**Stanford Global Supply Chain
Management Forum**

Supply Chain Security – Are You Ready?

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Executive Summary

Today's supply chains are vulnerable to security threats and the uncertainties associated with them. While governments and the private sector are working together to launch new initiatives to create more secure and reliable supply chains, industry is rapidly exploring the potential of new technologies such as RFID towards the same goals. We conducted a study based on a panel of leading shippers to understand better the key problem areas faced by shippers in international shipping, the current capabilities of shippers in gaining control of their supply chain information, the potential of RFID in addressing these problems areas, and the investment plans in RFID of the shippers.

Our shippers' biggest performance objectives are still the ultimate dual goal of reducing stockouts and inventory. These two objectives directly impact a company's bottom line. In pursuing these objectives, our shippers found that the biggest pain points faced by them are uncertainties and lead time in customs and transit, as well as the visibility of their products en route from the origin ports to the destination ports. While some capabilities to give visibility in a supply chain exist today, they are still quite limited.

To address the biggest pain points so as to achieve the dual goal of reducing stockouts and inventory, our shippers did see RFID technologies as a potential avenue. Indeed, after adjusted for the significance of the problem areas, RFID was found to focus precisely on the problems of uncertainties in customs and transit, and en route visibility. Moreover, RFID also holds the promise of providing order and product content information efficiently. Our shippers seem to be putting their views in action, as 75% of them are expecting to have RFID deployed in their supply chain by 2006 or 2007.

This report confirms the commonly held thought that RFID could be a major technology that improves supply chain security and confidence. Our study has indicated the exact problem areas that are both important and effectively addressed by RFID.

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1. The Need for Supply Chain Security and Confidence

September 11, 2001 was a wake-up call to the importance of supply chain security. International shipments, especially ocean containers, in a global supply chain are most vulnerable to security threats. More than 90% of world trade involves containers aboard ships, amounting to about 20 million containers trips annually (Cuneo, 2003). For the US, 17,000 containers arrive at US ports each day. The economic impact of terrorist attacks using weapons of mass destruction (WMD) can be disastrous (Mottley, 2002). WMD can result in significant loss in human lives, destruction of infrastructure, and erosion of public and business confidence. Prevention activities, such as increased inspection, information exchange, training and education, insurance premiums, and monitoring efforts can also be a major economic drain that could threaten global trade and prosperity.

Besides WMD, supply chain security is also threatened by a host of potential illicit behaviors, which could make use of the international cargo system to further their interests. Cargo security therefore encompasses: contagions, import/export duties, theft/pilferage, contraband, drug smuggling, product counterfeiting, people smuggling, and environmental hazards, etc.

Governments and industry have already responded with proposals to create more confidence in supply chain security, while maintaining smooth flows of goods and services in a global supply chain (see, for example, Stein, 2004). Some of these proposals call for increased information exchange among trading partners, ports, shipping companies, and the governments. Some call for heightened inspection and scrutiny of the goods flowing through a supply chain. These measures can add cost, delays, and uncertainties in the supply chain. At the same time, supply chain disruptions resulting from security breaches can be disastrous.

The private sector has also experienced the cost of heightened security in the form of reduced supply chain confidence. Freight and insurance rates have risen. For example, since September 11, 2001, the general liability rates for trucking companies have increased by an average of 32% as carriers renewed their policies in the subsequent year (Hannon, 2002). The longer cycle time of the supply chain due to longer delays in getting goods through the global supply chain threatens supply chain practices such as Just-in-Time and lean inventory processes. Some companies have expanded their supply bases and source from higher cost local suppliers to safeguard against potential international transportation disruptions.

One technology has been heralded to hold promise as a means to help companies increase supply chain security and confidence. RFID (radio-frequency identification technology) can be used to track the movements of containers, providing in-transit visibility to shippers (companies that contract carriers to ship products), customs, carriers, port infrastructure operators, and other interested parties. It can also enable easy transfer of important information on the contents of the containers, the routing of the shipments, and the condition of the containers in transit, such as humidity and temperature. Finally, RFID can be the basis of sealing technologies for containers to ensure that the containers have not been tinkered, tampered, or opened without authorization. The "Smart and Secure Tradelane" initiative is an example of the use of such a technology. All these applications of RFID can potentially help to improve supply chain security and restore supply chain confidence, so that one can potentially achieve "supply chain security without tears (Lee and Wolfe, 2003)."

