IMPACT OF THE EXPANSION OF THE PANAMA CANAL:

AN ENGINEERING ANALYSIS

by

Charles W. W. Mitchell, III

A thesis submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Master of Civil Engineering

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Charles W. W. Mitchell, III

Approved: ____

Earl E. Lee II, Ph.D.
Professor in charge of thesis on behalf of the Advisory Committee

Approved: ____

Harry W. Shenton III, Ph.D.
Chair of the Department of Civil and Environmental Engineering

Approved: ____

Michael J. Chajes, Ph.D.
Dean of the College of Engineering

Approved: ____

Charles G. Riordan, Ph.D.
Vice Provost for Graduate and Professional Education

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ABSTRACT

By 2014, the Panama Canal will have completed a major project that will expand the capacity of the present lock and lake system to handle a new class of container vessel. These container vessels will be more than twice the size of vessels capable of transiting the canal prior to the expansion completion. With these larger ships come more shipping containers per ship and a new set of challenges for U.S. East Coast ports. This research looks at the effects the expansion of the Panama Canal will have on U.S. East Coast and Gulf Coast ports through three primary research questions. First, what is the existing transfer of containerized freight from the West Coast to the East Coast. Second, what are the tradeoffs between the all water route to the East Coast and the intermodal route via the West Coast. Third, how will the expansion of the Panama Canal affect port operations for East Coast ports. The research of these three questions is limited to containerized freight.

The research indicates there is not a significant freight movement from the West Coast to East Coast that is going to create a significant shift after the canal expansion. The largest impact is expected to be larger container ships calling on ports less frequently which will create new operational challenges for ports to consider when planning for the future.

Chapter 1

INTRODUCTION

The Panama Canal is presently undergoing major changes in infrastructure that will allow the canal to expand its service capacity significantly beyond the existing capacity of the canal. Ever since the opening of the Panama Canal in 1914, it has been an integral link for shipping traffic from the Pacific Ocean to the Atlantic Ocean. Each year, more than 14,000 ships transit the canal, 70% of the containerized freight is inbound or outbound from the U.S. East Coast (Knight, 2008). Over the nearly 100 years of canal operation, expansion projects have been proposed but never implemented. However, the canal is presently undergoing a major expansion project to expand the lock capacity and allow significantly larger ships to transit the canal. The project is expected by many to cause an increase in vessel calls on the U.S. East and Gulf Coasts as shippers move away from the congested West Coast (Knight, 2008).

The Panama Canal transit system is a fifty miles long, consisting of a system of locks to raise and lower ships to the level of a lake connecting the two channels. This combination connects the Atlantic and Pacific Oceans. However, the size of this channel and lock system prevents many ships from transiting the canal. To remain competitive in the international market, it became evident the canal would need to expand its capacity.

Prior to the expansion, the largest ship the canal could handle is referred to as a panamax vessel and any ship larger than the canal's capacity is referred to as a "post-panamax vessel." The panamax vessel is currently 965 feet long, 106 feet wide and has a draft of 39.5 feet. This type of ship is capable of handling up to 4,500 twenty foot equivalent units (TEUs). The TEU is a non-standard unit of measurement used to quantify the size of a shipping container and is essentially a twenty foot long container with either an eight and a half foot or nine and a half foot high height and a eight foot width. A container nine and a half feet high would be referred to as a “high cube.” A twenty foot long container is referred to as one TEU and a forty foot long container is referred to as a two TEU container.

Ship building trends in world container ships have been increasing to be much larger than the present panamax ship. Post-panamax ships carry 5,000 to 8,000 containers and there are now even larger ships referred to as “super post panamax” which carry over 9,000 containers. Figure one shows the size comparison between the two types of vessels. There are possibilities of a Suez Max vessel (the largest ship the Suez Canal could handle) at 14,000 TEUs and there is an 18,000 TEU vessel in the design phase and is being referred to as a Malaccamax Vessel or the largest vessel that could navigate the Straits of Malacca between Malaysia and Indonesia.

