Analyzing the Use of Radio Frequency Identification (RFID) on the Container Industry

by

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National Technical University of Athens, 2004

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Master of Science in Ocean Systems Management

at the

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June 2007

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Abstract

After the terrorist attacks of 9/11 US realized the importance of building and maintaining a secure environment that would protect US borders. The significance of having a secure supply chain in the US is apparent, since the amount of cargo containers that enters US borders through ports is at an all time high.

To ensure that, US government bought a new set of policies which have as their main purpose to ensure that the shipments that will enter its borders will not jeopardize US public, but also maintain the smooth operation of country’s trade relations after unforeseen events. This legal framework encourages the application of tracking applications/solutions that could provide visibility and security across the supply chain. One of the promising technologies that allows tracking of shipping containers, from their origin to destination is the application of Active RFID tags in a network that would allow tracking of the container movement on an end-to-end basis.

Through this study, we examine the parts and operation of such a solution, the parts and main characteristics of this technology. We set forth the potential benefits and the potholes that could make at the moment such a solution to fail, if the industry does not try to repair the systems faults and shows overconfidence in the proposed technology.

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Department of Mechanical Engineering, MIT
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A thank you goes to my parents, who supported me and encouraged me in continuing my studies in the US.

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# TABLE OF CONTENTS

Abstract ............................................................................................................................... 3  
ACKNOWLEDGMENTS ................................................................................................. 4  
TABLE OF CONTENTS ............................................................................................... 5  
LIST OF FIGURES AND TABLES ................................................................................ 6  
CHAPTER 1 - Container trade overview ........................................................................ 7  
1.1 Introduction ........................................................................................................... 7  
1.2 Studying the global containerized trade ............................................................... 8  
1.3 Containerized trade in the US ............................................................................. 10  
1.4 Concerns of the container trade in the US .......................................................... 14  
CHAPTER 2 - Security issues ..................................................................................... 15  
2.1 Importance of transparency for Port Security .................................................... 15  
2.2 Pilferage incidents ............................................................................................... 21  
2.3 Trojan box ............................................................................................................ 23  
2.4 US Customs Service view ................................................................................... 26  
2.5 Seeking a solution ............................................................................................... 29  
CHAPTER 3 - Port Security Initiatives ..................................................................... 30  
3.1 24-Hour Advance Manifest Rule ........................................................................ 31  
3.2 Container Security Initiative ............................................................................. 34  
3.3 Customs Trade Partnership Against Terrorism .................................................. 46  
3.4 The Smart and Secure Trade Lanes Initiative ..................................................... 53  
3.4.1 SST Participants .............................................................................................. 55  
3.4.2 The SST Solution .......................................................................................... 56  
3.4.3 Joining SST .................................................................................................... 60  
3.5 Conclusion ........................................................................................................... 62  
CHAPTER 4 - RFID Technology .............................................................................. 63  
4.1 Description and Comparison of RFID Technology ............................................. 63  
4.2 Radio Frequency range ....................................................................................... 69  
4.3 Legal framework .................................................................................................. 74  
4.4 Applications over the Supply Chain .................................................................... 78  
CHAPTER 5 - Proposed RFID usage - claimed benefits - impact .......................... 82  
5.1 Introduction ......................................................................................................... 82  
5.2 Proposed RFID usage ........................................................................................ 84  
5.3 Claimed benefits ................................................................................................... 85  
5.3.1 Claimed benefits (of quantifiable monetary value) ........................................ 86  
5.3.2 Claimed benefits (of unquantifiable monetary value) .................................... 88  
5.4 Break Even Point of the Project ........................................................................ 97  
5.5 Conclusion .......................................................................................................... 100  
CHAPTER 6 - Potholes ........................................................................................... 101  
CHAPTER 7 - Conclusions and recommendations .................................................. 107  
BIBLIOGRAPHY ......................................................................................................... 111  
APPENDIX .................................................................................................................. 114
LIST OF FIGURES AND TABLES

Figure 1.1 Containerized Waterborne Cargo Movements in the US 1997-2005........... 10
Figure 1.2 Import in main US ports (1997-2005)...................................................... 12
Figure 4.1 Electromagnetic radiation characteristics.................................................. 64
Figure 4.2 Regions of RFID regulations and standardization..................................... 74
Figure 5.1 Active RFID application on container across the supply chain .................. 84
Figure 5.2 Probability distribution of predicted Savings per container ....................... 92
Figure 5.3 Benefits per container Vs Value of Goods.................................................. 94
Figure 5.4 Benefits per container Vs Stock Outs that result in Missed Sales.............. 94
Figure 5.5 Benefits per container Vs Change in Transit Time...................................... 95
Figure 5.6 Benefits per container Vs Change in Transit Time Variance....................... 95
Figure 5.7 NPV Vs Number of Containers.................................................................... 99

Table 1.1 Forecast of global TEU movement................................................................. 9
Table 1.2 Total Cargo Waterborne Movement, Imports, Exports and their growth...... 10
Table 1.3 Imports of the main US ports in TEU’s....................................................... 11
Table 1.4 Statistical data of the imported TEU’s in the top first ports ......................... 12
Table 1.5 U.S. Waterborne Foreign Container Trade by Trading Partner.................. 13
Table 1.6 Statistical data of the imported TEU’s from US’s main trade partners.......... 13
Table 3.1 Shipping rates for Santos-Baltimore............................................................ 43
Table 3.2 Shipping rates for Casablanca-Baltimore...................................................... 44
Table 4.1 Comparison of Technical characteristics between Active and Passive RFID tags................................................................................................................................. 65
Table 4.2 Functional capabilities of Passive and Active RFID tags........................... 68
Table 4.3 Performance of Passive RFID tags.............................................................. 70
Table 4.4 Acceptance of common Active RFID system frequencies in major countries. 77
Table 4.5 Applications of Active and Passive RFID systems for supply chain visibility 81
Table 5.1 Costs.............................................................................................................. 97

Graph 4.1 Operating ranges of the RFID systems...................................................... 69
Graph 4.2 Frequencies between 100MHz and 1 GHz offer the best technical performance for Active RFID .............................................................. 72
1.1 Introduction

Growth in the container trade is ultimately driven by economic growth. A supporting assumption toward that direction is that for the next decade at least, the structural relationships between the growth in container trade and economic growth will remain basically unchanged. There is no doubt that the economic growth is in parallel with the container growth which is mainly driven by China’s growth which is the leading trade partner of the US.
1.2 Studying the global containerized trade

An analysis\textsuperscript{1} from the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) gives a fair estimation on the growth of the global container trade in the below Figure 1.1. The volumes which are shown in the figure below refer only to full origin-destination containers. Every container is counted only once during its movement from its origin to its destination, regardless if it was unloaded and the loaded again, no matter how many times it was handled as a transshipment.

![Figure 1.1 Forecast of total TEU movement](image)

In order to accomplish such a study it was necessary to estimate separate forecasting equations for each different country of the ESCAP region. For non-ESCAP countries, separate equations were estimated for each ‘region’, which was defined as a group of countries. In some of the cases, the historical time series data which was used was clearly not able to support a formal regression process. This was the case where the country was still in the very early stages of containerization. In such a case, it was necessary to have a group of experts giving their professional judgment, based on an examination of the

\footnote{www.unescap.org/tidw/Publications/TFS_pubs/pub_2398/pub_2398_ch3.pdf}
history of containerization in similar countries during a similar phase of economic development.

Estimations from this study show that the total number of full containers (as explained above) shipped internationally is expected reach 177.6 million TEU by 2015, up from an estimated 77.8 million TEU in 2002, but at a slower rate of 6.6 percent per annum compared to 8.5 percent per annum during 1980-2002. Average growth in the first half of the 2010’s is expected be less than in the 2000’s: 7.5 percent per annum is expected during the period 2002-2010, falling to 5.0 per cent per annum in the five subsequent years.

These comparisons are summarized in the following Table 1.1. Comparisons of the study’s forecasts with those provided by private consulting firms suggested that these global level estimates are within the range of expert opinions, but slightly towards the more conservative end of that range.

<table>
<thead>
<tr>
<th>Year</th>
<th>Containers Volume (in millions TEU)</th>
<th>Compound average growth rate over previous period</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>13.5</td>
<td>-</td>
</tr>
<tr>
<td>1990</td>
<td>28.7</td>
<td>7.8%</td>
</tr>
<tr>
<td>2000</td>
<td>68.7</td>
<td>9.1%</td>
</tr>
<tr>
<td>2010</td>
<td>138.9</td>
<td>7.3%</td>
</tr>
<tr>
<td>2015</td>
<td>177.6</td>
<td>6.0%</td>
</tr>
</tbody>
</table>

Table 1.1 Forecast of global TEU movement
1.3 Containerized trade in the US\textsuperscript{2}

Imports, export and the total volumes moved in the US can be seen in the following Tables and Graphs. The above statistics include government and non-government shipments by vessels into and out of U.S. foreign trade zones, the 50 states, District of Columbia, and Puerto Rico.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Imports</th>
<th>Imports Growth</th>
<th>Total Exports</th>
<th>Exports Growth</th>
<th>Total TEU'S movement</th>
<th>Total Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>7,787,430</td>
<td>-</td>
<td>7,072,938</td>
<td>-</td>
<td>14,860,367</td>
<td>-</td>
</tr>
<tr>
<td>1998</td>
<td>8,919,223</td>
<td>14.5%</td>
<td>6,637,032</td>
<td>-6.2%</td>
<td>15,556,255</td>
<td>4.7%</td>
</tr>
<tr>
<td>1999</td>
<td>9,960,465</td>
<td>11.7%</td>
<td>6,603,324</td>
<td>-0.5%</td>
<td>16,563,789</td>
<td>6.5%</td>
</tr>
<tr>
<td>2000</td>
<td>11,086,604</td>
<td>11.3%</td>
<td>6,851,065</td>
<td>3.8%</td>
<td>17,937,670</td>
<td>8.3%</td>
</tr>
<tr>
<td>2001</td>
<td>11,268,347</td>
<td>1.6%</td>
<td>6,848,234</td>
<td>0.0%</td>
<td>18,116,582</td>
<td>1.0%</td>
</tr>
<tr>
<td>2002</td>
<td>12,915,512</td>
<td>14.6%</td>
<td>6,813,910</td>
<td>-0.5%</td>
<td>19,729,422</td>
<td>8.9%</td>
</tr>
<tr>
<td>2003</td>
<td>13,899,132</td>
<td>7.6%</td>
<td>7,389,413</td>
<td>8.4%</td>
<td>21,288,545</td>
<td>7.9%</td>
</tr>
<tr>
<td>2004</td>
<td>15,805,478</td>
<td>13.7%</td>
<td>8,045,045</td>
<td>8.9%</td>
<td>23,850,523</td>
<td>12.0%</td>
</tr>
<tr>
<td>2005</td>
<td>17,290,350</td>
<td>9.4%</td>
<td>8,577,808</td>
<td>6.6%</td>
<td>25,868,158</td>
<td>8.5%</td>
</tr>
</tbody>
</table>

Table 1.2 Total Cargo Waterborne Movement, Imports, Exports and their growth.

From the data shown above, it is evident that there is an increasing pattern in the movement of containers making it a major issue in the US trade. For our analysis, we will focus on the imports and their growth of the last years which is steadily around 10.6%, with a standard deviation of 4.37%.

During the period 1999 to 2004, U.S. container imports measured in TEU’s, increased by 58 percent, while container exports increase by 22 percent. In 2004, Asia accounted for 60 percent of U.S. container trade (imports and exports), up from 55 percent 4 years earlier. On the U.S. side, the top ten U.S. container ports accounted for 88 percent of U.S. container trade. Over the last 4 years, container trade through these ports rose at about 5 percent faster than the overall U.S. container trade.3

Of a particular interest is the distribution of the imports amongst the US ports. In the following Table 1.3 and Figure1.3, we present the volume of TEU’s imported in the five top ranked ports.

<table>
<thead>
<tr>
<th>Year</th>
<th>Los Angeles, CA</th>
<th>Long Beach, CA</th>
<th>New York, NY</th>
<th>Charleston, SC</th>
<th>Seattle, WA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>1,413,726</td>
<td>1,757,153</td>
<td>1,057,769</td>
<td>406,775</td>
<td>459,302</td>
</tr>
<tr>
<td>1998</td>
<td>1,673,112</td>
<td>2,048,976</td>
<td>1,212,717</td>
<td>481,989</td>
<td>560,598</td>
</tr>
<tr>
<td>1999</td>
<td>1,912,159</td>
<td>2,264,216</td>
<td>1,362,438</td>
<td>553,633</td>
<td>582,431</td>
</tr>
<tr>
<td>2000</td>
<td>2,428,794</td>
<td>2,401,300</td>
<td>1,511,579</td>
<td>618,461</td>
<td>588,419</td>
</tr>
<tr>
<td>2001</td>
<td>2,613,777</td>
<td>2,376,417</td>
<td>1,587,675</td>
<td>612,163</td>
<td>499,584</td>
</tr>
<tr>
<td>2002</td>
<td>3,193,804</td>
<td>2,466,756</td>
<td>1,879,455</td>
<td>676,109</td>
<td>511,521</td>
</tr>
<tr>
<td>2003</td>
<td>3,641,579</td>
<td>2,367,612</td>
<td>1,964,759</td>
<td>720,639</td>
<td>485,943</td>
</tr>
<tr>
<td>2004</td>
<td>3,845,539</td>
<td>2,951,439</td>
<td>2,238,763</td>
<td>837,582</td>
<td>680,780</td>
</tr>
<tr>
<td>2005</td>
<td>3,821,325</td>
<td>3,354,711</td>
<td>2,415,165</td>
<td>893,515</td>
<td>875,359</td>
</tr>
</tbody>
</table>

Table 1.3 Imports of the main US ports in TEU’s

3 Containership Market Indicators, Maritime Administration, U.S. Department of Transportation, August 2005.
From Table 1.3, we can easily calculate the mean of the growth and its standard deviation, these results are presented in Table 1.4, showing the increasing pattern. The average growth rate over previous years are mainly well above the 10% that we have calculated as the total imports of containerized cargo.

