7x-0.9 | 2.2x-1.3 | 2.3x-1.7 | 2.1x | 1.9x |
| U.S. Xpress (XPRSA) [2] | 5.6x-4.5 | 6.1x-4.8 | 6.2x-4.7 | 5.1x | 4.3x | 0.9x-0.5 | 0.9x-0.4 | 1.2x-0.6 | 1.0x | 1.0x |
| **Group Average** | **6.2x-4.0** | **8.1x-4.6** | **8.3x-5.6** | **7.1x** | **6.1x** | **2.0x-1.2** | **2.5x-1.3** | **2.8x-1.8** | **2.42x** | **2.12x** |
| **Less-than-truckload (LTL) / Other** | | | | | | | | | | |
| Arkansas Best Corp. (ABFS) | 3.2x-1.9 | 6.7x-3.8 | 7.5x-4.6 | 5.4x | 4.5x | 1.7x-0.8 | 2.2x-1.1 | 2.3x-1.3 | 1.9x | 1.5x |
| CNF Inc. (CNF) | 4.8x-3.2 | 7.7x-4.8 | 7.8x-6.1 | 4.9x | 4.4x | 1.6x-1.0 | 2.5x-1.5 | 2.6x-1.9 | 2.1x | 1.6x |
| Roadway Corp. (ROAD) | 2.7x-1.6 | 6.9x-4.2 | 5.6x-3.7 | 4.6x | 4.5x | 1.4x-0.9 | 2.0x-1.0 | 2.0x-1.1 | 1.8x | 1.4x |
| Ryder System Inc. (R) | 3.7x-3.1 | 3.7x-3.2 | 4.1x-3.4 | 3.7x | 3.6x | 1.2x-0.7 | 1.1x-0.8 | 1.7x-1.2 | 1.5x | 1.3x |
| USF Corporation (USFC) | 5.3x-2.8 | 5.8x-4.1 | 10.5x-7.7 | 4.9x | 4.1x | 2.0x-0.8 | 1.5x-1.0 | 1.7x-1.2 | 1.4x | 1.2x |
| Yellow Corp. (YELL) | 2.4x-1.8 | 6.5x-4.5 | 7.1x-4.2 | 4.1x | 3.8x | 1.0x-0.6 | 1.2x-0.7 | 2.5x-1.4 | 2.0x | 1.6x |
| **Group Average** | **3.7x-2.4** | **6.2x-4.1** | **7.1x-4.9** | **4.6x** | **4.1x** | **1.4x-0.8** | **1.8x-1.0** | **2.1x-1.4** | **1.8x** | **1.4x** |
| **Trucking Average** | **5.0x-3.2** | **7.2x-4.4** | **7.8x-5.3** | **6.0x** | **5.2x** | **1.8x-1.0** | **2.2x-1.2** | **2.5x-1.6** | **2.1x** | **1.8x** |

**Footnotes:**
(1) CVTI reports revenue and fuel expense net of fuel surcharge.
(2) Reported revenue and operating expenses include fuel surcharge revenue and gross fuel expense, respectively.
(3) SWFT figures either actual or estimated pro forma. Merger with MSCA closed June 29, 2001.
(4) Multiples are relative to S&P 500 Average.
(5) Most recently reported (quarterly basis) fully-diluted share count.
(6) Date of last rating change along with direction of change (U=upgrade, D=downgrade).
(7) Historical P/E multiples represent blended forward P/E estimates.
(8) Enterprise value defined as market cap plus net debt minus cash and cash equivalents.

Note: All price targets are for calendar year-end 2003.

Source: Company reports; Bear, Stearns & Co. Inc. estimates.