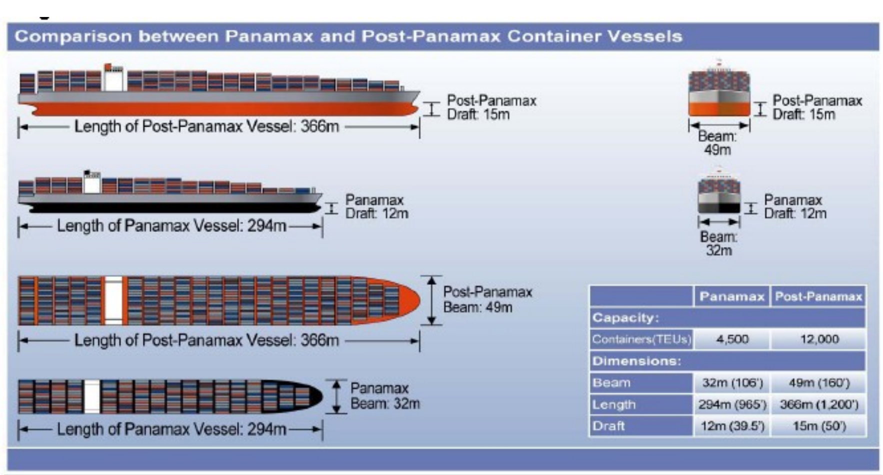

Figure 1 Panamax Vs. Post Panamax Vessels (Panama Canal Authority, 2006)

In order to accommodate larger ships that can carry more TEUs, the Panama Canal Authority (ACP) is adding a third set of locks and deepening the channel through the canal and Lake Gatun to allow post-panamax ships to be able to transit the canal. The new Panama Canal will be able to handle a post-panamax ship of up to 11,000 TEUS with a 51 foot draft. These vessels which will then be the largest vessels able to transit the Panama Canal are being referred to as new panamax (NPX) vessels or "E Class" vessels.

The expanded Panama Canal is expected to open in 2014, coinciding with the 100th anniversary of the original opening of the canal. It is uncertain what effect the expanded canal will have on U.S. East Coast and Gulf Coast ports. However the expansion of the Panama Canal will have some effect on operations, including relieving congestion at the canal entrance and allowing the canal to remain competitive in the international shipping market. The goal of the canal expansion is not to compete with alternative routes, but instead to have enough capacity for the users of the canal to better compete (Johnson, 2007). This research provides some insight into some of the possible effects the larger ships transiting the canal will have on U.S. East Coast and Gulf Coast ports.

The analysis contained within this report is limited to container shipping and looks at three primary research questions. First, what is the existing intercontinental flow of container freight across the U.S. "land bridge" from the West Coast to the East Coast. Second, what are the benefits and limitations of the all water route through the Panama Canal vs. the intermodal route by truck or rail across the United States. The third question gives insight to the possible effects a change in freight patterns may have on port operations and includes a case study of the Garden City Terminal of the Georgia Port Authority in Savannah, Georgia.

As a note, the shipping industry is filled with acronyms and at times it can be consuming understanding all the abbreviations. A list of definitions has been included for the reader prior to the appendix.

Chapter 2

LITERATURE REVIEW

The Panama Canal Service

The expansion of the Panama Canal is expected to have a significant impact on canal operations and the ships that transit the canal. The Panama Canal is no longer a option in the international shipping market but rather an important component of a worldwide shipping network. Expansion in advance of a trend of larger ships is going to prevent clogging and possible irrelevance of one of the world's most important trade arteries (Gellman, 2006). To illustrate the importance of the Panama Canal in the overall worldwide shipping network, currently the Panama Canal handles five percent of the world's trade with approximately 14,000 ships passing though the canal each year (Wilson, 2009).

The largest effects at the canal itself are expected to be an expanded capacity and an increase in cost to shippers. For containerized traffic, Traffic World (2007), an international shipping magazine, reports financial impacts that include an increase in TEU fees by about twelve percent per year over a period of three years. This is approximately a nine dollar (U.S.) increase per TEU in the toll for 2008 and 2009. There will be other similar increases in tolls for bulk tonnage, car carriers and other segments of the shipping market (Traffic World, 2007).The Panama Canal Authority has said they plan to double tolls by 2025 (Dupin, 2006).This is an estimated three and a half percent increase in tolls each year from 2005 to 2025 (Leach, 2006).

Prior to the expansion, the average toll for the Panama Canal was $32,000 per vessel and the canal was working at 93% of capacity. In addition to the regular toll, the final slot of the day is sold at "auction" to the highest bidder. For example, a spot that typically would have been $45,000 went for $230,000 in auction at the end of one day. There is concern over the increase in canal tolls and there is a fear that the Panama Canal Authority will raise tolls so high to pay for the expansion project that shippers will look for alternate, cheaper, routes to the East Coast. "The tolls are really high now, and if they are doubled, it will force carriers not to want to use the canal and seek alternative routes like the Suez Canal" (Leach, 2006).

Vessels typically won't plan to transit the canal unless they know they will have a slot. However with the expansion of the canal, there will be an increased capacity. One estimate is daily traffic will increase from 38 to 51 vessels per day. In 2003, there were approximately 13,000 canal transits, moving 260 million tons of freight (Bijo, 2004) and by 2025, some expect this number to increase to 15,000 transits (Dupin, 2006). Kevin Knight from the U.S. Army Corps of Engineers Institute for Water Resources estimates that freight volume is expected to increase by an average of 3 percent a year from 2005 which will double the 2005 tonnage by 2025.