<table>
<thead>
<tr>
<th>Port</th>
<th>Los Angeles, CA</th>
<th>Long Beach, CA</th>
<th>New York, NY</th>
<th>Charleston, SC</th>
<th>Seattle, WA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean growth</td>
<td>13.6%</td>
<td>8.8%</td>
<td>11.0%</td>
<td>10.5%</td>
<td>9.7%</td>
</tr>
<tr>
<td>St.deviation</td>
<td>9.10%</td>
<td>9.51%</td>
<td>4.86%</td>
<td>6.32%</td>
<td>18.62%</td>
</tr>
</tbody>
</table>

Table 1.4 Statistical data of the imported TEU’s in the top first ports

As it has become evident the imports in the US ports will be increasing year after year. What is of particular interest is the origin of these shipments. Data obtained from MARAD give as a clear view of the main trade partners of the US from 1997 to 2005. In the following Table 1.5 we can easily see the great impact of China in the US, but also the main other trade partners of the US.
From Table 1.5, we can easily calculate the mean of the growth and its standard deviation, these results are presented below in Table 1.6, showing the increasing pattern.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>1,477,199</td>
<td>1,770,999</td>
<td>2,065,031</td>
<td>2,787,710</td>
<td>3,080,271</td>
<td>3,926,439</td>
<td>4,447,235</td>
<td>5,960,627</td>
<td>7,388,175</td>
</tr>
<tr>
<td>Japan</td>
<td>720,731</td>
<td>761,480</td>
<td>759,195</td>
<td>776,937</td>
<td>698,584</td>
<td>696,694</td>
<td>722,336</td>
<td>771,996</td>
<td>831,388</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>630,618</td>
<td>799,448</td>
<td>1,020,940</td>
<td>961,917</td>
<td>960,830</td>
<td>1,198,060</td>
<td>1,292,006</td>
<td>1,138,791</td>
<td>826,900</td>
</tr>
<tr>
<td>Taiwan</td>
<td>569,722</td>
<td>627,309</td>
<td>624,508</td>
<td>614,447</td>
<td>542,878</td>
<td>593,533</td>
<td>651,073</td>
<td>588,099</td>
<td>589,608</td>
</tr>
<tr>
<td>South Korea</td>
<td>277,641</td>
<td>360,816</td>
<td>402,399</td>
<td>434,809</td>
<td>428,157</td>
<td>488,161</td>
<td>469,240</td>
<td>514,874</td>
<td>548,404</td>
</tr>
<tr>
<td>Germany</td>
<td>295,073</td>
<td>341,363</td>
<td>378,614</td>
<td>435,687</td>
<td>430,850</td>
<td>447,110</td>
<td>466,899</td>
<td>482,685</td>
<td>510,685</td>
</tr>
<tr>
<td>Brazil</td>
<td>191,787</td>
<td>205,247</td>
<td>259,666</td>
<td>258,293</td>
<td>264,737</td>
<td>339,186</td>
<td>387,542</td>
<td>476,424</td>
<td>487,389</td>
</tr>
<tr>
<td>Italy</td>
<td>311,270</td>
<td>353,748</td>
<td>384,515</td>
<td>440,665</td>
<td>469,973</td>
<td>499,907</td>
<td>473,005</td>
<td>480,126</td>
<td>463,686</td>
</tr>
<tr>
<td>Thailand</td>
<td>222,075</td>
<td>268,393</td>
<td>302,554</td>
<td>343,666</td>
<td>345,907</td>
<td>376,137</td>
<td>378,236</td>
<td>410,813</td>
<td>427,563</td>
</tr>
<tr>
<td>India</td>
<td>123,671</td>
<td>143,167</td>
<td>142,379</td>
<td>170,804</td>
<td>179,612</td>
<td>217,870</td>
<td>253,300</td>
<td>299,046</td>
<td>335,694</td>
</tr>
</tbody>
</table>

Table 0.5 U.S. Waterborne Foreign Container Trade by Trading Partner

The average growth rate over previous years are in the total volume of the containers imported in the order of 7%, while the imports from China have a mean growth of 22.6%.
1.4 Concerns of the container trade in the US

Since container cargo imports are increasing in the US, even after the terrorist attacks of 9/11 there is a lot of skepticism, on how safe is the US public from a new terrorist attack. One could make a lot of questions. Are the security inspections and current procedures sufficient in order to prohibit a container that could pose a threat, bringing danger and destruction to the public of the US? What additional measures, methods, applications and policies could be enforced in order to eliminate such a threat? Could we consider any contiguous benefits to these measures and procedures? What is the cost of these applications and their reliability? Are these proposed applications a panacea or do they constitute a step towards a feasible and economical solution that will bring the desirable results?

Before we go through the so-called solution (RFID) of which we will examine the use, impact, benefits and weaknesses, we consider important to review the security issues that arise in the present situation, when a container is being imported in the US. It is this continuing activity that shows the importance of container trade industry in the supply chain, making us to seek solutions.

For an analytical review of the procedures in importing a container, one could refer to the thesis of Nikolaos Harilaos Petrakakos, titled “Port Security and Information Technology”.
CHAPTER 2 - Security issues

2.1 Importance of transparency for Port Security

Since the terrorist attacks of 9/11 there is a great concern on the transparency on the Supply Chain Network on Ports. The fact that 96 percent of all overseas import in the US is by sea makes us realize that the visibility of the supply chain network on ports would be if not required at least desired. United States receives approximately 17,000 containers a day and unfortunately only 2 percent of the containers imported are physically inspected.

Security experts are concerned about a variety of terrorist threat scenarios at U.S. ports. Among other things, they are concerned that terrorists could use commercial cargo containers to smuggle terrorists, nuclear, chemical, or biological weapons, components thereof, or other dangerous materials into the United States.

In the event of a weapon of mass destruction or highly radioactive material is hidden in a container. The importance of securing that these shipments do not pose any threat to the public is enormous. If an incident like that was realized, they could also paralyze the movement of cargo containers globally, thereby shutting down world trade. Since the US and the whole world has declared war on terrorism, there have been found sound evidence that Al-Qaeda intended to use cargo shipping companies to smuggle high radioactive material to the US. If al-Qaeda’s network is as sophisticated as some people

\[4\] "Protection without Protectionism" by Aaron Lukas, CATO Institute
argue, it may have noticed the vulnerability of the American economy to disruption of its industries' supply chains.

A terrorist group like that might obtain a bomb, perhaps with the yield of the Hiroshima bomb, by several plausible routes. For example terrorists might try to smuggle WMD which currently exist in Russia and Pakistan.

In Russia, strategic (long-range) nuclear weapons are reportedly well guarded on missiles or, thanks in part to U.S. assistance, in storage. In contrast, thousands of shorter range lower-yield weapons intended for use in combat are less well secured, and numbers and locations are uncertain. (See CRS Report RL32202, Nuclear Weapons in Russia: Safety, Security, and Control Issues). There is an increasing fear that terrorists might buy or steal one of these weapons along with information on how to bypass any use-control devices.

In Pakistan, U.S., British, Chinese, French, and Israeli nuclear weapons are thought to be well guarded. Control is less certain for India and Pakistan. Some reports indicate that Pakistanis aided nuclear programs in Iran, Libya, and North Korea, and there are concerns about the security of Pakistani nuclear weapons if President Pervez Musharraf were assassinated.

Strong evidence supports that Al-Qaeda has made contacts to purchase nuclear, biological and chemical WMD. If a nuclear weapon was detonated in a major ship port it could result in losses of five hundred to one million human lives. The impact of such
attack would cause losses due to trade disruption of $100 to $200 billion, and impose further indirect costs of up to $1.2 trillion.\(^5\)

Terrorists might try to smuggle a bomb into a U.S. port in many ways, but containers may offer an attractive route. A container can be used on and moved between a tractor-trailer, a rail car, or a ship. Much global cargo moves by container. Nearly 9 million containers a year enter the United States by ship. Customs and Border Protection (CBP) screens data for all containers, and reportedly inspects about 6 percent of them.

For comparison, over 13 million trucks and rail cars cross the Canadian and Mexican borders. CBP analyzes cargo manifest information for each container to decide which to target for closer inspection, based on such factors as origin, destination, shipper, and container contents. Only a small portion has its contents physically inspected by CBP. Physical inspection could include scanning the entire container with a sophisticated x-ray or gamma ray machine, unloading the contents of a container, or both.

Containers could easily hold a nuclear weapon. Many believe that ports and containers are vulnerable. An FBI official stated, “The intelligence that we have certainly points to the ports as a key vulnerability of the United States and of a key interest to certain terrorist groups....”\(^6\)

---


CBP Commissioner Robert Bonner believes “an attack using a nuclear bomb in a container would halt container shipments, leading to “devastating” consequences for the global economy. ...”

In order to minimize the possibility of a “bad” container entering its borders US government has initiated a funding of security port investments that exceeds 1 billion USD.

The last line of defense against a terrorist nuclear attack is the ability to detect nuclear weapons or material entering the United States. A large effort is underway by government agencies, industry, and universities to develop key technologies. By one estimate, the fiscal year 2005 appropriation provides $4.1 billion for homeland security R&D. Operation Safe Commerce, a Department of Transportation-CBP “program to fund business initiatives designed to enhance security for container cargo ... will provide a test-bed for new security techniques.”

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The Trade Act of 2002, Public Law 107-210, sec. 343a, mandates the establishment of a task force to “establish a program to evaluate and certify secure systems of international intermodal transport.”

Terrorists can counter new technologies. If the United States deploys sensors at some ports, terrorists might detonate a weapon before it is inspected, or ship it to another port. If foreign ports screened containers before being loaded onto U.S.-bound ships, terrorists could infiltrate the ports. Securing the largest ports might lead terrorists to use smaller ones. Securing every U.S.-bound container might lead terrorists to smuggle a weapon in a small boat or airplane. Detecting a highly enriched uranium (HEU) bomb is difficult because HEU emits very little radiation. R&D is underway to address this key issue.

In 2002 and 2003, ABC News shipped shielded 15-pound cylinders of depleted uranium (DU, natural uranium minus most uranium-235) into U.S. ports in containers. CBP did not detect these shipments. ABC claimed that DU is a good surrogate for HEU; CBP claimed the opposite. In September 2004, DHS issued a report on the topic. They concluded that “improvements are needed in the inspection process to ensure that weapons of mass destruction ... do not gain access to the U.S. through oceangoing cargo containers” and recommended improving detection equipment and search methods.


Improving the ability to detect terrorist nuclear weapons in the maritime transportation system may make a terrorist attack on a port less likely to succeed, and thus less probable.
2.2 Pilferage incidents

At the early time when standardized containers entered the cargo industry, they initially cut small-time cargo pilfering, long a plague in ports. But that proved short-lived. Thieves soon learned that, by stealing a full container (usually in transit), they could increase their own productivity and especially if they knew in advance what the contents were. The average value of cargo theft increased fivefold (to $500,000) between the 1970s and 1990s. Containers also turned out to be handy ways to smuggle drugs, contraband and illegal immigrants. Unfortunately apart from convenience, the container offered criminals the same benefits as those enjoyed by ocean carriers and shippers: efficiency and security.

Government and industry soon came up with some ways to combat this crime. Container seals have been made tougher. (Thieves have been known to empty an in-transit container with no outward sign of entry.) Shipping lines that take part in anti-smuggling programs get faster clearance for their boxes. But more needs to be done.

Federal agencies and the container-transport industry have both recognized the threat but done little of substance. Stephen Flynn, an influential security adviser at the Council on Foreign Relations, a think-tank based in New York, has been sharply critical of the government's approach to security. The two front-line services, the US Customs and the US Coast Guard, were seriously under-funded, argues Mr. Flynn (himself a former Coast Guard commander, expert on the transportation border and infrastructure security), while the overall federal effort was undermined by feuding among agencies. Mr. Flynn
believes things may have improved since September 11th, but not enough to inspire confidence.¹²

The experience of the carriers suggests that he is right. Despite a big security presence around ports immediately after September 11th, carriers say they have not yet suffered any serious disruption to containers entering or leaving the United States. The US Customs Service has increased border inspectors and equipped them with mobile radiation detectors; the US Coast Guard has boarded ships with armed sea marshals; they have also demanded earlier notice of ship arrivals (24 hour rule) and the government has provided some emergency funding to improve port security.

But containers are still rolling along much as before. This worries the industry's representatives. Chris Koch, chief executive of the World Shipping Council, a trade body based in Washington, DC, believes a further terrorist incident could lead to a bungled government response, jamming up the system. Even worse, he thinks, could be a failure to do anything coherent, followed by a complete shutdown of ports after an attack.

¹²Port security debate on PBS aired on 02/23/06.
http://www.pbs.org/newshour/bb/terrorism/jan-june06/ports_2-23.html
2.3 Trojan box

The American government is only just beginning to realize how vast and complex the container-transport industry is. Last year, the world's total movement in containers amounted to 72 million TEU (the industry's standard, even though containers are increasing to 40 feet, or 13 metres, long). H.P. Drewry, a shipping consultancy, uses a much larger figure, of 244 million TEU, to express the number of containers handled in 2001 by all ports; this includes empty containers being repositioned and trans-shipped containers (usually dropped off by large container ships at large hubs for onward shipment by smaller feeder ships). Such numbers give as a fair idea of the scale of the problem: how can 72m containers be monitored, let alone 244m?

In addition, the movement of each container is part of a transaction that can involve up to 25 different parties: buyers, sellers, inland freighters and shipping lines, middlemen (customs and cargo brokers, for example), financiers and governments. A single trade can generate 30-40 documents, and each container can carry cargo for several customers, thus multiplying the number of documents still further.

A typical large container ship can carry up to 6,000 TEU and generate 40,000 documents. In 2001, around 9m TEU arrived in America's container ports by sea, which translates into around 17,000 actual boxes a day. Many more arrive in America from Canada, mainly by train or truck.
The fact that containers are “intermodal”—i.e., they can travel by sea and on land, by road or rail—means the system is difficult to regulate as it crosses jurisdictional boundaries. On a ship at sea, the container comes under the aegis of the International Maritime Organization (IMO), a United Nations body based in London. On land—in a port, or on road or rail—it passes into the hands of national governments, which may have separate legislation for the different transport modes.

This creates a problem for the United States when it seeks to enact container security regulations internationally through the IMO. The IMO’s writ ends at the shoreline. Whereas it can establish international rules for the identification of ships and their crews, it cannot force ports to adopt new security rules. In olden times, colonial powers solved that problem by seizing ports (such as Gibraltar or Singapore) over which they wished to exercise control. That is hardly a possible solution today. The need now is for international co-operation on port security.

The problem is worsening because governments have tended to see port security as a poor relation of airport security. In Britain, for example, the Aviation and Maritime Security Act was passed in 1990 after a bomb exploded in a Pan Am plane over Lockerbie, but the “maritime” bit was an afterthought. It was added only to reflect concerns over two terrorist attacks on cruise ships in the Mediterranean (on Achille Lauro in 1985 and City of Poros in 1988).

To overcome this jurisdictional divide between land and sea, America may seek bilateral agreements with those countries from whose ports most of its containers arrive. The main thrust of thinking is that America should push its borders out and pre-screen containers in
specially created security zones before they are loaded on to ships in foreign ports. This
would be done with the co-operation of the foreign authorities, and with American
inspectors present to help local officials. An arsenal of security measures would be
deployed—from x-ray machines in container terminals to transponders inside containers
that would detect whether they had been opened in transit. These devices would
broadcast a signal via satellite.
2.4 US Customs Service view

Robert Bonner, the (former) head of the US Customs Service, has proposed that, to begin with, America should focus on the top ten container ports that trade with it, and should seek to funnel as many containers as possible through approved gateways. The top ten—which include Hong Kong, Rotterdam and Shanghai—handle around half of all America-bound containers; Hong Kong alone accounts for 10%. Under Mr. Bonner's plan, they might increase that share markedly at the expense of smaller and higher-risk ports. But the United States is also considering proposals to help finance the extra security that would allow smaller ports to attain the necessary standards. This would help avoid any distortion of trade patterns that could add to the cost of running global supply chains.

Others think that America should go further and extend its border controls to the point of origin: the factory or warehouse where the container is first filled and sealed. Containers arriving at a port for loading on to an America-bound ship would not be accepted unless they met strict security criteria.

Rob Quartel, former federal maritime commissioner, is among those who are in favor of such point-of-origin controls. He also wants the new border to be “electronic” rather than physical, creating a profile of the container's contents by sophisticated use of databanks, which capture and combine existing electronic documents from both government and commercial sources. To this could be added data from financial sources (for example, letters of credit held by banks) and documentation covering the inland leg of the container's journey. Mr. Quartel, now chairman of Freightdesk Technologies, a freight-
management technology specialist based in Vienna, Virginia, believes that America will be unable to impose security requirements on foreign shippers. But he thinks it could ensure that the receivers of containers in America realize they will face delays unless they know their customers and can validate cargo security. The idea fits into the generally accepted concept of fast and slow lanes, graded by security rating.