## Exhibit 29. Bear Stearns Ground Transport Truck Universe — Comparative Financial Returns, 2000-04E

| COMPOUND ANNUAL GROWTH RATES 2001-2004E | Gross Revenue | Op. Inc. | EPS |
|---|---|---|---|
| **Truckload (TL)** | | | |
| Covenant Transportation (CVTI) [6] | 4.7% | 43.0% | 79.3% |
| Heartland Express (HTLD) [6] | 15.9% | 15.6% | 15.1% |
| J.B. Hunt Transport (JBHT) [6] | 8.6% | 51.1% | 59.6% |
| Knight Transportation (KNGT) [6] | 16.8% | 21.9% | 20.2% |
| Swift Transportation (SWFT) [6, 8] | 7.3% | 28.3% | 40.9% |
| Werner Enterprises (WERN) [6] | 9.6% | 20.6% | 22.9% |
| U.S. Xpress (XPRSA) [6] | 10.9% | 33.7% | NM |
| **Group Average** | **10.5%** | **30.6%** | **39.7%** |
| **Less-than-truckload (LTL) / Other** | | | |
| Arkansas Best Corp. (ABFS) | 2.9% | 14.0% | 20.8% |
| CNF Inc. (CNF) | 4.7% | 47.8% | 82.5% |
| Roadway Corp. (ROAD) | 8.5% | 27.1% | 27.1% |
| Ryder System Inc. (R) | -0.3% | 2.7% | 9.8% |
| USF Corporation (USFC) | 0.9% | 12.7% | 15.5% |
| Yellow Corp. (YELL) | 6.8% | 41.6% | 59.7% |
| **Group Average** | **3.9%** | **24.3%** | **35.9%** |
| **Trucking Average** | **7.5%** | **27.7%** | **37.8%** |

| OPERATING RATIOS [6] | 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|
| **Truckload (TL)** | | | | | |
| Covenant Transportation (CVTI) [5] | 94.8% | 97.2% | 94.8% | 94.2% | 92.8% |
| Heartland Express (HTLD) [6] | 83.2% | 82.1% | 81.8% | 81.9% | 82.3% |
| J.B. Hunt Transport (JBHT) [6] | 97.1% | 97.3% | 95.5% | 93.9% | 92.8% |
| Knight Transportation (KNGT) [6] | 84.6% | 83.6% | 83.0% | 82.0% | 81.6% |
| Swift Transportation (SWFT) [6, 8] | 92.8% | 95.9% | 94.1% | 93.8% | 92.9% |
| Werner Enterprises (WERN) [6] | 93.2% | 93.8% | 92.6% | 91.9% | 91.7% |
| U.S. Xpress (XPRSA) [6] | 97.2% | 98.2% | 97.6% | 97.4% | 96.9% |
| **Group Average** | **91.8%** | **92.6%** | **91.3%** | **90.7%** | **90.2%** |
| **Less-than-truckload (LTL) / Other** | | | | | |
| Arkansas Best Corp. (ABFS) | 92.4% | 95.0% | 95.1% | 94.2% | 93.2% |
| CNF Inc. (CNF) | 94.9% | 98.4% | 96.8% | 95.9% | 95.4% |
| Roadway Corp. (ROAD) | 96.8% | 97.7% | 97.0% | 96.2% | 96.2% |
| Ryder System Inc. (R) | 93.7% | 94.7% | 94.3% | 94.3% | 94.2% |
| USF Corporation (USFC) | 93.0% | 96.2% | 96.3% | 95.7% | 94.7% |
| Yellow Corp. (YELL) | 96.1% | 98.3% | 97.9% | 96.1% | 95.9% |
| **Group Average** | **94.5%** | **96.7%** | **96.2%** | **95.4%** | **95.0%** |
| **Trucking Average** | **93.0%** | **94.5%** | **93.6%** | **92.9%** | **92.4%** |

| RETURN ON AVERAGE EQUITY | 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|
| **Truckload (TL)** | | | | | |
| Covenant Transportation (CVTI) [6] | 7.2% | 2.1% | 6.6% | 8.1% | 10.6% |
| Heartland Express (HTLD) [6] | 18.5% | 17.6% | 16.8% | 16.5% | 16.3% |
| J.B. Hunt Transport (JBHT) [6] | 8.8% | 5.2% | 10.0% | 12.6% | 14.5% |
| Knight Transportation (KNGT) [6] | 18.9% | 16.4% | 15.2% | 16.2% | 16.5% |
| Swift Transportation (SWFT) [6, 8] | 10.8% | 5.5% | 9.0% | 10.4% | 12.5% |
| Werner Enterprises (WERN) [6] | 9.3% | 8.5% | 9.9% | 10.9% | 11.8% |
| U.S. Xpress (XPRSA) [6] | 2.2% | -0.4% | 2.0% | 4.2% | 6.7% |
| **Group Average** | **10.8%** | **7.8%** | **9.9%** | **11.3%** | **12.7%** |
| **Less-than-truckload (LTL) / Other** | | | | | |
| Arkansas Best Corp. (ABFS) | 29.7% | 11.7% | 10.4% | 13.3% | 15.4% |
| CNF Inc. (CNF) | 13.2% | 2.2% | 8.2% | 10.8% | 12.9% |
| Roadway Corp. (ROAD) | 17.9% | 8.8% | 10.4% | 14.8% | 14.6% |
| Ryder System Inc. (R) | 9.4% | 7.5% | 9.8% | 10.9% | 10.3% |
| USF Corporation (USFC) | 16.4% | 6.6% | 6.6% | 8.0% | 10.1% |
| Yellow Corp. (YELL) | 14.3% | 3.0% | 6.9% | 15.7% | 15.3% |
| **Group Average** | **16.8%** | **6.6%** | **8.7%** | **12.3%** | **13.1%** |
| **Trucking Average** | **13.6%** | **7.3%** | **9.4%** | **11.7%** | **12.9%** |