Additionally, some feel that the competitiveness of the Panama Canal route will increase because of increased transits, faster average transit times and greater average vessel size making this a more attractive route compared to the Suez and Cape Horn routes (Bijo, 2004). That competiveness and increased attractiveness is evident from the increase in Panama Canal traffic. In 1999 11% of freight destined for the U.S. East Coast arrived via the Panama Canal while 86% traveled across the U.S. first arriving on the West Coast. The remaining freight arrived via the Suez Canal. In 2004, the share of Panama Canal traffic increased to 38% and intermodal traffic was reduced to 61% leaving the Suez Canal with only 1% of the East Coast traffic (Dupin, 2006). Figure two below shows the gradual change in freight over the 1999 to 2004 time period. Some of this transition may be caused by congestion on the West Coast has caused shippers to switch to all water routes for goods destined for the East Coast (Knight, 2008).

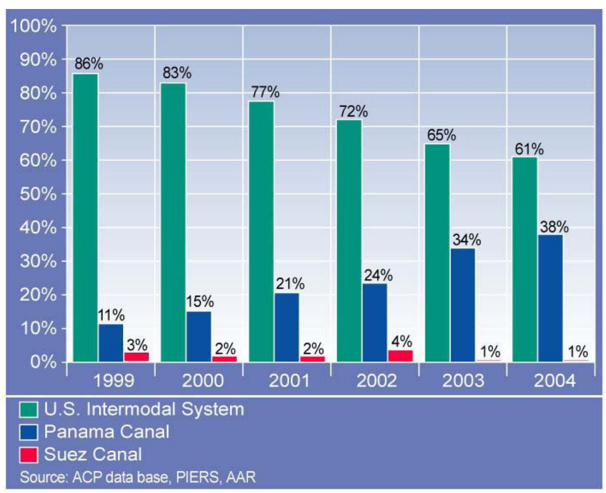

Figure 2 Market Share of the Container Segment on the Asia to the U.S. East Coast Route (Knight, 2008)

Currently, the container ships transiting the canal today carry 4,500 to 5,000 TEUs each. However, with the expansion of the canal, ships carrying up to 12,000 TEUs will be able to pass through the corridor. "The World Shipping Council estimates that in 2006, about ten percent of the world's container slots are on ships larger than 5,000 TEUs

… by 2011, 50% or more of the capacity of the world global fleet will be comprised of these larger ships" (Dupin, 2006).

Effects on Ports & Port Expansion

Much of the literature on the effects of the Panama Canal expansion on ports indicates that some ports will be easily ready for larger ship visits, while others will not. Hampton Roads, Virginia and Baltimore, Maryland have a history of handling vessels capable of navigating the Cape Horn of South America, which allows them to easily accommodate the New Panamax (NPX) vessels. Many ports are acquiring land and putting out contracts to increase capacity and operations at their facilities. These ports are expecting, in the long term, their business will come back and that expansion will be necessary to increase operations. Some ports are looking to privatization as the solution, due to the shift from West Coast to East Coast ports (Dupin, 2009). Virginia and Baltimore will be ready to accept larger ships that have transited the canal in 2014 because they already have 50 foot shipping channels while other ports such as New York / New Jersey may not due to existing limitations. Although New York will continue to be a major port because of the large population it serves, it may not be able to handle the NPX ships due to height restrictions on the Bayonne Bridge (Dupin, 2009).

Many ports are not ready, due to similar problems they face with their draft depths. However some analysts expect many ports will dredge their channels and purchase large post-panamax cranes to be able to accommodate larger ships (Dupin, 2006). Although, this is not an immediate answer because dredging is a lengthy process and can take many years before a project is approved and completed.

CSX and Norfolk Southern are also helping to improve the intermodal route with their Southern Heartland Corridor and National Gateway projects to allow double stacked trains to reach the Midwest quickly. There has also been a growth of distribution centers in the region and it is becoming more expensive to do business on the West Coast. This may lead to a possible increase in shipping of freight to the East and Gulf Coast (Dupin, 2009).

Some researchers feel that in addition to new distribution centers on the East and Gulf Coast, escalating rail costs and new population concentrations will make the East Coast ports more effective as a port of call in the next ten years (Miller, 2008). Additionally, with increasing fleets of larger vessels and a growing market in Asia, East Coast ports can expect larger vessels to arrive via the Suez Canal (Dublish, 2005).