Not surprisingly, the private-security industry is eyeing such ideas with relish. Charles Upchurch, president of SGS Global Trade Solutions of New York, an inspection company, argues that government should use only accredited private firms for security audits and container inspections. Shipping-industry representatives have been advancing their ideas in a seemingly endless round of hearings at the Senate and House of Representatives in Washington, DC, accompanying them with what must be a veritable container-load of papers.

Whatever scheme the United States finally adopts, government and industry agree that the aim should be to achieve the maximum security with the minimum disruption to trade. Security barriers can easily become trade barriers. The (former) head of the Coast Guard, Admiral James Loy, explains: “To sustain prosperity, we open the gates. To ensure security, we close the gates. We clearly need to get beyond the metaphor of an opened or closed gate.”

Some logistics experts, such as (the late) Mr. Delaney, argue that American industry could absorb the inevitable increase in inventory and logistics costs. A 5% increase in inventory would cost American companies an extra $20 billion, but that must be set in the
context of the $1 trillion spent annually by American business on logistics. “Just-in-time will bend, but it will not break,” Mr. Delaney confidently predicts. He is, however, talking only about inland transport.

Mr. Koch of the World Shipping Council says that America cannot solve the container problem alone; it needs more help from the rest of the world than it cares to admit. The issue is not merely about boxes on ships, he argues, but about how the basic mechanisms of world trade can operate so that they maintain efficiency while at the same time enhancing security.\footnote{Testimony of Christopher Koch, President & CEO of the World Shipping Council, Regarding Maritime Transportation Security Act Oversight, Before the Senate Committee on Commerce, Science, and Transportation, May 17, 2005. Found in http://commerce.senate.gov/pdf/koch.pdf} This particular opinion is the main one of which we would try to examine in later chapters.

Trade flows depend on trust to flourish. But total trust is clearly impossible in a world where death can arrive hidden in a metal box. Only with clever use of technology and international co-operation are the world's big trading countries likely to avoid disruption and expense. Even then, it will be a question of minimizing the threat rather than eliminating it.
2.5 Seeking a solution

What would be desirable is to achieve a level of visibility from the one end to the other, i.e. from the facility industry to which the container is shipped to the receiving party at the end of the supply chain.

Tracking cargo containers from origin to destination is a daunting task. A supply chain network has multiple nodes, which are points in the supply chain that a container will be stored, warehoused, transferred, or even re-stuffed. Supply chains also have multiple modes of travel, including truck, plane, train, and ship. Along with these multiple nodes and modes that are involved in a supply chain, are further complications arising when the container must cross through international borders. In today’s global economy, where manufacturing is commonly outsourced, and raw materials and products are shipped internationally, supply chains have become more complex, and having an efficient supply chain is essential for a successful importer and exporter of products.
3.1 24-Hour Advance Manifest Rule

Under this rule, shipping companies are required, 24 hours in advance, to provide manifest data for all cargo containers which are not necessarily destined for the U.S., but might use a U.S. port for transshipment. The 24-hour Advanced Manifest rule (AMR), is more known as the 24-hour rule "establishes a system for freight forwarders and shippers to inform the Customs officials of the contents" of every container at least 24 hours before loading onto U.S.-bound ships. This policy includes containers which may originate from a CSI port, therefore every single container that arrives in the U.S. has complied with this requirement. The 14-point data that is collected on containers is based on the shipping manifest, and includes information on the co-signer, co-signee, intermediaries, origin port, description, count, the Harmonized Tariff Schedule classification for the cargo (up to 6 digits in detail), number and quantities from the master bill of lading, carrier, vessel, voyage, container and seal numbers, country of origin, first port of loading and arrival date in U.S. port, and hazardous materials indications. This Information is sent to the Customs and Border Protection (CBP) National Targeting Center, where the risk of every container is being scored by the Automated Targeting System (ATS), according to a selected and secret criteria, including origin, destination, and carrier. This risk assessment system assigns a number rating to every container, this rating information then is sent to CBP field officers, so that "risky" containers can be scanned before loading onto U.S-bound ships. This rule is mandatory for 100% of containers sent to the US, regardless of whether this is the final destination or if the container is in transshipment.

There will be fines for carriers that do not comply with the 24-hour rule in a range from US$ 5,000 to $10,000, and any ships that have not supplied this data by the time they have reached U.S. ports may be denied the right to dock\textsuperscript{15}. The stakeholders who will be required to carry the costs of compliance with the 24-hour rule are shipping companies, carriers, and third party logistics companies, who have to invest in new IT systems, personnel training and working hours, due to the necessity to computerize the submission of manifests, and the need to send this information to CBP officials.

One shipping company was reported to have hired an additional 45 people to handle 24-hour rule data processing, and to handle the additional 1,400 hours of computer programming time\textsuperscript{16}. An OECD report estimated that industry-wide administrative costs would increase to approximately $287 million, at the implementation stage. These costs will probably be passed onto the exporters in the form of documentation fees charged by carriers. According to a report by PBB Global Statistics, most carriers have begun to charge between $25 and $35 per bill of lading in order to recover administrative expenses. This cost, as we have already mentioned, is one that will be faced by all imports to the U.S., whether or not they originated from a CSI port.

The highest costs associated with implementation of the 24-hour rule will be felt by carriers and shippers from the developing and least developed countries. In many instances, manifest information has been traditionally completed either by hand or by typewriter, and in many cases while the goods are being loaded onto ships. There it is\textsuperscript{15} Container Security: Major Initiatives and Related International Developments". United Nations Conference on Trade and Development. Commission on Enterprise, Business Facilitation and Development Seventh session. Geneva (24–28 February 2003). pg. 13.
\textsuperscript{16} Container Security. UNCTAD. Pg.18.
CHAPTER 3 - Port Security Initiatives

After the catastrophic terrorist attacks of 9/11, the U.S. government through the Department of Homeland Security initiated a legal framework whose main purpose is to guard the safety of US Borders, protecting thereby its public. In order of initiative first came 24-Hour Advance Manifest Rule (AMR), then the Container Security Initiative (CSI), followed by the Customs Trade Partnership Against Terrorism (C-TPAT) and the Smart and Secure Trade Lanes Initiative (SST). Though these governmental actions it is evident that nowadays United States are alarmed of any potential threat to its trade patterns. The aforementioned policies allow for special handling of containers or cargoes which are enhanced with technological solutions that could provide a certain level of transparency while complying in the same time with these policies.
obvious that the 24-hour rule has a larger impact on the business processes which are currently followed. With the 24-hour rule, this practice will effectively end, since investments in IT infrastructure will be made, and carrier employees will be trained in using these systems. This can lead to a staggering investment for small- to medium-sized carriers who have increasing difficulty competing against larger carriers from Asia, the US and EU.

Regardless of the heavy initial investment which is required to comply with this policy, it would appear self-evident that by upgrading IT systems and training in these systems would lead to revolutionary process improvements for these companies, and improve their efficacy and profitability as well as building their capacity to compete in servicing the US market.
### Container Security Initiative

The Container Security Initiative has captured most of the media and the international policy community attention out of new supply chain security regulations. This project establishes the tracking and targeting of “high risk” containers, which are sometimes referred to as Trojan Boxes, and their subsequent scanning with X-ray machines, before their loading onto U.S.-bound ships. To date, 44 of the world’s largest ports have either agreed to become CSI compliant, or are already operational (see Annex 1). Of these ports, 3 are in Canada, 21 are in Europe, and 16 are in Asia, while only one is located in Africa (Durban) and other two in Latin America (Santos and Buenos Aires). CBP’s goal is to have 50 operational CSI ports by the end of fiscal year 2006.

The Container Security Initiative has four basic requirements that candidate ports must meet: 1) they must determine criteria for establishing if a container represents a “high risk”; 2) have local customs officials work with U.S. Customs agents who are posted at these ports to identify “high risk” containers; 3) pre-screen “risky” containers before they are loaded onto U.S.-bound ships with non-intrusive inspection (NII) equipment (including gamma or X-ray imaging capabilities) and radiation detection equipment. 4) Lastly, the port must implement the use of “smart” or tamper-proof container-seals in order to secure the containers once they are en route to the U.S..

An “automated risk management system” has also to be implemented by the Port authorities, who should also be willing to share intelligence on potential security threats from within the country with U.S. Customs agents, identifying and resolving security breaches in port’s area. Although this program is a U.S.-led initiative, compliance costs are not covered by the U.S. government. Every non-intrusive inspecting device (NII), so
called “container scanners”, costs anywhere between $1 and $5 million, and it is generally considered that a minimum of two is required for even the smallest ports. If we add this cost to the IT investment that is needed for targeting and identifying high-risk containers and upgrading existing port facilities, in order to accommodate scanning devices, we can conclude that even small ports would need to spend roughly $5-$15 million. The only reason for which a small port would bear such costs is because these investments have a considerable payoff, though, as U.S.-bound containers that originate from a CSI port are allowed to forego screening and inspection in the U.S., instead entering the country via the “green lane”. Containers not originating from CSI ports will then be routed through relatively “slow lanes”, potentially creating a trade barrier for exporters from countries lacking a CSI port.

CSI required scanners, also known as VACIS machines (for Vehicle and Cargo Inspection Systems), can provide imaging capabilities for CBP officials to visually identify undeclared cargo and/or human stowaways. Hand held radiation detection devices (similar to Geiger counters) are used to search for radioactive materials and “dirty” bombs. Currently, there are no requirements for CSI on having Chemical or Biological weapons detection devices, due to the relative lack of affordable and effective technology. The implementation of CSI abroad has two established phases. The reason why CSI is implemented in phases derives from the trade relations of the U.S. with ports around the world and is based on port’s strategic importance and the volume, which is being traded between the port and the U.S.

Phase I of the initiative has succeeded in expanding CSI in the top 20 international “Megaports”, more than half of which are located in China, Korea and Japan.
For a port to be eligible for consideration for inclusion in Phase I of the CSI it must have "regular, direct, and substantial container traffic … originating, transiting, exiting, or being transshipped" through their facilities to the U.S.

Approximately 70% of all goods entering U.S. ports originate from these "Megaports", including Singapore and Hong Kong, Tokyo, Shanghai, and Shenzhen, Pusan, Halifax, Rotterdam, Hamburg, Antwerp, and Algeciras, among others.

Once Phase I has been completed, a port may become eligible for Phase II CSI consideration if it has strategic importance and if it has demonstrated willingness to undertake the requirements. Phase II ports include Port Klang, Tanjung Pelepas, Marseilles, Naples, Barcelona, Buenos Aires, Santos, and Colon. This phase of the program extends the program to a number of ports in "middle-income" developing countries, namely Argentina, Brazil, Panama, Sri Lanka, Malaysia and South Africa, but does not include ports in any least developed countries. In the long run, CSI will run into Phase III, which targets ports that did not qualify under the previous two phases. Furthermore, DHS has stated that it will work in collaboration with the World Bank, the Inter-American Bank and the World Customs Organization to establish assistance for the necessary systems upgrading. No dates have been provided for the start of this phase, nor have potential candidates been identified for inclusion in the project. Phase III will likely lead to the inclusion of more ports in "middle income" developed countries, although the roll-out date for this project will begin within 7-10 years, at the earliest.

In the long run 100% of U.S.-bound containers will be screened and, if necessary, scanned at their ports of origin. In the short to medium-term, this project has the potential
to create an advantage for goods entering the U.S. from CSI-compliant ports, while potentially causing delays at entry to the U.S. for the remainder of containers. Because all of the current CSI ports are located in industrialized countries, the delays associated with “slow lanes” will disproportionately affect developing countries, in the short to medium term. Eventually, however, if CSI succeeds in encompassing the majority of world ports, the discriminatory effects will be mitigated to such a degree as to only negatively impact a small number of ports and exporters. Much has been written about the potentially discriminatory effects of this measure on international trading flows especially in terms of the competitiveness of exporters from the developing countries. While developing countries represent roughly 18% of the total volume of TEU traffic flow to the U.S., during the transitional period when CSI is not applied to all ports, exporters from these countries may face higher barriers to trading in the U.S., either due to costs associated with rerouting or to delays at U.S. ports.

In contrast, countries that enjoy modern IT customs systems and overall port infrastructure, as is the case of Singapore, Hong Kong, Taiwan, Japan and Korea, will enjoy a relatively easy transition in becoming CSI compliant. This could provide exporters in the region a comparative advantage over competitors in the U.S. import market.

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Before reviewing the costs associated with the Container Security Initiative, it is necessary to identify the various stakeholders that will be affected.

This initiative will arguably represent increased costs to the parties which are involved in international trade: foreign exporters, port authorities, shipping companies/carriers, U.S. manufacturers who rely on foreign inputs, retailers who sell goods with imported components, and finally U.S. consumers. Evidently, the initial costs will fall on the port authorities, because of the requirements for purchasing and upgrading capital. Quite probably they will pass this cost onto shippers and carriers, who in turn will recover this cost by increased charges for exporters.

At some level these costs will factor into the prices that U.S. importers are charged, leading to small increases in the prices consumers pay. Three stakeholders will be highly affected by the CSI related cost increases: port authorities, shippers/carriers, and exporters.

Port Authorities: The costs associated with becoming CSI compliant will initially fall on the port authorities. As noted earlier, the cost of purchasing, or upgrading, container-scanning devices varies between US$1-5 million per device (see below). In comparison, the other costs associated with this initiative (i.e. developing IT systems for tracking containers passing through the port, personnel training, etc.) are highly variable due to the divergent costs of labor across different countries. According to a report for the World Customs Organization, related equipment and infrastructure upgrading may cost up to two to three times the initial investment in the actual container scanning devices, yet this too depends on the individual ports, as some may require more investment in
infrastructure than others. The port authority of Buenos Aires established a budget for purchasing and installing four container scanners at US$ 33 million\(^\text{18}\), with roughly $20 million reserved solely for the scanners, and an extra $13 million for related infrastructure upgrading. The required number of NII scanners in each case varies, because it depends on the magnitude of container flows from individual ports to the U.S. The port of Singapore, which accounts for almost 5.8% of all containers arriving in U.S. ports, has purchased two container scanners, while the port of Hong Kong, accounting for 9.8% of container flows, has purchased four devices.

Costs related to CSI are not limited to the capital and infrastructure investments for upgrading ports. It has been noted by many multilateral organizations (especially the E.U.), that CSI will damage the competitiveness of non-CSI ports. Shippers are expected to choose CSI ports for distribution to the U.S., while using non-CSI ports merely for “pre-carriage purposes, goods being loaded at one of these ports on feeder vessels to join the nearest CSI ports”\(^\text{19}\). By signing CSI agreements, ports immediately obtain a "preferred" status, as they will be the only ports from which goods may be shipped to the U.S. without the risk of encountering delays at customs due to the need for screening. CSI ports are likely to attract more shippers and also more carriers or freight forwarders. Not every port, however, may be eligible to join the program or be financially in a position to obtain CSI status.

Depending on the nature of the port, the costs of these scanning devices will be borne either by the port management (public or private), the national customs authorities, or


commercial terminal operators. The manner in which these costs will be recovered
depends on the body that initially bore the capital investments, whether they were
privately or publicly owned. This will have implications on the surcharges or fees that are
passed onto exporters.

Shippers/Carriers: The Port Klang authority in Malaysia charges shipping companies a
fee of between RM130 and RM260 (US$30-150) for containers picked for scanning,
billed under ‘extra movement charges’\(^\text{20}\). In comparison, the Singapore Port Authority has
declared that it will not charge shippers any added fees for CSI-related infrastructure
expenses, nor for scanning. It should also be noted that CSI requires that ports and
shippers must also “develop secure and “smart” containers”. This includes the use of
electronic container seals on each container, which can cost between US$150 and
US$400 per device\(^\text{21}\). This cost will initially be borne by freight forwarders, and although
this will most likely be passed onto exporters through increased fees, no evidence of this
has been reported.