| PRETAX RETURN ON ASSETS | 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|
| **Truckload (TL)** | | | | | |
| Covenant Transportation (CVTI) [5] | 7.4% | 4.1% | 7.9% | 8.6% | 10.7% |
| Heartland Express (HTLD) [6] | 18.0% | 18.1% | 18.1% | 18.2% | 17.8% |
| J.B. Hunt Transport (JBHT) [6] | 5.4% | 4.5% | 7.9% | 10.9% | 13.0% |
| Knight Transportation (KNGT) [6] | 17.2% | 17.7% | 18.1% | 19.4% | 20.0% |
| Swift Transportation (SWFT) [6, 8] | 9.6% | 5.6% | 7.7% | 8.6% | 10.1% |
| Werner Enterprises (WERN) [6] | 9.1% | 8.4% | 9.8% | 19.9% | 14.9% |
| U.S. Xpress (XPRSA) [6] | 5.3% | 3.3% | 4.8% | 5.7% | 7.5% |
| **Group Average** | **10.3%** | **8.8%** | **10.6%** | **13.1%** | **13.4%** |
| **Less-than-truckload (LTL) / Other** | | | | | |
| Arkansas Best Corp. (ABFS) | 18.3% | 10.0% | 9.3% | 12.3% | 15.0% |
| CNF Inc. (CNF) | 9.7% | 2.5% | 5.3% | 7.6% | 8.8% |
| Roadway Corp. (ROAD) | 11.1% | 5.0% | 7.1% | 9.9% | 10.1% |
| Ryder System Inc. (R) | 6.0% | 5.1% | 5.6% | 5.9% | 6.2% |
| USF Corporation (USFC) | 14.2% | 6.9% | 6.6% | 7.9% | 9.9% |
| Yellow Corp. (YELL) | 10.7% | 3.4% | 5.3% | 10.2% | 10.8% |
| **Group Average** | **11.7%** | **5.5%** | **6.5%** | **9.0%** | **10.1%** |
| **Trucking Average** | **10.9%** | **7.3%** | **8.7%** | **11.2%** | **11.9%** |

| RETURN ON AVERAGE TOTAL CAPITAL [1] | 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|
| **Truckload (TL)** | | | | | |
| Covenant Transportation (CVTI) [6] | 2.0% | 0.1% | 3.6% | 5.0% | 6.4% |
| Heartland Express (HTLD) [6] | 18.5% | 17.6% | 16.8% | 16.5% | 16.3% |
| J.B. Hunt Transport (JBHT) [6] | 7.5% | 5.5% | 7.8% | 9.8% | 12.4% |
| Knight Transportation (KNGT) [6] | 18.2% | 13.7% | 15.2% | 16.3% | 16.7% |
| Swift Transportation (SWFT) [6, 8] | 9.9% | 6.3% | 7.4% | 8.5% | 10.1% |
| Werner Enterprises (WERN) [6] | 8.5% | 7.8% | 9.7% | 10.8% | 11.8% |
| U.S. Xpress (XPRSA) [6] | -1.4% | -3.1% | -0.8% | 0.3% | 2.0% |
| **Group Average** | **9.0%** | **6.8%** | **8.5%** | **9.6%** | **10.8%** |
| **Less-than-truckload (LTL) / Other** | | | | | |
| Arkansas Best Corp. (ABFS) | 19.4% | 9.4% | 8.7% | 12.0% | 15.0% |
| CNF Inc. (CNF) | 10.3% | 2.5% | 5.8% | 7.9% | 9.0% |
| Roadway Corp. (ROAD) | -3.0% | 7.3% | 7.7% | 30.2% | 9.6% |
| Ryder System Inc. (R) | 4.8% | 4.2% | 4.8% | 5.1% | 5.4% |
| USF Corporation (USFC) | 12.5% | 5.3% | -6.2% | 6.9% | 8.7% |
| Yellow Corp. (YELL) | 12.0% | 3.8% | 8.1% | 14.4% | 14.5% |
| **Group Average** | **9.4%** | **5.4%** | **4.8%** | **12.7%** | **10.4%** |
| **Trucking Average** | **9.2%** | **6.2%** | **6.8%** | **11.1%** | **10.6%** |