Additional Challenges

In addition to physical limitations of the canal and ports, there are external factors that may be responsible for future changes in shipping. Recent reports have indicated there may be a shift in manufacturing from Northeastern China to Western India which causes New York to be 3,308 miles closer via the Suez Canal, over the Panama Canal. This westward movement in the production of goods will favor movement to the East Coast through the Suez, making the East Coast more appealing (Knight, 2008). Additionally, Los Angeles and Long Beach are becoming “boutique ports” with imports primarily becoming destined for the region immediately around the port (Miller, 2008).

Freeport, Bahamas is in the market to become a hub port where large post-panamax vessels could offload their cargo and transfer it to smaller ships destined for U.S. ports. If this were to become a popular mode of freight transport, it is possible that

U.S. ports may not need to deepen as many ports or even dredge as deeply as originally thought (Knight, 2008).

Research Suggestions from the Community

There are many unknowns related to the expansion of the Panama Canal and its affect on global shipping. Some are concerned that the size of the ships may not be the most important factor, but instead an increase in traffic brought by globalization (Knight, 2008). Also, researchers are concerned that if tolls at the Panama Canal become too high, other routes such as the Suez Canal will become more popular (Knight, 2008). A third and perhaps the most important concern is the readiness of the existing East Coast and Gulf ports. Even ten years after the expansion of the canal, most ports will not have the necessary capacity to accommodate post-panamax ships. In order to accommodate larger ships, infrastructure investments will need to be made. Some of these investments include deeper channels, longer docks, more storage area and the ability to move containers from ships to truck or rail (Knight, 2008). At the present time, there generally is a wide spread belief that the ports just cannot be ready in time to accept an increase in capacity and frequency of ships.

Port Expansion

The issue of larger post-panamax ships calling on ports is not just a scheduling issue, but also a physical issue. Larger container ships require longer docks, more cranes, deeper water and make on-dock rail even more attractive especially with limited storage space. Additionally, as containers are stacked wider and higher, it requires larger and more cranes to efficiently unload these larger ships (McCray and Gonzalez, 2007). Not all ports are ready to accept larger ships or an increase in the frequency of arrival of these types of ships. Additionally, there is a lot of lead time required to expand to have the necessary capacity to become a port that handles NPX ships. New cranes cost nine million dollars (U.S.) to eleven million dollars (U.S.) and acquiring more land can be costly or possibly, not even an option. Deeper water can take years, including the time for environmental studies, permits and expensive dredging (McCray & Gonzales, 2008). All this indicates that if ports are not ready now, they will not be ready in the near future to handle post-panamax ships.

The impact to the East Coast and Gulf Coast ports is truly the debated question. Some say “Enlarging the Panama Canal will be one of the most significant logistical ‘Game Changers’ in U.S. shipping history, providing East Coast ports positioned to handle larger ships an economic windfall” (Abt, 2008). The key in that statement is “ports positioned to handle larger ships”. The ability of ports to handle post-panamax ships will likely be one of the limiting factors in how much of an increase there will be (Abt, 2008). Ports that want to be a part of this possible opportunity are outlining their plans for upgrades to increase capacity and size of ships that they are able to handle. “Besides increased dredging, the most frequently mentioned plans were investments in rail yard expansion and electric freight handling equipment and larger greener warehouses” (Abt, 2008).

Four ports on the East Coast are expanding in preparation for a need for additional capacity as a result of the Panama Canal expansion. These ports include Portsmouth, Virginia; Charleston, South Carolina; Savannah, Georgia; and Jacksonville, Florida (Carey, 2006). A logistics specialist at the University of Tennessee, Tom Mentzer, believes Charleston, Savannah, and Jacksonville will be in a good position to expand because the West Coast ports will be operating near capacity after 2010. This may result in shippers exploring alternate routes via the Suez and Panama Canals (Carey, 2006).

"The ports of New York/New Jersey, Savannah, Charleston, Virginia all are going to benefit, while smaller ports like Philadelphia, Baltimore, Wilmington, Boston are poised to become niche, ports rather than compete with bigger ports" (Dublish, 2005).

With a possible increase in freight in these locations, both CSX and Norfolk Southern will likely benefit especially as the interstates become more congested (Carey, 2006).

A Transportation Research Board (TRB) discussion panel in 2010 focused on this very topic. Laurie Mahon, an independent advisor for Infrastructure and Project Finance, said that many of the ports initially felt that they were going to see an increase in traffic from the expansion project in Panama. However people are realizing that they are no longer going to see ships making four or five ports of call, but, instead, one or two ports of call leading to ports competing for business. Additionally, Mahon suggested that even with a decrease in traffic, there is a general East Coast shift to shipping due to congestion and increased port charges in Los Angeles and Long Beach.