Exporters: The least cost burden of all will be incurred to exporters located near a CSI
port, while they will be reaping most of the benefits. CSI-ports, and shippers operating
out of them, will most likely recover CSI-related expenses by charging either an across
the-board fee to all exporters (documentation fees), or specific fees targeted at containers
that are selected for screening (movement fees).


\(^{21}\) UNCTAD report on Container Security. Pg. 20.
The government of New Zealand has entered into a “CSI-like” agreement\textsuperscript{22} with the U.S. because it is “not prepared to accept the distortionary regional economic impact of all goods to the US having to be shipped through one port”. It has stated that it will charge exporters a US$ 6.00 (8 NZD) fee per “export document” (Bill of Lading), while the British port of Felixstowe has levied a US$20 (GBP 10.50) charge per full container exported. This charge is meant to cover all expenses related to the 24 hour rule and CTPAT. As the CSI program expands into Phase II, the methods used to recover CSI-related charges will most likely multiply. However, if compared to overall costs of transporting a container, these costs do not appear excessive, and for a hypothetical rate of US$ 1,000 for shipping a container, these fees do not exceed 2% of total transport costs. Additionally, these containers do not face any delays because they enter the U.S. through “green lanes”. However for exporters who are not located near a CSI port, it is certain that they will incur additional costs whichever will be the strategy they will choose to comply with the new rules. They might choose to maintain their direct route to the U.S., and face the delays of entering through the “slow lane”. According to a World Bank report, every day spent in customs adds almost 1% to the costs of goods. The European Shippers council has cited examples of containers being delayed for up to two weeks at U.S. ports due to security screening, although this is by no means a normal occurrence. On average, goods clear U.S. customs within three to four days. Exporters could also choose to reroute their containers through a CSI port, thereby increasing the length of the journey, and hence the cost. The expense of transporting a container has many variables, including the supply and demand of a particular route, freight insurance,

the value and commodity category of the goods shipped, and the distance of the route. The supply/demand variable of transport costs is especially noticeable of the imbalance that exists on container traffic between China and the U.S. For every three containers that the U.S. imports from China, one container is exported. For a 40' container imported from Asia the current average rate is approximately US$ 2,500\textsuperscript{23}, while for an export this figure would probably be under US$ 500. Furthermore, the transportation costs for containers is especially dependent on the commodity category and the value of the good, “even though the ubiquitous container makes it so that there is no practical cost difference to the shipping company whether the load inside is DVD's or cheap lawn furniture”\textsuperscript{24}. Shipping costs for trading pharmaceutical products represent 1% of the customs value, while this same cost accounts for 15% of trade in agricultural products\textsuperscript{25}. Lastly, insurance costs also account for an important aspect of shipping costs. While, median insurance rates only represent 0.15% of the ad valorem value of goods traded by the U.S., this figure is much higher for goods from other countries.

For the sake of this study we will focus on the costs of distance in transporting a container, and how this is significantly more for some exporters as a result of CSI. Limao and Venables, in a study on geographical distance and transportation costs, computed the average cost of shipping a container per 1,000 kilometers of distance by comparing quoted rates between Baltimore, Maryland and 64 destination cities. They concluded that it costs an average of US$190 per 1,000 kilometers of distance. In the following exercise, this flat rate is used to calculate the added costs that CSI will have on the transportation rates for shipping from two non-CSI ports: Santos and Casablanca. These ports were

\textsuperscript{23} Ibid. pg. 4.
\textsuperscript{24} Ibid
\textsuperscript{25} Lukas, Aaron. pg. 4.
chosen because both are the principal ports for container traffic for their countries (Santos 38%, Casablanca 40%), both are currently not CSI ports, and neither has a CSI port directly en route to the U.S. Approximately 125,000 containers left the port of Santos bound for the U.S., while Casablanca only reported roughly 5,000 U.S.-bound containers. The container traffic between the two ports is by no means comparable, and yet for the purposes of this exercise, this asymmetry has no bearing.

The Brazilian port of Santos, which lies 9,299 kilometers from the U.S. city of Baltimore, is not yet a CSI-designated port. Buenos Aires, however, which will soon be a CSI port, is located 11,075 kilometers from Baltimore. Buenos Aires was chosen as the South American pilot port despite the fact that container flows from this port account for only one-third of that of Santos. The following table illustrates the differences in distance, approximate costs and journey time for shipping one standard length container either from Santos directly to Baltimore, or via Buenos Aires. Shipping one container via Buenos Aires represents an increase in transportation costs per Twenty Equivalent Unit (TEU the standard unit of measurement for containers) of roughly 40% more than shipping directly from Santos to Baltimore.

<table>
<thead>
<tr>
<th>Distance</th>
<th>6021 nautical miles-9299 km.</th>
<th>Santos-Buenos Aires-Baltimore: 8977 nautical miles-12621 km.</th>
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<td>Rate</td>
<td>(US$190/1000km)</td>
<td>(US$190/1000km)</td>
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<tr>
<td>Time</td>
<td>Approx. 9.5 days</td>
<td>Approx. 13 +1 day minimum transshipment: 43</td>
</tr>
<tr>
<td>Shipment cost</td>
<td>US$1786.81</td>
<td>US$ 2454.86</td>
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</table>

Table 3.1 Shipping rates for Santos-Baltimore

An identical container traveling from Buenos Aires directly to Baltimore would not face a similar increase due to rerouting, giving Argentine exporters a clear cost advantage over
their Brazilian counterparts. Again, it should be noted that this figure does not consider the supply and demand forces that ultimately set transportation prices. If many carriers were to offer this route from Santos, the price difference between the two scenarios would likely decrease. Regardless of this mitigating factor on the transportation price, the Santos-Buenos Aires- Baltimore route would nevertheless take considerably longer. According to Hummels, each extra day of shipping time would on average raise the transportation costs by 0.5% ad valorem. In this scenario, then, the added shipping time would raise the transportation costs roughly 2.5%.

A similar scenario for the Moroccan port of Casablanca does not offer such striking contrasts. Casablanca is located 3,428 kilometers from Baltimore, while the Spanish port of Algeciras is the closest local CSI port. The choice of Algeciras as a CSI port over Casablanca is easier to understand, as the container flow from Algeciras represents 1.6% (approximately 98,000 TEUs) of all containers that enter the U.S., while Casablanca does not rank within the top fifty ports of origin. Based on the same distance-to-rate calculation arrived at by Limao and Venables, the following table calculates the different rates exporters will be faced with when shipping their goods to the U.S.

<table>
<thead>
<tr>
<th>Distance</th>
<th>Casablanca-Baltimore: 6349 km.</th>
<th>Casablanca-Algeciras-Baltimore: 6619 km.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate</td>
<td>US$190/1000km</td>
<td>(US$190/1000km)</td>
</tr>
<tr>
<td>Time</td>
<td>Approx. 6.5</td>
<td>Approx. 6.5 + 1 minimum transhipment.</td>
</tr>
<tr>
<td>Shipment</td>
<td>US$1206.23</td>
<td>US$1257.61</td>
</tr>
</tbody>
</table>

Table 3.2  Shipping rates for Casablanca-Baltimore
Clearly, in the case of Casablanca the cost difference is much less (roughly a 4% increase). It is clear from this exercise that CSI-related transport costs will have the greatest impact on exporters who are located the furthest away from a CSI port. While this increase in shipping costs may not have a great effect on ports like Casablanca, for others this may “make or break” their chances on staying competitive in the U.S. market.

As noted earlier, transportation represents higher ad valorem costs for lower value added goods, especially agricultural products and raw commodities. Exporters of these goods will feel more of an impact from increased transportation costs due to rerouting through CSI ports. Yet these same exporters will also suffer a greater loss from delays at ports, most notably in the case of perishable goods. In some cases though, the extra time spent on the journey to a CSI port may be equal to the time spent at U.S. ports due to “slow lane” customs clearance delays. In the above scenarios, the time difference for the Brazilian exporters was considerable, while for the Moroccan exporters it was not.

The decision that an exporter makes in terms of whether or not to ship their goods through a CSI port depends on the level of risk they are willing to take. If, under normal circumstances, goods clear U.S. customs in considerably less than a week, then the exporter would need to look at the costs and benefits of shipping directly or of rerouting their goods. However, in the event of a terrorist attack on a U.S. port and the subsequent port closures, containers could experience U.S. Customs delays of nearly three months. Thus, in calculating the cost benefits of shipping directly or through a CSI port, the exporter would need to factor in all possible risks, and make a choice accordingly.
3.3 Customs Trade Partnership Against Terrorism

The third leg of the DHS maritime security strategy, the Customs-Trade Partnership Against Terrorism (C-TPAT), is another voluntary program, specifically aimed at including the private sector into the government efforts at combating terrorist exploitation of the international logistics system. With C-TPAT, DHS seeks to provide the same “green lane” customs entry to compliant importers, freight forwarders, and importers that CSI offers compliant ports. In a sense, C-TPAT provides U.S. importing firms the ability to maintain production sourcing in countries that have not been selected for CSI participation. To date, 4,171 importers, 1,287 brokers, 1,456 carriers, 48 port authorities, and 289 foreign manufacturers have sought and received C-TPAT certification. Firms are also promised to receive a lower Automated Risk System rating, leading to significantly fewer cases of CBP searches of containers. Moreover, C-TPAT firms are notified early of any changes in the Homeland Security alert system. The higher the risk level and the increased number of container inspections make “green lane” access much more desirable.

To become C-TPAT certified, firms must conduct a comprehensive self-assessment of supply chain security: procedural, physical, and personnel security, training, and access controls. A supply chain security profile questionnaire must be submitted to CBP, which will be used later to conduct the CBP assessment on the firm’s eligibility. Lastly, applicants must develop and implement a program to enhance security throughout the supply chain. In order for a foreign manufacturer to apply for C-TPAT consideration, they must manufacture or produce goods for shipment to the U.S., as well as pack and prepare the goods for shipment, including the loading and sealing of containers, prior to
loading onto U.S. bound ships. Firms engaged in selling goods to the U.S. who do not fall into this category can also become certified if they are wholly or majority owned by a U.S. C-TPAT-compliant firm, be controlled by a C-TPAT firm, or be included into a "Related Party Importer's approved C-TPAT Supply Chain Security Profile". Independent or contracted manufacturing exporters would fall into the latter category, and require the invitation from their U.S. buyer.

It remains to be seen whether the benefits from C-TPAT certification, namely "green lane" customs entrance and the promise of fewer inspections at U.S. ports, constitute a sufficient incentive for firms to invest in the required time and systems setup. It should be noted that at lower security alert levels, the difference between "green" and normal lane customs entry is relatively minor when compared with the differential during heightened levels of security.

Moreover, large firms with established supply chain management strategies in place may be in a better position to integrate security programs into their operational planning than small or medium size counterparts, and would also likely stand to benefit more from assured speedy customs clearance. The revision of one's entire supply chain structure for security purposes can also provide firms with spillover benefits such as reduction of cargo theft, loss and damage, by becoming more involved in the movement of goods from the origin to the destination. Moreover, increased self-assessment and improvement of supply chain security may also potentially lower insurance costs associated with movement of goods. It should be noted, however, that application to C-TPAT does not necessarily equate to acceptance, as there is approximately a 15-20% rejection rate.
C-TPAT is often touted for its spillover effects of increasing asset visibility, and yet, if this benefit is as substantial as has been advertised, this leads to the question of why is asset visibility something that is being promoted by the Customs and Border Patrol, and not by private actors themselves. Furthermore, if a firm relies on highly responsive “just-in-time delivery”, and requires the timely delivery of components from overseas for their production process, logically it would in all likelihood already be using air shipment, as opposed to maritime shipment. On the other hand, if large retailers, like Target and Home Depot rely on purchased goods from overseas, no single shipment is crucial to their overall operations, due to the high volume of goods they sell. “Big box” retailers only really need a rough estimate of the delivery time of their supplies, and if this is delayed due to inspections, it is the supplier and not the retailer that suffers.

The Customs-Trade Partnership Against Terrorism was developed using the framework of previous Customs programs aimed at combating narcotics smuggling, particularly the Business Anti-Smuggling Coalition (BASC) focused primarily on Latin American and South-East Asian countries. Although C-TPAT differs in scope and area of focus, the expedited customs clearance rewards program for becoming a member is essentially the same, as is its voluntary nature. The program has had a significant degree of success, with nearly 8,000 “partners”, including importers, shippers, carriers, customs brokers, and foreign manufacturers. As noted earlier, participants who conclude the required self-assessment of their supply chain and the associated security protocol of their business partners, qualify for the following benefits: customs clearance at port of entry through
dedicated "commercial lanes"; the assignment of an individual Customs Service point of contact; reduced inspections, and account based payment of duties.

C-TPAT compliant companies are eligible for early notification of increased security levels, potentially allowing them to divert US-bound cargo to other ports to avoid lengthy delays. It should also be noted that C-TPAT certification provides a company with a "corporate good citizen image". C-TPAT has also been touted by its proponents for its ability to reduce cargo theft and pilferage incidents. According to a study by the OECD, worldwide cargo theft accounts for between $30-50 billion per year. By increasing the visibility of the whereabouts of containers and their ships at all times, companies could identify the weakest link in their supply chain and address this. Lastly, firms that source their goods from geographic areas that are located far from CSI ports can still be eligible for expedited customs clearance if they agree to undergo the security self-assessment and certification procedures associated with C-TPAT certification.

There has been considerable speculation that C-TPAT "green lanes" for expedited customs clearance do not actually provide such dramatic benefits as have been hyped. Moreover, the mere existence of such green lanes has been called into question. George Cummings, Head of Homeland Security Operations at the Port of Los Angeles, noted that in his capacity at one of the major US seaports for incoming containers he is not aware of the actual existence of an easily identifiable lane where C-TPAT or CSI containers are sent for fast scanning. Many private firms that have become C-TPAT-compliant have also noted that the promised benefits of the expedited clearance processes are not always clearly noticeable. According to David Jones, Vice President, Loss Prevention and
Security for Tommy Hilfiger USA, Inc, “this is not to say it will never happen, only that no significant changes have been noted, to date, by many C-TPAT certified companies”.

On the U.S. land borders with Mexico and Canada, the designated Fast and Secure Trade (FAST) lanes do exist for C-TPAT-compliant trucking companies and maquiladora assembly plants. FAST customs lanes at land borders are clearly marked, the time saving benefits are easy to assess, and the demand for FAST certification is high. However, this clear dichotomy between “green lane” and standard customs processing is not as clear at seaports. Part of this ambiguity of the benefits of C-TPAT membership may stem from the fact that the difference between a compliant company and a noncompliant one is not that C-TPAT “partners” automatically receive faster customs clearance than before they signed up, but that they are not subject to the increased inspections that all other firms are. According the Beth Peterson, a supply chain security consultant and former manager of Hewlett Packard’s $7.5 billion per year U.S. import operations, the most effective method for quantifying C-TPAT membership is through projection analysis. While Peterson concedes that “there is no clear “green lane”, [...] if your cargo inspections do not increase, nor the associated delays, this is a real tangible benefit”. Furthermore, “if it takes between 24 to 48 hours to inspect a container, (sometimes up to a week), and if up to 6% of all your company’s freight is scanned, compared to 1% of C-TPAT partners, the difference between the two represents the benefit to becoming C-TPAT certified. For a multibillion dollar company, this is a multimillion dollar difference.” Peterson went on to cite one firm she has worked with that is comprised of 18 divisions, 17 of which were C-TPAT certified. The firm was able then to effectively compare the cost of customs delays
to the one remaining non-C-TPAT division, and thus quantify the benefits it derives due to membership.