As part of an on-going set of research projects at Stanford University on the impact and evolution of ubiquitous technologies (such as RFID, smart phones, smart objects, and others) on the global supply chain, we have focused on studying how some companies view the potential of RFID on supply chain security. Parallel studies are also being conducted on supply chain security – specifically, we are pursuing detailed economic studies to quantify the benefits of Smart and Secure Tradelane and other initiatives (see Lee and Whang, 2004).

This report gives results of a focused study on the views of a sample of US shippers on the subject of supply chain security and the role of RFID. The objectives of this study are three-fold:

1. To identify the major challenges faced by leading shippers in assuring supply chain security and maintaining supply chain confidence.
2. To assess the current capabilities of leading companies in addressing the need to provide supply chain security and confidence.
3. To explore the potential value of RFID, and the willingness of shippers to invest in such a technology, towards improving supply chain security and confidence.

The study was based on a detailed questionnaire survey completed by a set of eight targeted shippers. These shippers represented industry segments like: general merchandiser importer, automotive parts, linen apparel and home furnishing, mass merchandise discount retailer, club-based retailer, office equipment and optical electronics manufacturer, pharmaceutical manufacturer, and automobile safety systems. This is a set of leading shippers with tradelanes with originating ports like Japan, Hong Kong, Yantian (China), Kaohsiung (Taiwan), Long Beach, Detroit, Antwerp, Paris, Frankfurt, London, Chicago, and other South-East Asian countries; and destination ports like Long Beach, Baltimore, Halifax, Vera Cruz, Yokohama, Rotterdam, New York, Brazil, Frankfurt, Chicago, Keelung (Taiwan), and Busan (Korea). The respondents of our survey hold titles like Chief Supply Chain Officer, EVP of Logistics and Allocation, VP and General Manager of Logistics, Manager of Logistics Services, Distribution Leaders, and Director of Customs Compliance. Nevertheless, we note that although the study results indicate solid evidence, the reader

should be cautioned that the small sample size means that the study results are subject to statistical errors.

2. Background on Some Initiatives for Supply Chain Security

In the past two years, the governments of the US and its trading partners have instituted some security initiatives that are focused on prevention instead of final inspection (see, for example, Aichlmayr, 2002; and McHugh and Damas, 2002). Parts of this section can be found in Lee and Whang (2004).

The US Customs has instituted an Advanced Manifest Rule (AMR) in February, 2003, which requires detailed cargo data be submitted to US Customs at least 24 hours prior to lifting containers to a US-bound ship. When fully implemented, containers will only be allowed into the US if detailed contents information has been provided electronically to Customs at least 24 hours before the container is loaded on the ship. The information will be useful to pre-screen questionable containers prior to arrival to US ports and select containers for inspection at ports of entry. Besides US ports, the World Customs Organization (WCO), based in Brussels, has also been developing standard sets of customs data elements and guidelines for member countries to enable advanced electronic transmission of such data (Gillis, 2002).

US Customs has also launched the Container Security Initiative (CSI) and the Customs-Trade Partnership Against Terrorism (C-TPAT) in January and April of 2002, respectively. The C-TPAT program involves multiple countries, and promotes the use of best security practices. Shippers and carriers that certify the use of best security practices are given expedited processing at US ports of entry. Manufacturers, importers, carriers, and third party logistics service providers can all participate by submitting detailed questionnaires and self-appraisals of their supply chain security practices, while Customs would perform periodic audits and verifications of such practices.

Under CSI, the US and some trading partner governments are also pursuing supply chain security by pushing inspections and screening upstream to originating ports. CSI focuses on the twenty ports where most of the US-bound containers originate. The goal is a series of bilateral agreements that would permit exchange of Customs officers and more screening of shipments at the outbound ports. The processes involved in pick and pack, staging of outbound loads, and the final loading, are to be tightly monitored and documented (e.g., the identities of pickers, packers, loaders, checkers, and if any seals are used on the container, etc.).

To assure complete supply chain security, we also need to monitor the shipments while they are in transit. Any tampering of the containers would have to be detected. On July 2, 2003, U.S. Senator Patty Murray of Washington State, Chairman of the US Senate Appropriations Committee's Subcommittee on Transportation, announced the formation of the Smart and Secure Tradelane initiative (SST). Under this initiative, the world's three largest seaport operators – Hutchison-Whampoa Ltd, PSA Corporation Ltd., and P&O Ports

– representing over 70% of the world's container traffic, will collaborate to demonstrate and deploy automated tracking detection and security technology for containers entering US ports (see McHugh and Damas, 2002, and Cuneo, 2003, for more details). Hence, containers leaving the participating ports will eventually be equipped with special electronic seals that could be used to track whether the containers have been tampered with during transit. Containers identified can then be sorted out for special inspection. A by-product of such monitoring efforts is cargo handling accountability theft reduction due to the authenticated and auditable chain-of-custody these systems enforce.