Even with a shift of traffic to the East Coast, Mahon explained that each port has its own issues. According to Mahon, the dredging program is unorganized without a strategic allocation of resources. This gives ports with deep water an advantage above others, which includes Norfolk-Newport News, Baltimore, Savannah, and Charleston. There is an additional issue with rail connectivity and a lack of federal funding for rail investment. However, Jeffrey Heller from Norfolk Southern at the TRB discussion panel said Norfolk Southern has an "eastern rail perspective" and is investing in a number of large corridor projects, because they feel the capacity will be needed in the future. Norfolk Southern is expecting a growth of 33% between 2010 and 2014 in intermodal shipping. Heller notes that, prior to 2000 most freight moved across the land bridge either starting or ending on the West Coast. However, in 2000, Norfolk Southern noticed a shift towards the East Coast. For various reasons, including the Suez Canal, the East Coast ports have become more attractive. Heller believes on dock rail is one of the key attractions when shippers are looking for a port of call and this is one of the included features in some ports' new designs. Heller showed that it is the position of Norfolk Southern that container volume between East Coast ports and inland destinations will be increasing and they have been working on a number of projects that decrease the number of barriers for freight flow and increase the capacity from the East Coast.

Russell Adise from the U.S. Department of Commerce at the TRB discussion panel said others tend to describe ports as a window or a doorway with the rail lines and highways being corridors. In order to best use the system, one must look at the whole system and where freight is going. Adise makes the recommendation that users pick ports for the following reasons: cost, congestion, fees, transportation network, access to transportation networks, capacity, frequency of vessel service, quality of roads, quality of on dock rail service, the distribution network, the connecting infrastructure channel and berth depth and width. Adise stated that there is a potential for greater U.S. throughput and a resilience of port infrastructure as a result of the Panama Canal expansion. Additionally, he adds that these benefits can be maximized through the use of dredging, connecting infrastructure and expansion of inland infrastructure.

Several of the ports on the Gulf Coast and East Coast have put out literature on why they are ready for the expansion of service as a result of the canal expansion. Charleston in particular has advertisements marketing their abilities as a deep water port and their infrastructure abilities that make them able to accept larger ships. Charleston is also promoting information about larger ships regularly calling on the East Coast.

What Ports are doing to Prepare

Florida

In Jacksonville, a new terminal is being built by TraPac, the operating component of Mitsui OSK Lines, a Japanese shipping company, that will double the operating capacity of Jacksonville's port. This is one of four ports involved in expansion in preparation for an expected influx of freight to the East Coast ports (Carey, 2006).

Virginia

The Virginia Port Authority (VPA) was the first member of the Smart Way port traffic retrofit program sponsored by the Environmental Protection Agency (EPA) that provides low interest loans to drayage drivers that want to upgrade equipment. "Many of these steps are aimed directly at preparing for increased freight coming through the Panama Canal" (Abt, 2008). Additionally, the port of Norfolk has an advantage over other ports with a naturally deep channel, at 50 feet (Dublish, 2005). The VPA has purchased cranes that can handle ships 26 containers wide and plans to double its on-dock rail capacity at the Norfolk International Terminal (Dublish, 2005).

Maryland

According to Kathleen Broadwater of the Maryland Port Administration, the Port of Baltimore has reached an agreement about placement of dredging materials from the harbor deepening project. Additionally, they plan to build a new facility for additional marine terminal service (Abt, 2008).

South Carolina

Charleston appears to have a significant advertising campaign about what makes their port unique and why they are ready to accept post-panamax ships now. Charleston maintains a mean low water depth of 47 feet at the entrance channel and mean low water depth of 45 feet in the main channel. Additionally, Charleston maintains deep water at their docks so that if a ship can navigate the channel it will be able to safely dock as well. They are putting in place a sediment suspension system that will maintain the depths of their berths at a much lower cost. "'Charleston has a significant advantage over many ports because the channel is such that ships can meet easily without a problems,' Bennett said" (Bull, 2004). Charleston's channel is 500 to 1500 feet wide. The deep water and wide channel allows ships to safely transit the channel (Bull, 2004).

New York/New Jersey

NY/NJ has plans for a 1.6 billion dollar investment to improve the infrastructure, including deepening their channel to 50 feet by 2014 (Dublish, 2005). Additionally, they are increasing their rail capacity and putting in to place more intermodal links. However, the port of New York & New Jersey has limitations on ship heights due to the Bayonne Bridge crossing the shipping channel.