Conversely, whatever positive effects C-TPAT holds for its “partners”, the opposite holds true for the non-certified importers, carriers, brokers, and foreign manufacturers. It has been estimated that since 9/11, physical inspections of cargo containers have increased from 2% to 6% of the total. As noted earlier, stopping a container, completing the required paperwork, and conducting a physical inspection can take three customs agents up to five hours, while non-intrusive imaging devices can scan many more containers during the same amount of time. Regardless of the time it takes to inspect a container, the disruption to delivery schedule can prove far more costly. In the event that a container is selected and screened by agents, the resulting delay may mean that the following stage in its voyage, whether by truck, train or ship, may not be available for anywhere between 24 hours and one week.

Many critics of C-TPAT have speculated that large U.S. firms that rely on international sourcing for their “just-in-time” production will alter their operations in light of potential customs delays if their foreign manufacturers are not “partners” in either program. Yossi Sheffi, director of the Massachusetts Institute of Technology’s Center for Transportation & Logistics has put forward the idea that what sourcing changes do occur will take place over a long-term period. Sheffi speculates “it is unlikely that companies will forgo the benefits of low-cost, high quality offshore manufacturing altogether…[but that they] will only hedge their bets with local suppliers.” Procter & Gamble has reported that the company’s global sourcing strategy division has recommended building “slightly higher inventories and forming new relationships with domestic suppliers.”
At the inception of C-TPAT in 2002, DHS officials sought to recruit the participation of the largest US importers, while small- and medium-sized companies were not targeted as aggressively. Yet, in many instances the negative effects of not having access to the "green lanes" can have very severe consequences on smaller firms. Depending on the nature of the supply chain of the end user, delays of between 24 hours and one week could prove decisive to the survival of the firm. According to Tom Cook of the import/export management consulting firm American River International, "even a small electronics importer who brings in one container a month, for instance, can lose his livelihood if his container was to be detained for an extended period of time". Unfortunately, the costs associated with becoming C-TPAT-certified may prove excessively burdensome to small and medium sized importers. Conducting assessments of their entire supply chain, from foreign manufacturer, to shipper, to customs broker and domestic trucking company, can cost anywhere between $10,000 and $100,000 depending on the size of the company and the number of actors in the supply chain. Thus, for many small importers, no matter the cost advantages to becoming C-TPAT certified, the costs may prove overwhelming.

However significant are the costs to become a C-TPAT partner, the most vocal critics of the program do not find fault here, due to the voluntary nature of the program. In much the same way as with CSI, there is concern that because C-TPAT partners are granted "green lane" customs clearance, non-partner firms are being subjected to unfair treatment "two tier" system are presented in more detail.
3.4 The Smart and Secure Trade Lanes Initiative

Launched by the Strategic Council on Security Technology, The Smart and Secure Trade Lanes Initiative (SST) is an industry-driven, supply chain security initiative that is deploying a global security network for end-to-end supply chain security - from point of origin to point of delivery - across multiple global trade lanes and transportation modes.

Recognized as the world's most comprehensive and practical security initiative for the intermodal cargo community since the Sept. 11th terrorist attacks, SST combines the people, processes, and technologies involved with supply chain security in a global network for container security. SST participants are also committed to improving productivity while taking an aggressive, flexible and innovative approach to complying with international government requirements. SST is rapidly expanding throughout Europe, Asia and North and South America. Most importantly, SST enables global ports to drive proven, security-based solutions throughout a worldwide infrastructure. The initiative’s ultimate goal is to enhance the visibility of each container shipment as well as the transparency of those shipments within the overall supply chain, improve the physical security of containers and their contents and create an audit trail that enables the system to analyze, learn and adjust to dynamic changes.

Phase I Objectives

SST was announced in July 2002 and has been operational since October 2002. SST was formed to address the global supply chain security issues facing the container shipping industry and leverage international ports as strategic control points in the supply chain. The key objectives for SST are:
o Rapidly deploy a baseline functional infrastructure to secure, track and manage containers, leverage proven technology and the global networks of 5 out of the 6 top global port operators (Hutchison Port Holdings (HPH), PSA, P&O Ports, SSA Marine (Stevedoring Services of America) and China Merchants Holdings (International) Company Limited (CMHI).

o Enlist a diverse group of multi-national shippers who, in collaboration with their transportation network partners (port operators, carriers, forwarders), implement end-to-end container security (origin to destination).

o Synchronize and ensure compatibility with existing government initiatives such as: Customs CSI, C-TPAT, Operation Safe Commerce, and ISPS.

o Develop an overall economic model that clearly demonstrates the operational efficiencies created through real-time visibility into the status and location of individual shipments.

From the announcement in July 2002 to February 2003, SST has accomplished these Phase 1 goals: Security assessment of the global supply chain and ports, business process analysis of shippers, service providers and ports, and the development, execution, and implementation of new security processes and technology solutions.

To date, 15 of the world’s largest international ports and trade lanes are participating in the SST initiative. The shippers and container routes represent all types of supply chains and products, including high-tech electronics, mass retail, consumer package goods, auto
parts, aviation, petro-chemical, rubber and tires, clothing, footwear, and toys. Based on this extensive shipper community, the SST initiative has been able to test and prove its value by shipping about 1,000 “smart and secure” containers from point of origin to point of destination.

3.4.1 SST Participants

The Smart & Secure Tradelanes initiative is made up of a diverse group of partners, each bringing their expertise and business practices to the consortium. Partners include:

- Supply Chain Domain Expertise to evaluate supply chain vulnerabilities and solutions:
  - Stanford University, Transportation Logistics Institute, Asia Pacific, Pinkerton Logistics Security, Sandler Travis Trade Advisory Services and Georgia Institute of Technology.

- About 20 major shippers and importers across 13 vertical industries.

- Global port operations making up over 80% of the world’s container trade:
  - Hutchinson Port Holdings with 30+ ports - PSA with 15+ ports including Singapore - P & O Ports with 20+ ports - China Merchants (operator of ports in China) - SSA (Stevedoring Services of America)
  - U.S. Port Authorities: Port of Seattle, Port of Tacoma, Port of Los Angeles, Port of Long Beach, Port of New York/New Jersey, Port of Houston, Port of Savannah, and Port of Charleston
U.S. Terminal Operators: SSA, Marine Terminals Corporation (MTC), Total Terminals International (TTI), P&O Ports, Georgia Ports, Charleston Port Authority, Port of Houston Authority, Global Terminals.

International Carriers including 6 out of the top 10 global carriers.

Service Providers: Parsons Brinckerhoff, Cotecna, Boeing, SembCorp Logistics, PSA Logistics, Copas.

Technology Providers for a total solution approach combining multiple automatic identification technologies, sophisticated security systems and enterprise-class software to enable supply chain security including: Qualcomm, Savi Technology, OneSeal, EJ Brooks, China International Marine Containers (CIMC), Symbol, Intermec, Sun Microsystems, Compaq, Microsoft, IBM, Oracle, EXE, Manugistics, Vigilos.

3.4.2 The SST Solution

During Phase I of SST, ocean cargo transport events were evaluated and analyzed to identify shortcomings in the supply chain process, key security areas at risk, and essential infrastructure requirements. Initial qualitative and process evaluation found that compliance with government programs such as U.S. Custom’s 24-Hour Advance Manifest Rule (AMR) can be automated to ensure compliance, and that SST enables better supply chain execution.

The SST global security network also improved shipment visibility and supply chain transparency. For example, SST provided greater capabilities to identify dwell time, (inventory at rest is at risk) as well as routing variability, which hinders accurate
reporting and planning. These same issues are critical impediments to supply chain efficiency. One example of improved tracking was demonstrated when an automated SST event showed that a shipment had arrived at its U.S. port destination whereas the EDI transmission for the same shipment showed it (incorrectly) arriving two days later. Other research has revealed that the complexity and dynamic nature of global supply chains requires a common open technology infrastructure. With an open infrastructure framework, processes and technologies can be easily implemented and tested as they become available.

Based on these discoveries, the SST solution will continue to move forward as a combination of people, processes and technologies incorporating three fundamental capabilities:

- The capturing, storing, monitoring, and transmitting of essential data associated with ocean-containerized cargo, including but not limited to: line item manifest data, container identification, sealing, shipper/consignee, booking, route planning, physical status, location, origin, and bill of lading information.

- Making the container smart: Automated anti-intrusion and tracking sensor systems for real-time location, physical integrity and status of the containers, including route planning, deviations from plan and tampering events.

- An automated end-to-end supply chain security audit trail that may be used by the participants in the supply chain as well as international regulatory government agencies.
SST is based on international standards and the existing U.S. Department of Defense Total Asset Visibility network that is actively deployed in over 40 countries and 750 checkpoints worldwide. Because of SST's global momentum, the International Organization for Standardization (ISO) has selected the initiative to help it refine container security standards.

The technical solution is made up of various technologies, including Radio Frequency Identification (RFID) hardware, GPS, GSM, tracking and management software, anti-intrusion sensor systems and automated video surveillance. The SST solution is designed to comply with and complement the following government programs: US Customs Trade Partnership Against Terrorism (C-TPAT), 24 Hour Advance Manifest Information Rule, the Container Security Initiative (CSI), Operation Safe Commerce (OSC), and National Strategy for Homeland Security, and support the cargo security components of the ISPS code.

Although the overall SST infrastructure is constantly developing and evolving with cutting-edge technology, there is a core network in place at all participating ports.

The fundamental process begins at the point the container is first stuffed – The Secure Point of Origin. This may be a factory, warehouse, or consolidation center where all certified containers are entered into the Smart & Secure Tradelane. Here, items are either originally packed or received and inspected. The authorized container operator digitally signs onto a handheld terminal with an authorized password, and enters the container data into the system.

The container becomes a conveyance of real-time information itself by being equipped with anti-intrusion and tracking sensor systems, which enable it to be tracked throughout
its supply chain journey. When the sensor-equipped container reaches critical checkpoints along its route, its status and location are monitored, and any tampering, deviation from the expected route, or change in status will automatically alert the authorized users. This real-time information is aggregated and relayed by a powerful software network to the Transportation Security System application. Additionally, the software can be configured to automatically transmit required data to the relevant authorities along the route.

Status reports and any pre-scheduled information about the particular cargo shipment such as arrival alerts are generated in the real-time tracking software application.

Phase II - Global Expansion

SST continues to expand globally into new ports, trade communities and routes – both ocean and surface. Phase II of the SST initiative started in February 2003. SST Phase II plans underway include:

- Extend the infrastructure of SST’s global security network inland at both the point of origin (factory or consolidation point) and point of destination (deconsolidation and distribution points).

- Refine 24 hour manifest information processes and enabling technologies to obtain manifest information at point of origin for all supply chains, including early electronic submittal to U.S. and non-U.S. Customs authorities.

- Refine the automation of an expedited “Greenlane” for secure cargo through ports and terminals with no deterioration in operational efficiencies.
• Develop new smart and secure container prototypes that retrofit or incorporate sensor and tracking systems at the time of manufacture with various technology providers.

• Expand depth and breadth of processes and technologies worldwide, adding sensors and non-intrusive inspections systems at key chokepoints in the supply chain.

• Expand beyond the current CSI mega ports in SST to other high-risk regional ports.

• Expand to other shippers and their supply chains, including hazardous materials as well as continuing to expand to smaller shippers and consolidators.

• Combine other technologies, including GPS in-transit tracking, chemical-biological-radiological sensor devices, and a variety of anti-intrusion, tamper-response sensor systems for multi-layered security.

3.4.3 Joining SST

Now is the time to get involved with the Smart & Secure Tradelanes initiative. The initiative is for those that are concerned with global transportation security and operations such as ports, terminal operators, carriers, shippers, consolidators, service providers or government and border crossing authorities. There are three key ways to get involved with SST:

• Extend the SST network – The more points on the trade lane route the more secure the transport of containers. Ports and terminals in the SST network are part of a secure ocean cargo supply chain that applies best business practices, utilizes advanced technologies and follows the regulations of the supply chain security authorities.
• Extend the functionality of the SST network - Technology and service providers add value for the secure trade lanes with their technology and solutions. These providers bring specific functional and technical enhancements to the baseline network that can continually enhance the capabilities and effectiveness of the network.

• Use the SST Network - Shippers and freight forwarders benefit by using the Smart & Secure Tradelanes for all their intermodal cargo. Shipments traveling through the secure process of SST will be part of a tested and proven supply chain process. This means more shipments will arrive on time with all their content intact.
3.5 Conclusion

There have been made significant efforts nowadays through which a legal framework has been established. What is an issue now is how policy hand in hand with technology will lead to an optimal environment where sufficient measures to comply with the policies will be made by applying technology in such a way that cost will be at its minimum. Radio Frequency Identification technology is considered today as a good solution. There are firms which offer hardware and software which applies this technology in containers. There have been also tests through which industry related players try to understand how this technology could be used effectively and what are its benefits. In the next chapter we will get through this solution and its acclaimed benefits.
CHAPTER 4 - RFID Technology

4.1 Description and Comparison of RFID Technology

There are two types of Radio Frequency Identification Tags. Active RFID and Passive RFID technologies, even though they have similar use in the supply chain they have different capabilities and advantages. Usually, there is a lot of confusion when someone refers on RFID tag and therefore we consider essential to describe these distinct technologies.

Both technologies use radio frequency energy to communicate between a tag and a reader (sometimes is called an interrogator). To better state that radio frequency energy is actually electromagnetic radiation, energy propagated as electromagnetic waves through free space or a material medium. This energy is characterized by the frequency, speed and amplitude. Each of these characteristics has a different impact on the electromagnetic radiation which is transferred.

Frequency is measured usually in Hertz (KHz, MHz or GHz) or wavelength. It is characterized by the number of waves repetition per second. Therefore, different frequencies are associated with different wave qualities. Speed at which waves travel depend on the material waves traveling through. The speed that could be achieved through a vacuum is at the speed of light (c is approximately 186,282.397 miles per second). Amplitude is the ratio of Height: Power level of the wave. These properties,

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frequency, amplitude, or phase can be altered (moderated) to carry (encode) information through the wave.

![Electric field and Magnetic field](image)

**Figure 4.1 Electromagnetic radiation characteristics**

Active RFID tags are continuously powered through an internal power source, a battery within the tag, while Passive RFID tags gets energy from the reader device which transfers electromagnetic radiation (radio frequency) in order to power the tag.

This difference could seem minor but it is significant for the operation of these systems. Passive RFID tags could either reflect the energy that is sent from the reader or absorb and temporarily store a very small amount of energy from the energy that was sent from the reader in order to generate its own quick response. In both cases, a passive RFID tag needs a very strong signal send from the reader, to send a response to the reader which is constrained to very low levels by the limited energy that receives from the reader.

In contrast, an active RFID tag allows very low signals to be received by the tag, since the tag is self-powered. This tag can generate high-level signal back to the reader. Since
an Active RFID tag is continuously powered, it sends signals whether or not there is a reader that will receive this information in the area. These differences have an impact in the communication range, in multi-tag collection capability, in the ability to add sensors, in data logging and in various other functional parameters. In the following Table 4.1, we present a comparison of the technical characteristics between the Active and Passive RFID tags.