More recent developments include the development of "smart" containers, with containers built with sensors so that the condition of the containers in transit, such as humidity and temperature, can also be monitored.

Figure 1 describes the potential savings from the use of RFID-based technologies in a trade lane.

Figure 1: Potential Savings from RFID-Based Technologies

| Cost Category	Cost Elements	Comments
Bill-of-Lading Compliance	• Direct labor cost savings • In-transit inventory reduction due to more efficient BOL transmission process	These savings are independent of the amount of inspection carried out at the port of entry, and are a function of how much the current process has already been automated.
Tracking Efficiency	• Reduction in inspection cost • Reduction in pilferage • In-transit inventory reduction due to less inspection	These savings depend on how much reduction of inspection that Customs will give for containers with tightened & monitored security. Pilferage reduction is due to tighter monitoring of the in-transit process.
Supply Chain Confidence	• Safety stock reduction as a result of reduction in the mean and variance of lead time • Safety stock reduction as a result of transparency of advanced lead time information (e.g. delays, product damage/spoilage)	These savings depend on how much reduction in the mean and variance of lead-time can be achieved with increased visibility. The manufacturer should also have an advanced scientific inventory control system in place to take advantage of such improvements.

3. Shipping Pains

What are the priorities of shippers regarding their global supply chain shipment? We asked our respondents to rank a list of supply chain performance objectives that indicate the importance and priorities of these objectives at the company:

- Reduced foreign-to-domestic transit time
- Reduced stock-outs
- Reduced inventory carrying costs
- Reduced labor & admin for transportation & logistics management
- Increased flexibility of the flow of goods
- Early warning for damaged goods
- Reduced theft during transit
- Increased customer service (delivery windows, defective identification, reroute substitutes)
- Compliance with DoD, Wal-Mart, US Customs & other mandates
- Reduced product stagnation/obsolescence

Figure 2 shows the average ranking on these priorities (note that the higher the score, the higher the priority).

## Figure 2: Priorities in International Logistics
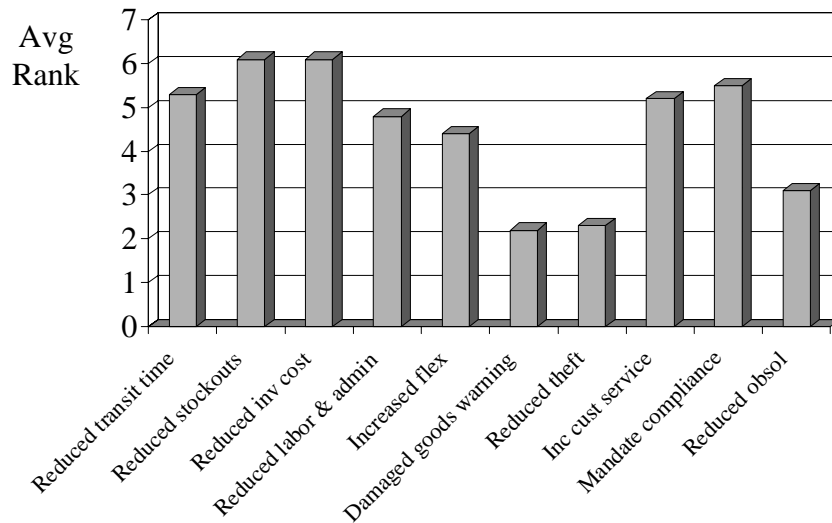
The highest priorities of shippers seem to be reducing both stockouts and inventory costs. Interestingly, these two objectives are often viewed as competing with one another, i.e., lowering inventory would increase stockouts. But shippers are definitely trying to accomplish the dual goal of reducing BOTH stockouts and inventory, and these two objectives receive almost equal average top rankings. Interestingly, the dual goals of reduced stockouts and inventory are also high priorities to companies that are piloting RFID in the US and Europe. The next highly ranked objectives are reducing transit time, improving customer service, and complying with key mandates related to information requirements by key customers or government. While companies are pursuing key supply chain performance objectives, they also have experienced major pain points and challenges

in international shipping. The respondents were asked to rank the following international shipping problems, and their average rankings are shown in Figure 3:

- Customs clearance prior to port of departure
- Increased/uncertain lead times due to time in customs
- Increased/uncertain lead times due to transportation time variability
- Quantity received incorrect due to wrong amount shipped
- Quantity received incorrect due to pilferage en route
- Quantity of received acceptable goods incorrect due to damage en route
- Uncertainty caused by lack of visibility of what is en route and where it is
- Concern regarding whether illegal items were smuggled in your container
- Concern regarding whether terrorists could use your container
- Time and cost to receive order and confirm shipment contents
- Compliance with Wal-Mart RFID Mandate
- Compliance with US Dept of Defense RFID Mandate
- Lack of knowledge of conditions within container (humidity, temperature, etc.)
- Cost to insure cargo
- Others

Figure 3: Problems in International Shipping
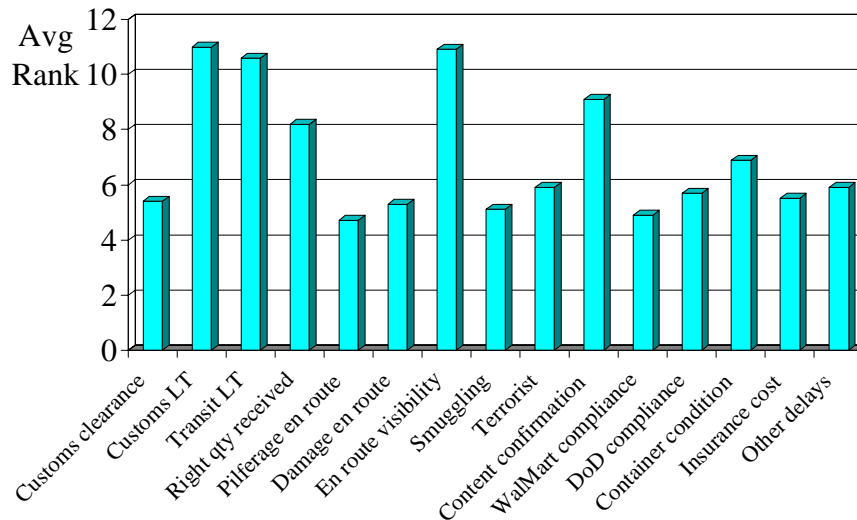
In addition to the list above, one of our respondents identified as his company's concerns the possible delays caused by other government agencies.

To support the priorities of the companies, the shippers found that the biggest problems faced by them in international shipping were lead times of going through customs and in transit, as well as the ability to have en route visibility. All these three problems together create greater uncertainties in the supply line of a supply chain. Supply uncertainty

is known to have a great impact on safety stock and product availability. Hence, our shipper executives recognized supply uncertainties as the biggest problems that inhibit them from achieving their prioritized objectives of reducing stockouts and inventory. The implication is that shippers must find ways to reduce the uncertainties induced by customs clearance and transit, and at the same time, provide the information (visibility) en route to show how these uncertainties are unfolded.

The emergence of uncertainties in customs and transit, and en route visibility, as the biggest problems faced by shippers, is easily understandable. With the threat of terrorists and other supply chain security initiatives, the uncertainties and the lead times in customs and transit have increased. The lack of visibility en route makes the uncertainty problem worse, since shippers could not have early information to be proactive and respond to any supply disruptions or delays.

Another significant problem identified by our shipper executives is the resources needed to obtain order and confirm shipment contents. Again, this is a problem related to the efficiency and timeliness of shipment information, the criticality of which has been amplified as a result of supply chain security threats and the current ongoing supply chain security initiatives.

We can therefore summarize that, to support the prioritized objectives of reduced stockouts and inventory, companies need to find ways to:

1. Reduce the uncertainties from customs clearance and transportation.
2. Provide information/transparency for products in transit, as well as shipment contents.

4. Current Capabilities

Recognizing the high prioritized objectives and the biggest problem areas confronted by shippers, let us now examine what level of capabilities exist today to help our shippers to gain control of their supply chain in international shipping.

Recall that having en route visibility was viewed as a major problem area by shippers. Yet we are far from having that visibility today. We asked our respondents whether they currently have the capabilities to get information and visibility on a number of areas:

- Scanning when loaded for international transport
- Scanning at intermediary points (inter-modal change or transfer)
- Scanning upon receipt at final destination
- GPS tracking of container
- Proactive reports when container deviates from planned route or timing
- Others

In addition, we asked whether the company would be investing in these areas. Figure 4 shows the results.