Georgia

Savannah has the rare advantage that it has major highways next to the port and plentiful space for warehousing and distribution centers, unlike many of the other ports (Dublish, 2005). Savannah also has on dock rail with both of the major rail shippers in the South East, CSX and Norfolk Southern. There is plenty of room for expansion in Savannah's Garden City terminal and they plan to more than double their annual container load in the future.

The Caribbean

David Bindler, in his article "Are Mega Ships Coming to the Caribbean?" says that the development of the Panama Canal will have a major impact to the Caribbean ports. Some Caribbean ports, such as Kingston and Freeport, have pursued larger ships, but their ports are already at capacity. The Caribbean ports are being used in a hub and spoke system where large ships transfer their containers to smaller ships with less draft in the Caribbean. However, if they wish to remain competitive, Bindler recommends they are going to need to become more cost effective and have structural and cultural changes (Bindler, 2006). In order to become more cost effective, Bindler's recommendations include increasing crane productivity, ensuring Caribbean equipment is in service greater than 95% of the time, reducing truck turnaround times to less than an hour, extending delivery times, upgrading and streamlining their technology, continue training and implement strict safety and security measures.

Chapter 3

RESEARCH QUESTIONS

This research looks at three specific questions related to determining what the expected change in freight patterns will be as a result of the expansion of the Panama Canal. Components of these questions have been recommended by researchers, specifically in a white paper by the U.S. Army Corps of Engineers Institute for Water Resources (Knight, 2008).

Question One

What is the existing flow of freight from the West Coast to East of the Mississippi River and Texas? Is there significant movement that would indicate an influx of freight to East & Gulf Coast ports by the expansion of the Panama Canal?

Question Two

What are the differences between the intermodal “land-bridge” route and the cost of shipping through the Panama Canal to an East Coast Port? Which route is more economical, has lowest emissions and is the fastest for delivery?

Question Three

What will the likely changes in shipping patterns do to container terminal operations in the future?

Chapter 4

QUESTION ONE: FREIGHT MOVEMENT: WEST TO EAST

The first question aims to determine in the quantity of shipments that arrives at a West Coast port and ultimately ends up east of the Mississippi River and Texas. This provides some insight into how much the West Coast ports are serving the eastern United States and how much of a shift there might be after the Panama Canal expansion.

Methodology

For this analysis, data from the Commodity Flow Survey (CFS) was used to quantify the movement of freight within the United States. This data is available from the Bureau of Transportation Statistics (BTS), Research and Innovative Technology Administration (RITA), U.S. Department of Transportation. The CFS is said to be the primary source for domestic freight shipments by several economic sectors including mining, manufacturing, wholesale, auxiliaries and select retail industries. The CFS is conducted every five years and is a shipper-based survey as part of the economic census. The most recent CFS study was in 2007 and is the data used in this analysis.

The 2007 Survey is a sample of 100,000 organizations within the Unites States in the already mentioned sectors. The CFS does not include data from businesses classified as forestry, fishing, utilities, construction, transportation and most retail service industries. Additionally, foreign businesses were not included in the survey, but the domestic portion of a shipment would be included once arriving at a U.S. location.

The BTS recommends CFS data for use in analyzing trends in goods movement over time, forecasting future demand for goods movement and several other uses (Research and Innovative Technology Administration (RITA) 2007). Both of these uses of the data suggest that the CFS data is appropriate for use in this study.

For this analysis, the 2007 CFS data was analyzed to look at how much freight, by ton, arrived in the West Coast ports and then ultimately ended up in a state east of the Mississippi River and Texas. CFS statistical areas that have ports in within them that are highly ranked by number of TEUs moved annually were chosen for the analysis. The CFS area is a particular metropolitan area defined by the Commodity Flow Survey. The port rankings can be found in Appendix A, which is a table of North American port container traffic, ranked by TEUs for 2009. Additionally, for comparison, a similar analysis was conducted for the amount of freight originating in East Coast ports and traveling west of the Mississippi.

Commodity Flow Survey Data

The CFS data indicates there is not a significant amount of freight that originates on the West Coast and ultimately has an East Coast / Texas destination. Table 1 is a summary of the CFS results. These metropolitan areas have ports, and the rank of the port(s) is given in the Rank by TEU column. The column "Tons East of the Mississippi" represents the amount of freight in short tons that originates in the CFS area and ends in a state east of the Mississippi River or Texas. The column "Tons to U.S." represent how much freight originates in the CFS area and is distributed to the entire Unites States. "Tons to CFS Area" represents how much freight stays within the CFS area and % to CFS of U.S. shows what percent of freight to the entire U.S. stays within the CFS area.