<table>
<thead>
<tr>
<th>Source of Power</th>
<th>Active RFID tags</th>
<th>Passive RFID tags</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tag battery</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Power intervals</td>
<td>Continuously</td>
<td>When reader is present</td>
</tr>
<tr>
<td>Signal Strength from Reader to Tag</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Signal Strength from to Tag Reader</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>

Table 4.1 Comparison of Technical characteristics between Active and Passive RFID tags

The differences as explained above have an apparent impact on the functionality of these tags. The effect of the way to which Passive RFID tags are powered, limits their communication range. That is due to the strong signals which have to be sent from the reader to the tag, in order to activate the tag and the inadequate amount of power which is available to the tag to transmit its response, the information encoded in the tag's memory to the reader, thereby creating a constraint to the tag to reader range. This range limits the range of Passive tag operation to the order of 3 meters, whereas Active RFID tags, having
their own power are not subject to any constraint of power allowing them a communication range in the order of 100 meters.

An effect of the communication range of the Passive RFID tags is that when we try to obtain information from multiple tags which are in motion it is hard to obtain information from all the tags and most of the time unreliable. An illustration of this case would be when someone tries to get information from a moving pallet with multiple tagged products. In order to get the signal that carries the identity of each product it is essential that there would be substantial communication from the reader to the tag and vice-versa. To ensure that the reader should be able to communicate separately with each tag, to send energy to the tag, which in response will send a response signal back to the reader. In practice this is very difficult, since every communication takes time and also the possibility of interference increases with the number of tags to be read, thereby increasing the needed time to identify the tags. Additionally, while the tags are moving they must stay in the communication range of the reader (from 9 feet to 25 feet, depending on the frequency of operation), thus creating another restriction in the operational capability of Passive RFID tags. A common Passive RFID system requires more than 3 seconds to read 20 tags, if we take into consideration the communication range constraints this limits the speed of the moving tagged items to 3 mph.

In contrast, Active RFID tags have an operating range of 300 feet or more and a reader is able to read thousands tags with a single reader, even if they are in motion at a speed of 100mph with accuracy and reliability.
RFID applications in the supply chain have the ability to monitor environmental or status parameters when RFID tags have built-in sensor capabilities. Environmental parameters include, but not restricted to temperature, humidity, vibrations, radiation, while status parameters are related to security and tamper-proof. Passive RFID tags have not the ability to continuously monitor the status of a sensor, since they are not continuously powered, but only when a reader is present and only in a limited range close to the reader, this constraints obtaining and monitoring their status only when a reader is on range. Active RFID tags, are continuously powered and regardless if a reader is present they can monitor and record by writing sensors status to the tag. They do not only record the status of each sensor, but also the date and time at which every event or measure value occurred. This feature is specifically important in recording container seal status and depending the application, temperature, humidity or even radiation status.

An important difference between the Passive and Active RFID tags is their feature of dynamically storing data within the tag. Passive tags, due to the power constraints to which we referred earlier, can read/write not store more than 128 bytes of data, with no search capability or other manipulation characteristics. Active RFID tags, which are continuously powered, allow the transmittance of considerably larger data of 128Kbytes (1000 times the data that Passive tags can store), with dynamically searchable read/write features.
In the following Table 4.2 we summarize the functional capabilities of both RFID tags, while having in the same time a short comparison between them.

<table>
<thead>
<tr>
<th></th>
<th>Active RFID tags</th>
<th>Passive RFID tags</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication radius</td>
<td>Long in the order of 300 feet</td>
<td>Short or very short from 9 feet to 25 feet depending on the RF used</td>
</tr>
<tr>
<td>Multiple tag</td>
<td>1000 tags when moving at a speed of 100mph from a single reader</td>
<td>20 tags when moving at a speed of 3mph from a single reader</td>
</tr>
<tr>
<td>information</td>
<td></td>
<td></td>
</tr>
<tr>
<td>collection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitoring</td>
<td>Continuously monitor and record sensor’s input with date and time of record</td>
<td>Only when a reader is present</td>
</tr>
<tr>
<td>Intervals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage of data</td>
<td>128KB of read/write data with search and access capabilities</td>
<td>128byte of read/write data</td>
</tr>
</tbody>
</table>

Table 4.2 Functional capabilities of Passive and Active RFID tags
4.2 Radio Frequency range

Every RFID solution application has a different range of frequencies that is used or is applicable for use in each of the two distinctive technologies of Passive and Active RFID. In most of the bibliography, in spite of the fact that the frequency (RF) in which the systems operates is one of the most important elements of this technology, since is the way through which energy is transferred and makes the simple system of tag-reader communicate and operate, is undervalued. Therefore, I consider essential to review the ranges that are used in RFID applications. In the Graph 3.1 below we will review the ranges of the RFID systems.

![Radio Frequency Operating Ranges Graph](image)

Graph 0.1 Operating ranges of the RFID systems
In the following Table 3.3 we are present the ranges of Passive RFID tags, ranging from the order of 100 KHz to 2.4 GHz.

<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>LF (&lt;135 KHz)</th>
<th>HF (13.56 MHz)</th>
<th>UHF (860 - 930 MHz [1])</th>
<th>Microwave (2.45GHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specifications</td>
<td>AutoID HF class 1</td>
<td>AutoID class 1</td>
<td>AutoID class 0, class 1</td>
<td></td>
</tr>
<tr>
<td>Typical Read</td>
<td>&lt;0.5m</td>
<td>~1m</td>
<td>~4-5 m[2]</td>
<td>~1m</td>
</tr>
<tr>
<td>Range</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General</td>
<td>Larger Antennas resulting in higher cost tags, least susceptible to performance degradations from metals and liquids</td>
<td>Less expensive than LF tags, Best suited for applications that do not require long range reading of high number of tags. This frequency has the widest application scope.</td>
<td>In volume UHF tags have the potential to be cheaper than LF or HF due to recent advances in IC design. Good for reading multiple tags at long range. More affected than LF and HF by performance degradations from metals and liquids.</td>
<td>Similar characteristics to UHF but faster read rates. drawback is microwaves are much more susceptible to performance degradations from metals and liquids.</td>
</tr>
<tr>
<td>Tag power source</td>
<td>Mainly passive using inductive coupling (near field)</td>
<td>Mainly passive using inductive coupling (near field)</td>
<td>Active and passive tags using E-Field back scatter in the far field</td>
<td>Active and passive tags using E-Field back scatter in the far field</td>
</tr>
<tr>
<td>Typical</td>
<td>Access Control, Animal tagging, Vehicle immobilizers</td>
<td>Smart cards, Access Control, Payment, ID, item level tagging, baggage control, Biometrics, Libraries, laundries, Transport, Apparel</td>
<td>Supply Chain-pallet and Box tagging, Baggage Handling, electronic toll collection</td>
<td>Electronic toll collection, Real Time Location of goods.</td>
</tr>
<tr>
<td>applications</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Notes</td>
<td>Largest installed base due to mature technology. However will be overtaken by higher frequencies</td>
<td>Currently the most widely available high frequency world-wide due to the adoption of smart cards in transport</td>
<td>Different frequencies and power allocated by different countries US 4W (EIRP) 915MHz, Europe 0.5W (ERP) 868 MHz [2]</td>
<td>5.8 GHz more or less abandoned for RFID</td>
</tr>
<tr>
<td>Multiple Tag</td>
<td>Slower</td>
<td>Faster</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Read Rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability to read near metal or wet surfaces</td>
<td>Better</td>
<td>Worse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passive Tag</td>
<td>Larger</td>
<td>Smaller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.3 Performance of Passive RFID tags

From the above table it becomes evident that whenever the use of Passive RFID technology is to be applied there should be a decision over the appropriate frequency.

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which should be used which is clearly linked with the characteristics of the system, such that the application of the technology at the business process would be the optimum.

In the applications of Active RFID technology the range of frequency to which the system operates is also a major concern. Frequency affects systems technical performance, i.e. the maximum communication range and propagation within crowded environments.

Radio waves of lower frequencies propagate in longer distances than radio waves of higher frequencies, if power level is constant. Radio signals propagate in longer distances through a medium (e.g. air) when wavelength is longer. Signals of lower frequencies have longer wavelengths and as a result the decrease of signal's strength occurs at a lower rate frequency is lower. To illustrate this if a signal of a certain frequency \( F \) decreases by a certain rate over a length \( L \), then a signal of half this frequency i.e. \( F/2 \) will decrease by the same rate in two times the length \( L \), i.e. \( 2xL \).

Wavelength and consequently frequency affect the signal's capability to propagate within crowded environments. RFID systems operate in terminals, warehouses, ocean or air terminal and therefore their ability to propagate at these environments, where there are various obstructions like trucks, intermodal containers and other metal objects. Active RFID signals have the ability to propagate around rather than passing through the
obstructions. This is achieved through diffraction, as the ratio of the object’s size to the signal’s wavelength converges to one.

As it is documented, at a frequency of 433 MHz the wavelength is about a meter, allowing the signal to diffract around obstructions. At 2.4 GHz, the wavelength is a tenth of a meter, as a result diffraction is limited, resulting in blind spots and inadequate coverage. At range of frequencies from 2 to 4 GHz (primarily the 2.45 GHz and 5.8 GHz bands), there are disadvantages of that devices are more susceptible to noise, frequencies are shared with other technologies making necessary additional use of a spread spectrum.

As it is presented in the following Graph 4.2, which illustrates a comparison of frequency and its effects to system’s Technical Performance and Line-of-sight.

Graph 0.2 Frequencies between 100MHz and 1 GHz offer the best technical performance for Active RFID

As it was presented, a proposed optimal selection for a global standard of Active RFID applications would be a frequency 433 MHz, with which read ranges of up to 100 meters can be achieved.
4.3 Legal framework

Use of frequencies is regulated in countries and varies from country to country. Therefore what it had been proposed as the optimal technical solution might be not a feasible solution.

Also, another concern is the regulations that exist over the feasible solution and the standardized specification which differs at various regions of the world. There are three regions as it can be illustrated in the following Figure 4.2.

![Regions of RFID regulations and standardization](image)

Figure 4.2 Regions of RFID regulations and standardization

The way, in which the regulations are documented, refer primarily to the maximum radiated power emission which is quoted either in Equivalent Isotropic Radiated Power (EIRP), i.e. the product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna (an antenna that radiates power equally in all directions, e.g. a sphere) or Effective Radiated Power (ERP), i.e. the product of the power supplied to the antenna and its gain relative to a half-wave dipole in a given...
direction. These two different values are related by the following equation: \( \text{EIRP} = 1.64 \times \text{ERP} \).

However, another factor described to the regulations is the duty cycle, i.e. how often and for how long they transmit the information which is stored in the tags. Usually, Active RFID tags are reliable when operating for the 10% of the time. Even operation in the order of 1% or even less could be considered as a standard, but due to the impact of transfer rates of data, this inherits reliability issues.

Lastly, an additional concern is the modulation scheme, since some frequency and power emission regulation are linked with it. Operating in two frequency bands requires the use of spread spectrum regulation for full power operation. This increases the cost of the tags and the cost of the whole system applied.
Regulation framework at the three regions

**REGION 1:** In the USA, the responsible regulatory authority is the Federal Communications Commission (FCC).

UHF regulations are the FCC-Part 15 (15.249)\(^{29}\). The Allocated UHF band is 902-928 MHz, with Max Power emission 4W EIRP - Frequency Hopping

**REGION 2:** In Europe, the responsible regulatory authority is the European Conference of Postal and Telecommunications (CEPT).

UHF regulations are the ERC REC 70-73\(^{30}\). The Allocated UHF fixed band is 869.3 – 869.65 MHz, with power emissions limited to 500mW EIRP (under some limitation can reach 2W). Readers must operate within a 10% duty cycle – No Frequency or channel hopping.

**REGION 3:** In Japan, the responsible regulatory authority is the Ministry of Public Management, Home Affairs, Posts and Telecommunication (MPHPT).

Regulation: Japanese Radio Law. Refers to ARIB (Standards Association of Radio Industries and Business). Japan has only recently announced the allocation of a UHF frequency at 950 MHz.

In terms of regulative acceptance and duty cycle, it is proposed as it can be shown from the above Table 4.4, that the most widely accepted amongst the most common Active RFID bands is the 433 MHz.

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\(^{29}\) [http://www.access.gpo.gov/nara/cfr/waisidx_01/47cfr15_01.html]

\(^{30}\) [http://www.ero.dk/doc98/official/pdf/rec7003e.pdf]
<table>
<thead>
<tr>
<th>Band</th>
<th>303 MHz</th>
<th>315 MHz</th>
<th>418 MHz</th>
<th>433 MHz</th>
<th>868 MHz</th>
<th>915 MHz</th>
<th>2400 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>302-305 MHz</td>
<td>314.7-315 MHz</td>
<td>418.06-418.975 MHz</td>
<td>433.050-434.700 MHz</td>
<td>868-868.6 MHz</td>
<td>902-928 MHz</td>
<td>2400-2483.5 MHz</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Canada</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Great Britain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>France</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Germany</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Netherlands</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Singapore</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taiwan</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>China / Hong Kong</td>
<td>✓</td>
<td>In process</td>
<td></td>
<td></td>
<td>Limited</td>
<td>Limited</td>
<td>Limited</td>
</tr>
<tr>
<td>Australia</td>
<td>Limited acceptance</td>
<td>Limited acceptance</td>
<td>Limited acceptance</td>
<td>Better Choice</td>
<td>Limited duty cycle</td>
<td>Limited acceptance</td>
<td>Poor technical performance</td>
</tr>
<tr>
<td>Summary</td>
<td>Limited acceptance</td>
<td>Limited acceptance</td>
<td>Limited acceptance</td>
<td>Better Choice</td>
<td>Limited duty cycle</td>
<td>Limited acceptance</td>
<td>Poor technical performance</td>
</tr>
</tbody>
</table>

Table 4.4 Acceptance of common Active RFID system frequencies in major countries
4.4 Applications over the Supply Chain

Due to their technical specifications and functional capabilities, Passive and Active RFID tags can be applied in different parts of the supply chain to provide asset visibility. When movement of assets is constrained in a specific and controlled area, where there are no or limited security and sensors data to be read or recorded, then Passive RFID applications are the suitable solution. But when tagged assets are continuously moved across points of the supply chain, then there is a need for advanced security and for continuously recording and reporting of environmental and security parameters, then Active RFID tags are more appropriate to use. Both tags can provide end-to-end and top-to-bottom supply chain visibility.

Applications include: Area Monitoring, High-Speed, Multi-Tag Portal Capability, Cargo Security and Electronic Manifest.

In Area Monitoring, Active tags can provide a continuously or in regular intervals monitoring of the tagged assets over a large area. This can be useful in warehouse where one can obtain real-time inventory information. When containers or trailers are tagged in a yard, a terminal or an air terminal, monitoring their location and their security status is considered an easy task.

Active RFID is used also for High-Speed, Multi-Tag Portal Capability, since tagged items pass through portals of various sizes and shapes across the whole supply chain.
Every gate, doorway or opening, through which items pass, can be included in this description. In order to identify multiple tagged items passing through portals, we have to take advantage of two functional capabilities of Active RFID tags, i.e. multiple tag information collection at high speed and locating tags within the portal.

For example, entry/exit gates at an intermodal terminal, dock doors at a distribution center, conveyor checkpoints where packages are sorted, roadside monitoring of an eight-lane highway etc.

Use of RFID is also considered for Cargo Security, where RFID seals are an effective mean of securing every type cargo – ocean, land, rail and air. But different types of tags, active and passive can offer different capabilities and levels of security.

Passive tags are efficient, when simple tamper detection is adequate, when the time and date of tampering is not important and when fear of possible pilferage is negligible. Capabilities of passive RFID tags in such applications, is limited due to the fact that they are not continuously powered and therefore they cannot provide information of cargo location and the status of the seal while in transit. In such scenarios information can only obtained when Passive RFID tags communicate and “activated” by readers at the next read point of the supply chain.