| FREE CASH FLOW RETURN ON AVG. TOTAL CAPITAL [4] | 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|
| **Truckload (TL)** | | | | | |
| Covenant Transportation (CVTI) [5] | 9.1% | 15.1% | 4.2% | -2.3% | -1.1% |
| Heartland Express (HTLD) [6] | 0.9% | 15.2% | -2.8% | 8.3% | 15.6% |
| J.B. Hunt Transport (JBHT) [6] | 1.5% | 17.2% | 1.2% | 1.2% | 10.9% |
| Knight Transportation (KNGT) [6] | 0.4% | 9.1% | 6.8% | 3.3% | 9.5% |
| Swift Transportation (SWFT) [6, 8] | -6.7% | 9.2% | -1.8% | 2.8% | 2.1% |
| Werner Enterprises (WERN) [6] | 7.9% | 14.9% | -2.8% | 18.8% | 13.8% |
| U.S. Xpress (XPRSA) [6] | 3.1% | 9.1% | 4.3% | 4.3% | 10.1% |
| **Group Average** | **2.3%** | **12.8%** | **1.3%** | **5.2%** | **8.7%** |
| **Less-than-truckload (LTL) / Other** | | | | | |
| Arkansas Best Corp. (ABFS) | 10.6% | 4.3% | 10.7% | 6.2% | 11.9% |
| CNF Inc. (CNF) | 3.2% | 1.8% | 9.8% | 4.4% | 4.5% |
| Roadway Corp. (ROAD) | -2.7% | 6.8% | 5.3% | 28.3% | 8.4% |
| Ryder System Inc. (R) | -3.7% | 3.5% | 8.4% | 3.1% | 3.3% |
| USF Corporation (USFC) | 6.3% | 7.2% | -9.9% | 4.9% | 5.8% |
| Yellow Corp. (YELL) | 14.6% | 1.0% | -9.2% | 4.8% | 8.0% |
| **Group Average** | **4.7%** | **4.1%** | **2.5%** | **8.6%** | **7.0%** |
| **Trucking Average** | **3.4%** | **8.8%** | **1.9%** | **6.8%** | **7.9%** |

| DEBT RATIO [2,3] | 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|
| **Truckload (TL)** | | | | | |
| Covenant Transportation (CVTI) [6] | 53.6% | 48.6% | 43.4% | 43.1% | 41.9% |
| Heartland Express (HTLD) [6] | 0.5% | 0.4% | 0.3% | 0.2% | 0.2% |
| J.B. Hunt Transport (JBHT) [6] | 56.8% | 58.4% | 49.2% | 42.8% | 34.8% |
| Knight Transportation (KNGT) [6] | 40.4% | 18.6% | 12.2% | 9.7% | 8.5% |
| Swift Transportation (SWFT) [6, 8] | 50.9% | 41.5% | 40.4% | 38.1% | 33.7% |
| Werner Enterprises (WERN) [6] | 17.2% | 8.3% | 3.0% | 0.0% | 0.0% |
| U.S. Xpress (XPRSA) [6] | 65.2% | 66.3% | 65.8% | 64.5% | 60.9% |
| **Group Average** | **40.7%** | **34.6%** | **30.6%** | **28.3%** | **25.7%** |
| **Less-than-truckload (LTL) / Other** | | | | | |
| Arkansas Best Corp. (ABFS) | 42.6% | 33.0% | 29.1% | 13.7% | 4.2% |
| CNF Inc. (CNF) | 46.2% | 53.9% | 49.1% | 47.4% | 45.1% |
| Roadway Corp. (ROAD) | 27.5% | 60.2% | 52.1% | 42.6% | 34.6% |
| Ryder System Inc. (R) | 70.8% | 66.9% | 68.3% | 65.0% | 61.5% |
| USF Corporation (USFC) | 35.6% | 32.0% | 33.2% | 30.6% | 27.6% |
| Yellow Corp. (YELL) | 30.9% | 30.9% | 27.0% | 21.3% | 16.7% |
| **Group Average** | **42.3%** | **46.2%** | **43.1%** | **36.8%** | **31.6%** |
| **Trucking Average** | **41.4%** | **39.9%** | **36.4%** | **32.2%** | **28.4%** |