Table 1 West Coast to East Freight Movement (In Tons)

Rank by TEU	CFS Area	Tons East of Mississippi	Tons to U.S.	% of Tons to U.S.	Tons to CFS Area	% to CFS of U.S.
1-2	Los Angeles - Long Beach – Riverside	19,859,000	421,081,000	4.72%	327,397,000	77.75%
6	San Jose - San Francisco – Oakland	3,628,000	206,762,000	1.75%	163,783,000	79.21%
10-11	Seattle - Tacoma – Olympia	2,247,000	139,088,000	1.62%	107,357,000	77.19%
33	Portland - Vancouver - Beaverton (OR part)	2,840,000	99,037,000	2.87%	59,994,000	60.58%
40	San Diego - Carlsbad - San Marcos	1,278,000	34,639,000	3.69%	25,394,000	73.31%
Total:		**29,852,000**	**900,607,000**	**3.31%**		

Results

From the data in Table 1, it becomes clear that there is not a significant amount of freight that originates in a West Coast metropolitan area, which includes a port, and ultimately ends up east of the Mississippi River and in Texas. These values vary from 1.75% of total freight from the metropolitan area to 4.7%. The percentage of the total freight that originates in these ports and moves east of the Mississippi is only 3.31%. An example of freight from LA/Long Beach to the U.S. is found in Appendix C. To further represent how much freight this represents it may be easy to think of this freight all in TEUs. However because of the non standard weights and heights in TEU sizes it is impossible to do an exact conversion. With some estimation it is possible to approximate the quantity of TEUs. According Schumacher Cargo Logistics, a shipping consultant, the maximum payload for a containerized shipment is 53, 460 lbs (Schumacher Cargo Logistics, 2006).

However not all containers are shipped at their full weight capacity, depending on the commodity being shipped. A range of possible TEU weights is found in Table 2 and corresponding conversions to TEUs. If we use a value of half of the maximum weight, 26,730 pounds, we find that the 29,852,000 tons of freight shipped represents 2,228,000 TEUs per year.

Table 2 Conversion of Weight to TEUs

Average TEU Weight (Tons)	TEUs West of Mississippi
2.4 (1/10th of Max Load)	11,056,000
6 (1/4th of Max Load)	4,456,000
7 (GIFT Model Load)	4,265,000
11.9 (1/2 of Max Load)	2,228,000

These values represent an estimate of container traffic if all freight movement from west to east was containerized. However, this would not be accurate as there is a significant amount of freight that is moved as a bulk commodity. To estimate the percentage of freight that is received as a containerized shipment, data from the Waterborne Commerce Statistics Center (WCSC) of the U.S. Army Corps of Engineers (Waterborne Commerce Statistics Center (WCSC) 2010) was used to estimate a percent of containerized foreign receipts. An example of these assumptions for Los Angeles Harbor is included in Appendix B and a summary of the data is found in Table 3.

Table 3 Containerized Vs. Bulk Freight by Port

Port	% Containerized	% Bulk	Tons E. of Mississippi	Containerized Tons	TEUs*
Los Angeles	76.5%	23.5%	19,859,000	12,769,337	1,824,191
Long Beach	52.2%	47.8%			
Oakland	90.0%	10.0%	3,628,000	1,857,536	265,362
San Francisco	12.4%	87.6%			
Tacoma	83.3%	16.7%	2,247,000	1,509,984	215,712
Seattle	51.1%	48.9%			
Average:		**60.9%**	**39.1%**		
					*Assumes 7 tons / TEU

The amount of containerized freight appears to vary between ports and within statistical areas, so an average of 61% was used for an approximation of TEUs moving from the West Coast to east of the Mississippi. With this taken into consideration the adjusted values of containerized freight at 61% of total freight are found in Table 4.

Table 4 Adjusted by 61% conversion of weight to TEUs

Average TEU Weight (Tons)	Annual TEUs West of Mississippi & Texas
2.4 (1/10th of Max Load)	6,744,000
6 (1/4th of Max Load)	2,718,000
7 (GIFT Model Load)	2,601,000
11.9 (1/2 of Max Load)	1,359,000

If an average of seven tons per TEU is used the data suggest approximately 2,601,000 loaded TEUs move east of the Mississippi in a year. This would break down to

7,100 TEUs per day spread out over all the states east of the Mississippi and Texas. For comparison single fully loaded new panamax ship would have approximately 12,000 TEUs. This shows that if all the freight that currently arrives on the West Coast and ultimately ends on the East Coast were to shift through the Panama Canal this would result in less than one additional post-panamax ship each day for the East Coast.