Figure 4: Current Visibility Capability for International Shipping

Percentage of respondents with capability
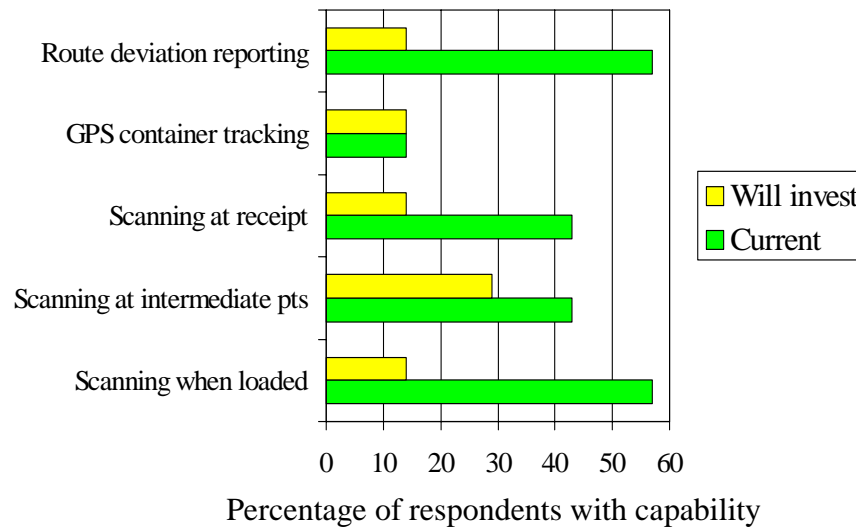
Only slightly more than half of the shippers have capability to have scanned information of their product when they were loaded for international transport, or have proactive reports on container route or timing deviations. Less than half have scanned information at intermediate points in transit or upon receipt at final destination. Only 14% had GPS container tracking. For companies not having such capabilities currently, some are planning to invest in the near future. It is clear that, while recognized as a major problem area to support the top prioritized objectives, the capability of supply chain visibility is far from being there for many companies. This is especially important in light of the fact that our respondents are already industry leaders in supply chain management. The investment holdouts could be a result of some shippers not confident of the visibility tools that are in the market.

Next, as customs and transit times are also viewed as key problem areas, we investigated the use of special actions to help speed up the customs and receiving process. Since transportation carriers often operate customs and transportation, we asked the respondents whether their transportation providers perform any of the following special actions:

- Advanced notice of contents sent to final destination
- Advanced notice of contents sent to customs
- Updates of altered delivery time/contents sent to final destination

- Updates of altered delivery time/contents sent to customs
- Shipper works directly with customs to become trusted shipper, allowing them to bypass some inspections
- IT systems between your firm and the logistics provider share data effectively
- CTPAT certification
- Others

Figure 5 shows the result.

Figure 5: Capability by Transportation Provider

Percentage of respondents with providers having capability
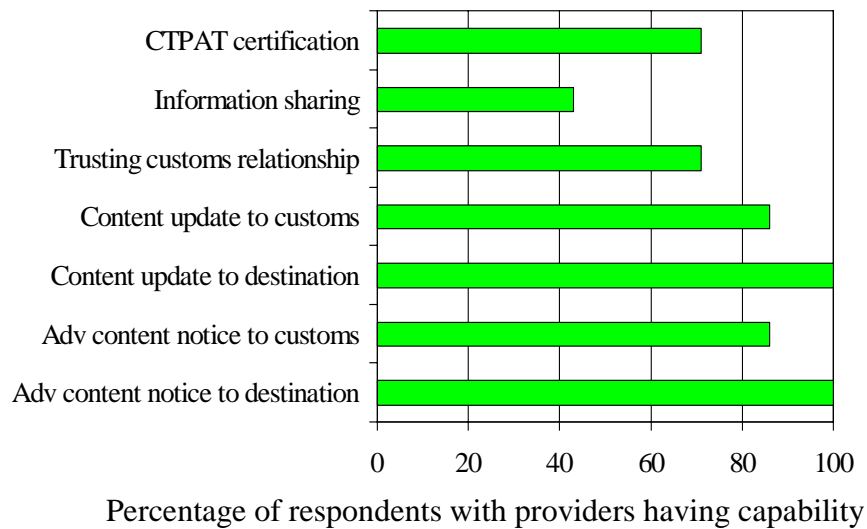
The transportation companies are able to provide advanced notice of contents sent to both final destination and customs. This could be a result of the success of AMR. The majority of the transportation companies are also able to provide altered delivery time/contents sent to final destination and to customs for the purpose of customs and receiving processes. Note that, in Figure 4, there were less than 60% of the companies who had the capability of having container route and timing deviations reported, but in Figure 5, more than 80% of the transportation companies did have the capability to provide content/delivery time update to customs and 100% could provide the same update to the final destination. The difference between Figure 4 and 5 on this issue indicate that, while transportation companies are able to provide such information to the receiving side and customs, some of the shippers may not get this information promptly to use it proactively for planning or re-planning.