On the other hand, Active RFID tags are capable to provide in continuous base information of the seal status, thereby identifying minute alterations of the seal’s position or integrity and implementing advanced anti-spoofing techniques. In case an incident is detected, the exact date and time of its occurrence is recorded in the tag’s memory, providing a timeline of the events which occurred during transit.
Another application of RFID is Electronic Manifest. Then the appropriate solution would be an Active RFID tag, since only with these tags have adequate data storage and include searchable data capabilities, which are essential to record an electronic manifest, such as customs inspection. Passive RFID tags are not considered a solution due to their data storage and capabilities.

Whenever technology is used to solve a business problem the main consideration is that the business processes are affected in the least possible way. In a generic approach proposes that use Passive RFID need more changes than Active RFID applications. This is because of a number of reasons: a) Passive RFID tags have to pass through specific checkpoints in the range of the reader and the trail they have to pass should be strictly defined to make sure that the tagged is read by the reader at the defined gate, b) Passive RFID tags should have a limited speed while passing a read-point, c) Also multi-tag information collection is limited due to the reasons we have already mentioned.

Consequences of these limitations of Passive RFID tags that some of the business processes might need to be re-designed and the personnel who will use the system should be well trained. Therefore when we examine whether or not Passive RFID solution should be used, we should account also these cost of re-designing the processes and training the business staff, this has to be taken into consideration also when use of Active RFID tags is proposed. In the following Table 4.5 we summarize some of the application of RFID technology and an applicability comparison between Active and Passive RFID solutions on these applications.
### Table 4.5 Applications of Active and Passive RFID systems for supply chain visibility

At the depth to which we have done our analysis thus far, it seems that use of the two distinctive RFID technologies should be applied when business applications and networks of the supply chain fit one of the characteristics and merits defined in the above table. Obviously there are problems where the applicable solution is either Passive or Active RFID systems. But, actually if we break the supply chain in shorter parts, we could solve the problem more effectively by applying each technology where it’s needed capabilities fit better in order to realize cost savings that will result to the minimum possible overall cost.
5.1 Introduction

We have already referred to the RFID technology. Now we have to examine the proposed usage of RFID on containers that makes the so called 'smart boxes'. This is the application of active RFID tags to containers. Nowadays, the only player of the industry that has successfully applied this technology is the U.S. Department of Defense.

AT Kearney, refers that “During Operation Iraqi Freedom, the military deployed 90 percent fewer containers, compared to Operation Desert Storm, and attributes more than US$300 million of efficiency savings to RFID”. At an article \(^{31}\) in the RFID Journal, by J. Collins, it is mentioned that “The U.S. Department of Defense (DOD) is already finding significant measurable benefits from its initial use of RFID across its huge supply chain. While the DOD continues to roll out RFID capabilities, it says ongoing trials are already proving the value of RFID...Implementing RFID in the Marine supply chain has cut inventory value in the chain from $127 million to $70 million. ...Average delivery times have dropped from 28 days to 16 days, while the supply backlog of 92,000 shipments has fallen to 11,000.... An internal U.S. government analysis of the DOD’s RFID use in its supply chain department would save $70 million over seven years.”

It is the potential of getting the benefits and having the convenience that the DOD has already taken advantage of the RFID technology that drives the container industry to the adoption of such a technological solution, through a continuous debate.
5.2 Proposed RFID usage

The use of this technology starts when the container is loaded. Placing an RFID tag to a container is not at all a difficult procedure. By that time the container tagged container is being tracked and using an information network between the authority/ factory where the tag was placed and the container destination, all the interested parties including ports can track the asset’s location and ensure that no intervention has taken place. An Active RFID tag is attached to the container as it is sealed. Each tag has a unique number in this manner it links that number to the container’s manifest, so that we can identify what are the contents of the container. From the Port or point where the container is loaded and sealed to the Port where it is discharged or to its final destination, there are points where readers track the containers and monitor container’s status. Points across the supply chain where readers are placed include the spot where a truck is loaded or unloaded, on a crane that transfers containers, a weight station, the port of loading or at the port of discharge. Each reader, handheld or stable is linked via middleware to the internet and automatically feeds information to networked software tools.

![Diagram of Active RFID application on container across the supply chain](source: A.T. Kearney)

Figure 5.1 Active RFID application on container across the supply chain
5.3 Claimed benefits

Active RFID tags are programmable, reusable and store much more data, and their cost is considerably higher in comparison to passive tags. Benefits that the applied tags offer are:

- Monitoring the containers even when there are no readers in range. This allows to detect tampering, vibration, light, humidity, temperature changes and other environmental fluctuations.

- They are more reliable because they can be read from a distance of 100 meters, while passive tags are readable in a range of up to three meters. Therefore it is possible to collect information from thousands of tags, even when the containers are in motion at speeds reaching 100 mph.

- They can be read even through liquids, while passive tags do poorly on that field.

These capabilities give us a flavor of the potential penetration of the discussed technology.

What makes the use of RFID technology intriguing and could bring smiles to the faces of the managers of large supplies chains are the quantified and unquantifiable benefits that may soon appear after using the proposed technology and realizing these benefits.

On that direction most of the information we have found stems from the “APEC STAR-BEST PROJECT, COST – BENEFIT ANALYSIS, November 2003” report. It might seem old at our time, but the use of RFID technology has not been applied to an end-to-end supply chain that could give us up-to-date info on the benefits and associated costs.
As this report points out, “Companies importing goods into the United States should realize impressive financial benefits by utilizing this technology to secure, track and manage their supply chains.”

5.3.1 Claimed benefits (of quantifiable monetary value)

Firstly, as we have emphasized a clear cost-saving that derives from the use of RFID technology would be the on time submission of the Manifest data, as it is required by the Advanced Manifest Rule (AMR), this could lead to an immediate saving of around $25, which is the cost that most carriers charge shippers on per container basis for AMR submission. The shipper has to provide the manifest to the carrier, which then will forward the data to the Advanced Manifest System (AMS). The proposed solution should enable the shipper to record and transmit the manifest directly to AMS and avoid paying the carrier surcharge. Clearly, by submitting the manifest to US Customs in an electronic format through AMS, we have an increased confidence in the validity of manifests. In addition, carriers often require that containers arrive early at the port to ensure compliance. This delay increases inventory costs for the shipper, and it could be avoided by ensuring that the manifest is being sent to AMS at the time the container leaves the facility at which it was loaded and it was sealed with the RFID tag.

Additionally, from the “Electronic Freight Management, Benefit Calculations”32, it is evident that we can realize reduced manifest preparation time, reduced paperwork

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32 “Electronic freight Manifest Benefit Calculations- Revised October 2004”, by the Science Applications Intermodal Corporation
handling time, reduced time in communicating with up- and down-stream intermodal partners and reduced load transference times between intermodal partners.

Based on the differences in mean time on task using manual or legacy processes versus Electronic Freight Management, monetized using a 50$ of labor cost per hour, we could realize savings as following (for outbound shipments):

- For the Manufacturers 5.01$ (6 min)
- For the Trucking companies 14.50$ (17.4 min)
- For the Carrier (derived from the data that we have on the Airline industry after making necessary adjustments) 8.90 $ (10.6 min).

It has been observed that the procedures which are involved in the inbound handling of shipments closely emulate those for outbound shipments. Taking this into account we can estimate the potential cost saving from point of origin to ultimate destination to 56.82$ per shipment.
5.3.2 Claimed benefits (of unquantifiable monetary value)

Only a small percentage of the containers that arrive at U.S. ports are inspected by the U.S. Customs. Therefore the probability to which a container will be selected for inspections is small. However, the costs which are incurred by the importer in such a case can be significant. Delays on the event of having the container inspected can be notable, causing delays on transporting the container from the port to the distribution center adding to carrying costs. Also, the occurrence of random inspections adds variability to the expected transit times and can force the importer to increase his safety stock levels. Customs has raised the possibility that inspections could be reduced for containers originating from companies in compliance with CTPAT. It can be easily assumed that ‘smart’ containers would receive even more favorable inspection rates, as has been also suggested through the Smart and Secure Trade Lanes Initiative (SST). A substantial drop in the probability of inspection could lead to substantial cost savings, through reduced safety stocks and consecutively a reduced risk of missed sales due to stock outs. To give an example of the impact that reduced safety stock has we will mention the case of Wal-Mart who currently has a 99% in-stock record, but the missing 1% equals almost $1 billion in lost sales. Therefore it has become evident that the importance of lowering the possibility of inspections and other forms of delays through the use of ‘smart’ containers leads to significant cost savings.

Applying the solution enables companies to have perpetual inventory management. Companies will be able to know what inventory is coming to them, regardless where it is.
In a company’s environment, real time inventory enables improved replenishment, reduced cycle times, in-transit tracking items, better accuracy forecasts, increased flexibility in responding to unexpected demands, improved item locating and easier recalls.

RFID application results in significant labor cost savings. Such savings could occur in the receiving side of stores or warehouses and at manufacturers. In fact 100% of the labor in physical inventory count could be eliminated.

Also, there are various estimation on this savings, in receipt, stocking, cycle counting and checkout, distribution, receiving cost and picking cost. The reduction of the discrepancy between inventory record and actual inventory on hand, by matching demand without carrying inventory, but carrying buffer stock to protect against the error terms, reduces related inventory costs by 5.9%.

Use of RFID technology, will strengthen the operational functionality of the ports, result in decrease of lead time and obviously would permit companies to enhance their trust in making more shipments by sea, avoiding having air cargo which costs at least five times more than shipping cargo by sea. By increasing container movement through ports there is an obvious benefit for the Port Authority, since in many cases alignment of the container shipments could allow scheduling with other modes of transport such as rail and trucks.
Having smart containers moving across the supply chain could lead to reduced pilferage incidents, lost containers and consecutively to reduce insurance costs. It will be harder for thieves to open a container and steal some of all of its contents or to steal the whole container. This is because by using RFID tags, we achieve visibility and can track the container location easily, then the appropriate parties interested in the smooth in-transit movement of the container across the supply chain will be alerted and will have the local authorities posted in the occurrence of such an event, to locate the container and hopefully prosecute the thieves before it is too late.

Nowadays both importers and logistic managers alike have a great uncertainty over the data which they possess, which most of the time is missing or is inaccurate. This has a great impact on their job processes, since most of the time they cannot track their inventory as it is moving across the supply chain. Unfortunately, they depended on data which comes from a variety of systems providing data that is far from certain. Shippers get data from carriers, who are using different systems and provide the data in a number of formats. Since data format is not given in a standardized format, data is timeless and most of the time inaccurate, it is far more difficult for shippers to locate their containers, container status, if containers are loaded in a vessel and vessel’s location and status. Because of the variety of data formats, importers have to use significant human and IT resources in order to organize the provided data and have the information in appropriate database. By using the proposed solution, container’s tracking and visibility across the supply chain will be achieved and the only part to which carriers will have to update their information would be vessel’s estimated time of arrival to the port. Additionally, RFID
tags could record unfavorable events like security breaches and then provide information regarding the time and in some cases the location where the breach incurred and also the current position of the container. It is obvious that time will be consumed more effectively in tracking and monitoring container movements.

Having accurate data on time, logistics managers can make adjustments when exceptions occur and design plans that reduce the probability of recurrence. It is suggested that potential savings related to tracking expenses are still unclear. There are estimations that savings would be in the range of $15 to $20 per container. However, it will take quite a time for this savings to be realized. At the APEC-STAR Project, there is the limitation of applying RFID technology on a single trade lane, in such a case the benefits which derive from tracking efficiency might be limited in comparison to having the technology operating in a number of trade lanes.

Therefore, what makes RFID solution appealing is the “Network Effect”. At the start only companies who transport relatively valuable good, such as electronic products will be willing to adapt the solution. But afterwards, since the infrastructure will exist and the secure trade line will be established, the cost of implementing the solutions will decrease as the number of adopters is increasing. Also, as the infrastructure between two ports is established and the tradelanes are operating adding one more port to the network requires investment on infrastructure only in the new ports, since the first two have already implemented the system. Also, if another port implements the solution to make business with only one of the others then it establishes at the same time tradelanes with all the other members of the network.
If the aforementioned benefits were realized, then as the Monte Carlo simulation results of the APEC-STAR Project indicate, a shipper who has shipped a container worth $300,000 to the U.S. could realize substantial returns ranging from $200 to $2000, by applying the proposed solution, as the following figure shows.

![Figure 5.2 Probability distribution of predicted Savings per container](image)

More likely saving will range from $600 to $700 on a container basis. After running the simulation the Predicted Savings were discounted for uncertainty. This was considered necessary due to an assumption that a 50% discount should be applied to the projected benefits. Projected benefits like avoiding the inefficiencies of the supply chain, completely avoiding BoL surcharges or that insurance companies will lower their premiums, have some uncertainty.
For example, if an importer wants to be 80% confident that the costs will not exceed the benefits. The analysis shows that the importer can be 80% confident that the benefits will exceed $220 per container. In that case the importer will be reluctant to pay more than $220 per container to utilize the solution.

However, most of the benefits incur at the importer’s distribution center. Having less safety stock and fewer missed sales is the main reason leading to the projected savings. There are four key variables which are tightly linked with the cost savings. Namely, the Value of goods per container, the transit time and its variance at the potential of reducing missed sales caused by stock outs.

At this particular project, costs are accumulated on a per container basis. Some sensitivity analysis shows that the benefits are strongly linked with the value of the good inside the container. This occurs due to that it is more expensive to have high-priced good sitting in inventory than low priced goods. Also, by using the proposed solution we achieve less transit time (and its variance), from the location where the container was loaded to the container’s final destination (i.e. the distribution center). For that reason, the greater the value that the container has, the greater (other things equal) the benefits the importer will realize. This can be shown by the following Figure 5.3.
Further sensitivity analysis of the simulation, shows that benefits are related to the reduction which is achieved to the missed sales due to stock outs. Obviously as greater the reduction is, as greater (other things equal) the benefits would be. Following Figure 5.4 shows this relation.
Last but not least, is the relation of the transit time and its variance to the benefits. In the following two figures we can see how this factor, which we regard as the second most important, affects the value of the benefits.

![Figure 0.5 Benefits per container Vs Change in Transit Time](image1)

![Figure 5.6 Benefits per container Vs Change in Transit Time Variance](image2)
All these findings lead us to a conclusion. Adoption of RFID Technology could be valuable if we examine the adoption of the solution case by case. This is valid due to the distinctiveness of each container, its value, the relevant processes which are followed in applying the technology, the probability of having unfavorable events like pilferage and delays at customs or other unpredictable events like lock-outs or even strikes.

Therefore, there is no straightforward answer whether or not we should apply the technology. There is some uncertainty, since it depends on a number of variables, in a case by case examination.

For example, as we have been told by an industry specialist. “In some cargos like computer hardware, memories and peripherals US customs don’t keep the container for inspection and if even they keep it for an inspection it will be really a brief one. RFID might have no use in such a case.”

Thoughts like the aforementioned lead us to be extremely cautious in doing generalizations. However, due to restriction of the data that we possess it’s inevitable to do so. As we will do in the next paragraph, in order to give a flavor of the way the solution should be applied.
5.4 Break Even Point of the Project

The feasibility of a full-scale implementation of the solution across the Model Tradelane to which, the project was applied or to which similar project will be built, is heavily dependent on three key factors: volume, revenue per container, and implementation time. To examine if the project is profitable we calculate its Net Present Value (NPV). If NPV is positive we should invest on the project, otherwise we should not. The Service Provider should go ahead with the project if he succeeds to recover from the fixed and variable costs associated with the Solution implementation.