| FREE CASH PER SHARE | 2000 | 2001 | 2002 | 2003E | 2004E |
|---|---|---|---|---|---|
| **Truckload (TL)** | | | | | |
| Covenant Transportation (CVTI) [5] | 1.97 | 3.07 | 0.75 | (0.41) | (0.22) |
| Heartland Express (HTLD) [6] | 0.03 | 0.65 | (0.14) | 0.50 | 1.10 |
| J.B. Hunt Transport (JBHT) [6] | 0.32 | 3.97 | 0.28 | 0.28 | 2.48 |
| Knight Transportation (KNGT) [6] | 0.02 | 0.45 | 0.36 | 0.20 | 0.67 |
| Swift Transportation (SWFT) [6, 8] | (0.90) | 1.26 | (0.24) | 0.38 | 0.29 |
| Werner Enterprises (WERN) [6] | 0.78 | 1.49 | (0.28) | 2.00 | 1.62 |
| U.S. Xpress (XPRSA) [6] | 0.74 | 2.20 | 1.00 | 0.97 | 2.19 |
| **Group Average** | **0.42** | **1.87** | **0.25** | **0.56** | **1.16** |
| **Less-than-truckload (LTL) / Other** | | | | | |
| Arkansas Best Corp. (ABFS) | 1.95 | 0.80 | 1.98 | 1.11 | 2.06 |
| CNF Inc. (CNF) | (1.97) | 5.05 | (1.74) | 0.70 | 1.61 |
| Roadway Corp. (ROAD) | (0.48) | 2.47 | 1.93 | 9.86 | 3.00 |
| Ryder System Inc. (R) | NM | NM | 3.42 | (0.50) | (0.53) |
| USF Corporation (USFC) | 0.42 | 3.57 | (0.27) | 0.93 | 0.91 |
| Yellow Corp. (YELL) | 3.40 | 0.24 | (1.39) | 0.81 | 1.49 |
| **Group Average** | **0.66** | **2.43** | **0.66** | **2.15** | **1.42** |
| **Trucking Average** | **0.52** | **2.10** | **0.44** | **1.30** | **1.28** |

**Footnotes:**
(1) Total Capital defined as total debt plus total equity, return on average total capital defined as net income + tax affected interest / total debt + total capital leases + total equity.
(2) Debt ratio for includes off-balance-sheet debt.
(3) Debt ratio defined as total debt / total debt + equity (%).
(4) Gross Cash Flow - dividend payouts - maintenance capital expenditures / total debt + total capital leases + total equity.
(5) CVTI reports revenue and fuel expense net of fuel surcharge.
(6) Reported revenue and operating expenses include fuel surcharge revenue and gross fuel expense, respectively.
(7) Total operating expenses as a percentage of total revenue.
(8) SWFT figures either actual or estimated pro forma. Merger with MSCA closed June 29, 2001.

Source: Company reports; Bear, Stearns & Co. Inc. estimates.

## *Disclosures*

Ratings for Stocks (vs. analyst coverage)
Outperform (O) — Stock is projected to outperform analyst's industry coverage universe over the next 12 months.
Peer Perform (P) — Stock is projected to perform approximately in line with analyst's industry coverage universe over the next 12 months.
Underperform (U) — Stock is projected to underperform analyst's industry coverage universe over the next 12 months.

Ratings for Sectors (vs. regional broader market index)
Market Overweight (MO) — Expect the industry to perform better than the primary market index for the region over the next 12 months.
Market Weight (MW) — Expect the industry to perform approximately in line with the primary market index for the region over the next 12 months.
Market Underweight (MU) — Expect the industry to underperform the primary market index for the region over the next 12 months.

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