Finally, we still have to work on getting more transportation companies to be able to share data with the shipper in an integrated fashion.

Of the eight shippers that we studied, three of them have three or more of the five capabilities described in Figure 4. We label these companies as ones that have higher capability levels currently. We then examine whether this set of companies would have the same views as the others on the problem areas on international shipping as identified in Figure 3. Figure 6 compares the average ranking of these problems areas by the high capability companies, versus those of the overall sample average.

Figure 6: Problems in International Shipping for Shippers with Higher Capability Levels
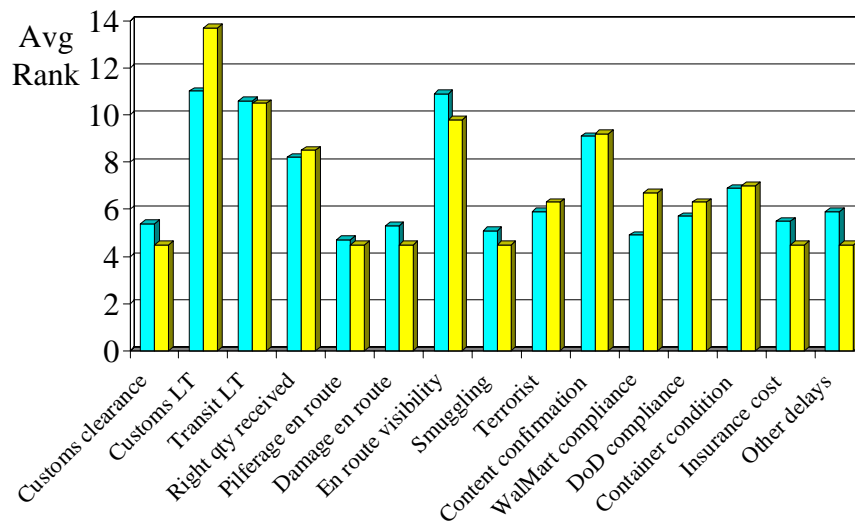
In Figure 6, the blue bars represent the average rankings of the problem areas by the overall sample, while the yellow bars represent the corresponding rankings by the high capability companies. It is interesting to note that the average rankings are very similar, with one exception. The uncertainties and lead times of customs become a much more significant problem identified by the high capabilities companies. In other words, for companies that have high capabilities of scanning and tracking today, they viewed customs uncertainties as their number one concern.

5. Potential of RFID Technology

Can RFID technology help to address the concerns and problems of international shipping? We asked our respondents their assessment of RFID's potential in alleviating the problems identified in Section 3. Each respondent was asked to rank the top 5 areas in which the technology could help. Since we have 14 problem areas listed, we gave, for each respondent, a rank of 10.5 for all the areas that the respondent did not pick as the top 5 for the ranking. This allows us to compute average rankings for all the problem areas. Figure 6

shows such average rankings. We also note that, for one respondent, RFID is viewed as a means to help address the counterfeit problem, which was one that was not listed in the original 14 areas.

Our shipper executives clearly identified the provision of en route visibility as the number one problem that RFID can help. Other highly ranked areas are reducing transit lead-time and uncertainties, reducing customs lead time and uncertainties, and providing and confirming content information.