In such an approach, as the benefits that we acquire by implementing the solution are increasing, the volume of the containers that should be equipped with the RFID technology is decreasing.

Under this thought we can compute the NPV, by calculating the fixed and variable costs which are applicable in the Model Project and which are shown in the following Table 5.1.  

<table>
<thead>
<tr>
<th>Expenses</th>
<th>Cost</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure (network equipment installed permanently in ports and terminals, handheld readers at customer specific locations)</td>
<td>$436,389</td>
<td>One Time</td>
</tr>
<tr>
<td>Implementation (personnel and travel expenses required to assess, design, implement, test and analyze the system)</td>
<td>$3,433,046</td>
<td>One Time</td>
</tr>
<tr>
<td>Variable (RFID seals applied to each container)</td>
<td>$86</td>
<td>Per Container</td>
</tr>
<tr>
<td>Operation Costs (maintenance of the Infrastructure and the costs of operating the information database and interface)</td>
<td>$100,000</td>
<td>Per Year</td>
</tr>
</tbody>
</table>

Table 5.1 Costs

In a yearly basis containers moving from Thailand to US are around 20,000 and given the relevant costs we compute the number of containers to which the RFID tags should be installed, to do so we have to know the associated costs.

The costs that a Service Provider will incur fall into the above three categories: infrastructure, implementation, and operation costs. Infrastructure costs include the network equipment installed permanently at ports and terminals, RFID seals/tags applied to each container, and handheld readers and signposts at customer specific locations. Implementation costs include personnel and travel expenses required to assess, plan, design, implement, test, configure, installing and analyze the system.

Operation costs include the maintenance of the existing infrastructure and the costs of operating the information database and interface, as well as maintaining a secure, accessible and timely network. Understanding that a Service Provider will be required to make a large, upfront investment to build out the system before any revenue has been realized, the financial model analyzes the NPV of installing and operating the solution over a five year period.
By doing the needed calculations and by taking in mind that the benefits on a container basis are estimated at $220, we found that the solution should be deployed to 40% of the container movement, i.e. 8,000 containers.

We should point out that in case that we apply the solution to one FEU, then the benefits derived from the RFID application are double as the one we would have in the case of a TEU containing goods with the same density value or value per unit.

These benefits would be multiplied if we connect another port, because we will realize the benefits of the “Network Effect”.

Installing the system in other ports we also get options to relocate our container-cargo to other ports in case that that an unfavorable event occurs.

Furthermore, port congestion will be mitigated since we will be able to move cargo more efficiently and effectively.
5.5 Conclusion

The proposed usage of RFID applications in containers might be a valuable investment on the advance of international trade and supply chain reliability, but it hinders some obstacles to which industry experts should be aware of before they decide to implement it. In the next chapter, we think it is vital and more useful for the engineers and experts of this field to consider and resolve to the extent to which is possible any pitfalls and technological shortcomings that may exist.
CHAPTER 6 – Potholes

At the moment, there is no other implementation of RFID technology at the context to which we are examining than the US Department of Defense.

This brings questions, since it really differs to apply a solution to goods like ordnance, missiles that worth millions of dollars, army stores and provisions by a government, than in an international trade application where all the kinds of cargo, having different monetary value, are moved.

In the next pages we will concentrate, not only in these differences, but also in other issues which in my opinion make RFID applications not a panacea, but only one additional measure towards an optimized and more secure supply chain.

Firstly, all the reports and studies which I have studied try to persuade the public and the industry officials that RFID is the total solution for the container cargo. However, I strongly believe that these people are trying to implement a technological solution, which as advanced they are trying to present, it is not that much sophisticated and it has not been sufficiently tested. This particular solution will be applied to a container, to a metal box. An article 34 describes a container as “A soulless aluminum or steel box held together with welds and rivets, with a wooden floor and two enormous doors at one end: the standard container has all the romance of a tin can. The value of this utilitarian object lies not in what it is, but in how it is used. The container is at the core of a highly

automated system for moving goods from anywhere, to anywhere, with a minimum of cost and complication on the way”.

It does not take someone long time to realize that trying to apply a so called technological solution to an object which entered global trade long time ago, in 1956 is rather complex. There is nothing technologically sophisticated on a container; it is only what we have described above. Terrorists, thieves and other types of criminals could either cut the doors hinges or disassemble the sides of it putting it afterwards in its initial position, as the container was intact. As an article\textsuperscript{35} that we have found warns us “door only security is not only inadequate, but also dangerous”.

There are sound facts that demonstrate that the above statement is truly valuable and should alarm industry’s experts and officials. Right now, active RFID tags are considered as the best available solution as way of tracking containers using a state-of-the-art device. The way DHS realizes the state of the art of RFID is the following “The container and trailer security device must be able to electronically detect closing and opening of either door of the container/trailer. Monitoring the door status must be continuous form the time of arming to disarming by authorized personnel.” I believe that the gap may be profound. If the RFID tag fails to electronically detect and record any breach, the systems fails. Ironically, in April 2005 a North Carolina firm demonstrated to national and foreign attendees, including the news media and the DoD, the capacity and ability to breach a container, and insert contents without ever opening the doors. This particulars demonstration was successfully repeated in Bremen, Germany, by the same firm. This

\footnote{\textsuperscript{35} “DHS caught in its own trap”, American Shipper, March, 2006.}
shows how primitive is the container concept in our era of globalization where terrorists pose a threat to international trade.

Additionally, RFID uses internet based solutions to submit AMS and to inform the involved parties of a container’s contents, location etc. This could hinder another danger in our time where internet security and relevant technologies are facing a continuous threat by criminals everyday. For example, a terrorist group of hackers or criminals could invade in such a network (Secure Internet Database) and cause many problems, by shutting down the network, putting a virus in it, altering the information stored of the RFID tags, changing the status from not intact, after a security breach to intact, and so on. By this they could cause a disruption with more than a billion dollars loss, in some times without even breaking into a container.

In June 2004 the Federal Communications Commission issued a final rule authorizing the use of 433MHz for commercial shipping containers. Since each nation or region approves and utilizes different frequencies and communication protocols, frequency identification is easily obtained through published documents. In the rest of the world other frequencies are allowed, therefore it would be necessary to resolve these incompatibilities before ever considering worldwide implementation. It is on the hand of the industry officials to decide on an international standard with which RFID technology will be deployed using the same frequencies, protocols and procedures.
The above mentioned regulation on the use of the 433MHz, as the frequency for commercial shipping containers hides a pitfall. As the same article suggests, if a container is breached while en route to the US, without opening the doors and shielded nuclear waste along with an explosive device can be placed into the container. In that case an RFID antenna could be cut in the wall of the container by a terrorist unseen from outside. The dirty bomb can be automatically armed by the interrogation signal of a RFID transceiver placed at the foreign port. They could also install the explosive device inside the container, connected with a door switch that will detonate the bomb when the container's doors will open. As the locked container arrives in a US port it is interrogated by the 433MHz frequency, responding with a “not-opened” signal and then explodes. Unfortunately, one could thing of a vast number of possible scenarios that take advantage of the solution's vulnerabilities leading with mathematical accuracy to destruction.

There is also the possibility that some of the players of the industry will not consent in sharing data in an IT network, like the one that the implementation of the RFID solution is proposing. Indeed, there arise privacy issues which quite probably will make shippers and their customers skeptic to provide full information on a container’s contents.

All the relevant papers refer that workers that will apply the RFID solution the supply chain should be trained on how to operate such a system. In my opinion, this is the least that should be done. Personnel that will operate and establish the solution should also be trustworthy. If this is not the case, then criminals of all kind could acquire information on
the whole design and take advantage of existing or future possible procedures that could pose threats to the global trade.

Another problem in the current proposal of the RFID in the supply chain is the fact that Active RFID Tags are read-write. This means that someone could alter the data which is stored in the tag’s memory. Maybe a handheld reader or other device could be modified to achieve that. Whether or not data stored in the tag is encrypted, an intervention is always a possibility. However, if tags are not read-write, then they could not record a breach and their use becomes limited if not pointless.

We should also not neglect that RFID requires a substantial amount of money to invest in infrastructure, in all the nodes of the supply chain in order to ensure the most effective tracking of the containers. This may significantly affect the business process in some of places around the world, which may be not so advanced in terms of IT infrastructure and where culture also may differ, requiring extensive training of people having different mindset.
CHAPTER 7 - Conclusions and recommendations

Our objective in this thesis was to obtain a better understanding on the environment to which RFID technology could be applied and how this application could be beneficial.

We were able to review the security issues that companies moving shipments across the supply chain are currently facing after the terrorist attacks of 9/11, but also in the previous period before that, given the practices that US customs, shippers and carriers are currently using.

Then we examined the legal framework that the U.S. government established through the Department of Homeland Security, having as a main purpose to guard the safety of US Borders, protecting in the same time US public. We reviewed the 24-Hour Advance Manifest Rule (AMR), the Container Security Initiative (CSI), the Customs Trade Partnership Against Terrorism (C-TPAT) and the Smart and Secure Trade Lanes Initiative (SST). It became evident that with these governmental actions United States became more alarmed of any potential threat to its trade patterns. We also referred to the special handling of containers which are enhanced with technological solutions, the so-called “smart” containers, abiding these policies, which are trying to provide a certain level of transparency.

Afterwards, we presented the basic parts of RFID applications, the way the different two types operate, their main characteristics, but also some of their advantages (capabilities) and disadvantages. Then, we examined the legal framework which abides the frequencies
in the different regions of the world to give a flavor of the implications that this issue could bring. We gave also examples, on the current use of the different types of tags, presenting also their capabilities and limitations.

But primarily we examined as analytically as we could the proposed usage of RFID technology in the supply chain in creating smart containers. The way this informative network will operate, the benefits which could be immediately realized (by cutting expenses), like the automatic manifest submission through AMS and the attainment of efficient tracking and monitoring of container movements.

Other benefits will be the ones that may be realized when the system becomes reliable (in the long term), through a well maintained operation of the solution, by having “smart” containers passing through “green” lanes, then companies which depend in the smooth movement of containers across the supply chain, will attain savings in inventory and significant reduction of missed sales due to stock outs.

At this point we should always have in mind that the claimed benefits will be capitalized, analogous to a case by case examination of the four factors (Value of Goods, Change in Transit Time and its variance, reduction of missed sales due to stock outs), that affect these benefits.
Following, we presented the potholes which are currently underestimated and which should be resolved before the Department of Homeland Security or individual companies may decide to mandate a use of the proposed solution.

Therefore, it became evident that, no one would disagree that RFID applications in the container industry might bring many benefits to its adopters. It encompasses many uses and characteristics. Tracking efficiency, environmental and status factors monitoring, that may bring the anticipated benefits.

I strongly believe that in the future more pilot programs should be encouraged, so that we will be able to test the RFID applications on the run, after solving or at least deteriorating some of the problems which exist, that will help us have a better understanding in the potential of the “smart” containers and in what extent can we really built a trust to them.

However, I consider vital that before any wide implementation its is necessary to improve the proposed system, correct any faults and pitfalls that could transform containers from Trojan boxes to “smart” Trojan boxes, that will carry not presents for the Gods as the Greeks deceived the Trojans in the epic Homer Iliad, but weapons of mass destruction.

It is certain that RFID should be only a part of a multi-layered security strategy for the US. The role of the Security Initiatives that have been adopted should still be the elevated. We have to take always in mind that still there is not around any affordable and
effective technology in Chemical and Biological weapons devices and that still the use of radiation detection devices might be overestimated. There is more to be done in this direction before visualizing a supply chain network that will operate effectively using RFID technology.

We also should not forget that even when the system will be efficient it might take a different period of time in the various regions of the world, to establish a competent use not only of the technology, but also of the business processes, which may have to change significantly in some countries, due to cultural differences and people’s mindset. The human factor is always critical when the world is advancing in new standardized and technological applications.
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Here under are the assumptions which were made in the APEC-STAR Project, as found in the report. They may reflect some of the costs and benefits that an importer would realize by implementing the Solution to make better his supply chain network. However, I am uncertain about the accuracy and reliability of the mentioned values. Not only about the one mentioned after, but also before the Solution’s implementation.

### APPENDIX

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>U.S. Customs Inspection Assumptions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time it takes for U.S. Customs to inspect a container</td>
<td>0.25</td>
<td>0.05</td>
<td>Days</td>
</tr>
<tr>
<td>% of Containers Subject to Inspection - Current</td>
<td>0.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of Containers Subject to Inspection as Customs Increases Capacity</td>
<td>0.5%</td>
<td>0.2%</td>
<td></td>
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<tr>
<td>Green Lane Container Inspection Rate</td>
<td>0.2%</td>
<td>0.1%</td>
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<td><strong>Importer Assumptions</strong></td>
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<tr>
<td>Annual Demand from Distribution Center</td>
<td>4400</td>
<td>500</td>
<td>Containers</td>
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<td>Monthly Demand Coefficient of Variance</td>
<td>0.7</td>
<td>0.2</td>
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<td>Value of Goods per Container</td>
<td>$300,000</td>
<td>$100,000</td>
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<td>Average Gross Margin for Containerized Goods</td>
<td>40%</td>
<td>5%</td>
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<td>Missed Sale Gross Margin Multiplier</td>
<td>2</td>
<td>0.25</td>
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<tr>
<td>% Stock Outs that result in Missed Sales - Before Implementation</td>
<td>30%</td>
<td></td>
<td></td>
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<tr>
<td>% Stock Outs that result in Missed Sales - After Implementation</td>
<td>25%</td>
<td>3%</td>
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<tr>
<td>Annual Inventory Carrying Cost</td>
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<td>2%</td>
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<td><strong>Pilferage &amp; Insurance Assumptions</strong></td>
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<td>Pilferage Incidents per Year - Before Implementation</td>
<td>2</td>
<td>1</td>
<td></td>
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<td>Pilferage Incidents per Year - After Implementation</td>
<td>0.5</td>
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<tr>
<td>Property Costs per Pilferage Incident</td>
<td>$130,000</td>
<td>$20,000</td>
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<td>% of Pilferage Losses Reimbursable by Insurance</td>
<td>25%</td>
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<td>Administration Cost per Pilferage Incident</td>
<td>$10,000</td>
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<td>Shipping Insurance as % of Container Value</td>
<td>2%</td>
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<td>Reduction in Insurance Cost after Implementation</td>
<td>1%</td>
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<td><strong>Tracking Cost Assumptions</strong></td>
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<td>Tracking Costs per Container - Before Implementation</td>
<td>$100</td>
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<td><strong>AMR Compliance / Bill of Lading (BOL) Assumptions</strong></td>
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<tr>
<td>Average Number of BOLs per Container</td>
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<td>Time Delay at Laem Chabang without load order</td>
<td>2.0</td>
<td>0.5</td>
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<td>% of BOLs Submitted on Paper</td>
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<td>$25</td>
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<td>Surcharge per BOL Admendment</td>
<td>$40</td>
<td>$10</td>
<td></td>
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<tr>
<td>% of BOLs requiring amendments</td>
<td>4.0%</td>
<td>2%</td>
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<td><strong>Transit Time Assumptions</strong></td>
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<tr>
<td>Average Transit Time (Point of Origin to U.S. Distribution Center)</td>
<td>29.5</td>
<td>0.2</td>
<td>Days</td>
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<tr>
<td>Estimated Change in the Mean Transit Time After Implementation</td>
<td>-2%</td>
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<td>Estimated Change in the Transit Time Standard Deviation After Imp.</td>
<td>-10%</td>
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<tr>
<td>Number of Days between Deliveries to the Distribution Center</td>
<td>7</td>
<td>2</td>
<td>Days</td>
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