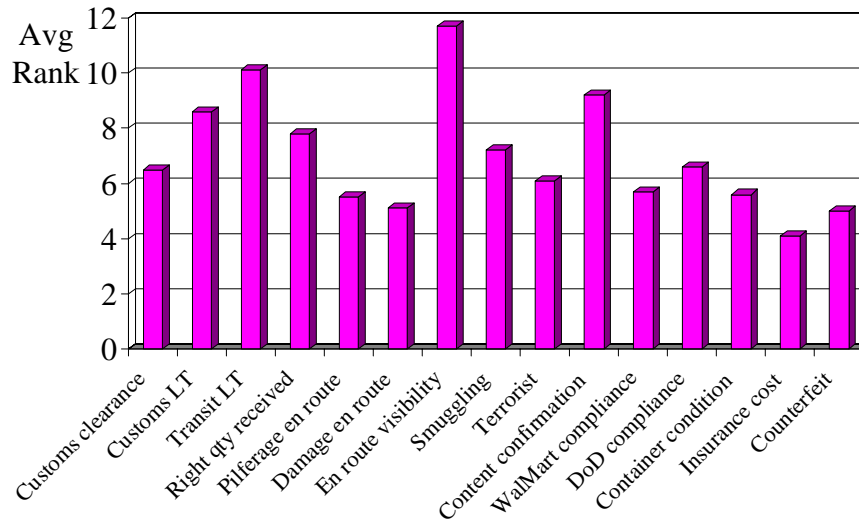# Figure 7: Effectiveness of RFID

Figure 7 only gives the direct assessment by the respondents on the potential effectiveness of RFID in addressing the problem areas. But we note that the rankings of the significance of these problem areas, as shown in Figure 3, are not uniform. So we attempted to examine the value of RFID towards the problem areas by weighting the problem areas in terms of the significance of the problem areas as viewed by shippers. Specifically, the weighting adjustment works in the following way.

Let *Value_Rank(i)* be the average ranking of the effectiveness of RFID towards problem area *i* (as represented by Figure 7).

Let *Significance_Rank(i)* be the average ranking of the significance of problem area *i* (as represented by Figure 3).

We compute the weight of problem area *i* as:

$$Weight(i) = \frac{Significance\_Rank(i)}{\sum_{j} Significance\_Rank(j) / Numberof\ \Pr oblemAreas}$$

The weighted ranking of the effectiveness of RFID, or *Wtd_Value_Rank*(*i*), is given by:

$$Wtd\_Value\_Rank(i) \ = \ Weight(i)* Significance\_Rank(i)$$

The weight given to a problem area is the original ranking divided by the average of all the average ranks. Hence, a ranking that is higher than the average will have a weight greater than one; while a ranking that is lower than the average will have a weight less than one. When the weight is applied to the ranking of the effectiveness of RFID, we can then have a combined value of RFID due to its effectiveness towards the problem area, AND the significance of the problem area. For example, the effectiveness of RFID towards one problem area would be adjusted upwards to a higher ranking, if the weight of this problem area were greater than one. On the other hand, the effectiveness of RFID towards a problem area would be adjusted downwards to a lower ranking, if the weight of this problem area were less than one.

Applying the weight to the average ranking of the effectiveness of RFID (Figure 7), we obtain the weighted ranking, given by Figure 8.

<p style="text-align:center">Figure 8:
Effectiveness of RFID Weighted by Problem Severity</p>
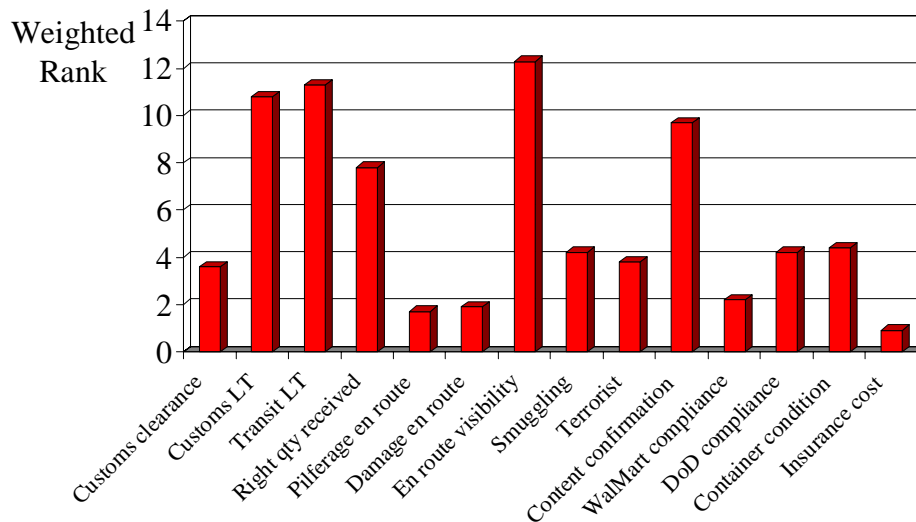
The average rankings in Figure 8 are much more polarized than those of Figure 7, i.e., the top ranked areas are even more highly ranked now; and the low ranked areas are even more lower ranked. Once the significance of the problem area is taken into account, we are able to differentiate even more concretely the most important areas that RFID can contribute to. Once adjusted for the significance of the problem areas, the problem areas in which the greatest potential values of RFID could be found are:

1. En route visibility
2. Reduce uncertainties and lead time in transit
3. Reduce uncertainties and lead time in customs
4. Provide and confirm information on order and content

One word of caution – it is possible that some respondents may have high expectations of RFID in addressing their biggest needs. As a result, they may give higher rankings to the impact of RFID on the problem areas of greatest importance to them. It is therefore possible that a respondent may "wish" that RFID could help to alleviate their operational pains, as opposed to the real belief that RFID could actually be effective to address those pains. Such bias could exist.

6. Investment and Returns on RFID Projects

Given the promise of RFID towards addressing the key problem challenges identified by shippers, which in turn could help them gain control of the key performance objectives of reducing stockouts and inventory, we next examine the shippers' willingness to invest and their expected returns.

Today, RFID is still an evolving technology, with adoption mostly limited to innovators in industry, and industry standards are just emerging. Hence, our shippers are quite realistic in their required minimum payback from new technology projects. One of our shippers indicated that their minimum payback was 50% *incremental* of the investment within 2 years. Another indicated 100% as the minimum incremental payback within 1 year, while one had 100% within 3 years. But the majority (63%) indicated that their minimum expected payment was 100% incremental of the investment within 2 years.

Figure 9: Minimum Return for New Technology Project
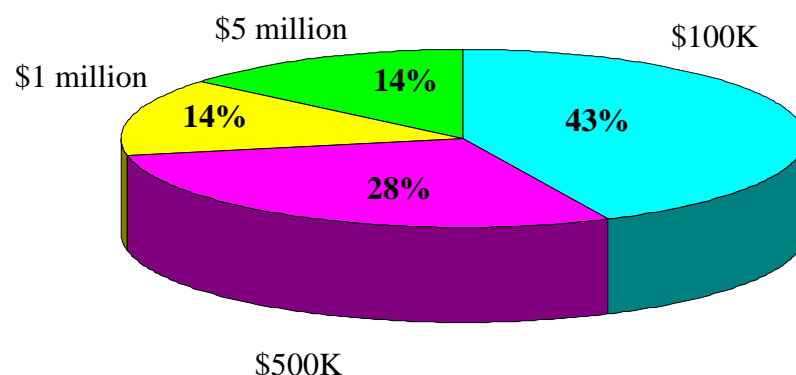
In dollar values, shippers naturally would expect a minimum return for any new technology investment, or else they would not be interested in the project. Figure 9 shows the distribution of the minimum dollar returns that our shippers demanded from new technology investment.

Interestingly, the majority of the shippers are requiring minimum returns from new technology investments that are below $1 million.

The advancement of RFID seems to be unstoppable. 63% of the shippers claimed that they would have the RFID technology deployed in their supply chain in 2006, while 13% claimed the corresponding time to be 2007.

7. Summaries and Conclusion

Today's supply chains are vulnerable to security threats and the uncertainties associated with them. While governments and the private sector are working together to launch new initiatives to create more secure and reliable supply chains, industry is rapidly exploring the potential of new technologies such as RFID towards the same goals. With all these new developments, this study gives a glimpse of how companies were coping with the problems of supply chain security and confidence, and assesses the effectiveness of RFID accordingly.

Our study was based on a panel of leading shippers, and although this is not a complete representation of the universe of shippers, we think valuable insights have been observed. Our shippers' biggest performance objectives are still the ultimate dual goal of reducing stockouts and inventory. These two objectives directly impact a company's bottom line. In pursuing these objectives, our shippers found that the biggest pain points faced by them are uncertainties and lead time in customs and transit, as well as the visibility of their products en route from the origin ports to the destination ports. These problems are naturally linked to the increasing threat of supply chain security glitches, and the existence of the many security initiatives in place.

Currently, the capabilities of shippers and transportation carriers in providing information to give more visibility to the supply chain are still limited. To address the biggest pain points so as to achieve the dual goal of reducing stockouts and inventory, our shippers did see RFID technologies as a potential avenue. Indeed, the effectiveness of RFID, after adjusted for the significance of the problem areas, was found to be exactly helping to address the problems of uncertainties in customs and transit, and en route visibility. Moreover, RFID also gives the promise of providing order and product content information efficiently.

Our shippers seem to be putting their views in action, as 75% of them are expecting to have RFID deployed in their supply chain by 2006 or 2007.

This report confirms the commonly held thought that RFID could be a major technology that improves supply chain security and confidence. Our study has indicated the exact problem areas that are both important and can be effectively addressed by RFID.

Acknowledgment

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