To further illustrate this point, freight originating on the East Coast with an ultimate destination of the West of the Mississippi is included and summarized in Table 5. The column representations are the same. The data in the westward direction indicates that there is even a smaller impact from East Coast ports transferring freight west of the Mississippi. In this case, only 1.17% of freight originating in the East Coast ever makes it west of the Mississippi river. In both directions these freight value are small and show that presently there is not as much West Coast to East Coast freight movement as some might expect. In most cases a large portion of freight never leaves the CFS area showing that freight does not appear to be traveling far from its port of arrival. An example of freight movement from NY/NJ to the U.S. is found in Appendix C.

Table 5 East Coast to West Coast Freight Movement

Rank by TEU	CFS Area	Tons West of Mississippi	Tons to U.S.	% of Tons to U.S.	Tons to CFS Area	% to CFS of U.S.
3	New York-Newark-Bridgeport	5,134,000	325,737,000	1.58%	197,419,000	60.61%
4	Savannah-Hinesville-Fort Stewart	98,000	18,622,000	0.53%	5,346,000	28.71%
8	Virginia Beach-Norfolk-Newport News	517,000	26,087,000	1.98%	14,027,000	53.77%
13	Charleston	54,000	24,055,000	0.22%	6,981,000	29.02%
16	Miami-Fort Lauderdale-Pompano Beach	642,000	157,356,000	0.41%	134,366,000	85.39%
Total:		**6,445,000**	**551,857,000**	**1.17%**		

Question One Conclusions

The commodity flow survey data shows there is a limited amount of containerized freight that moves from the West Coast ports to east of the Mississippi River and Texas. Additionally, a majority of the freight that originates in the West Coast statistical areas stays within that statistical area. Appendix C includes maps based upon tonnage of freight that originates in Los Angeles/Long Beach and New York/ New Jersey, respectively and what percentages of that freight ultimately end up in each of the U.S. States. Approximately 3.3% of the freight from the West Coast ultimately ends up on the eastern portion of the United States. With only approximately 61% of this freight being containerized, we end up with an average of 2,601,000 TEUs transferred each year. This represents 7,100 additional TEUs per day. If 100% of the freight currently received on the West Coast and shipped to the East Coast was moved through the Panama Canal, this data suggests the addition of one post-panamax ship's equivalent of containers a day for all the East Coast ports, in total (not each East Coast port). Knowing that the widening of the Panama Canal is not going to cause a complete shift of freight, the Commodity Flow Survey data indicates there likely will not be a large number of new ships calling on ports on the East Coast. Instead, ports will start to see larger ships less often on a new port of call rotation schedule.

Chapter 5

QUESTION TWO:

ANALYSIS OF LAND BRIDGE ROUTE VS. ALL WATER ROUTE

The second question analyzes the effect on time, cost and emissions of an all water freight movement as compared to an intermodal freight shipment across the United States. This analysis allows the two alternatives to be compared on a time value and emissions value of the shipments. Additionally, the cost per TEU is evaluated to give an estimate of the cost relationship between intermodal shipments and all water shipments to the East Coast.

Methodology

Two models have previously been created by the Rochester Institute of Technology and the University of Delaware that have been applied in the exploration of this issue. The models are the Geospatial Intermodal Freight Transportation model (GIFT) and the Ship Transportation Energy and Emissions Model (STEEM). The GIFT model is a geographic information systems (GIS) based model that includes all major U.S. and Canada rail, road and water transportation networks and connects them at intermodal transfer facilities. This creates a network that will allow comparison of routes based on emissions, time, cost and other parameters. The STEEM model is a similar GIS based model that includes the world’s shipping routes and major shipping ports around the world. Together, these two models combined allow for the comparison of emissions, cost and time from Asian ports to the U.S. East Coast via a multimodal U.S. land based route and a primarily water based route (The Laboratory for Environmental Computing and Decision Making (LECDM), 2008).

For this analysis, the ports of Singapore, Singapore; Shanghai, China and Kochsiung, Tiawan were selected as origin ports and New York/New Jersey and Savannah, Georgia were selected as destination ports. The origin ports rank number one, two and twelve, respectively, in world container traffic. The destination ports were selected for their ranks as number three and four in North America, respectively, and number one and two on the East Coast(American Association of Port Authorities 2009).

The analysis then compared statistics for three types of routing of containerized freight from the three origin ports to the two destination ports. These routes were all water via the Panama Canal, water to Los Angeles and then rail to the destinations and water to Los Angeles and truck to the destinations. Using the combined GIFT and STEEM model, each route returned a total travel time, energy, particulate matter, CO2 and operating cost.

GIFT: The Model

Environmental Decision

The GIFT model connects multiple transportation networks (rail, road and water networks) at intermodal transfer facilities for the United States and much of Canada. This network allows emissions, cost and time to be calculated for various intermodal routes across much of North America. Additionally the STEEM model has been integrated with the GIFT model to allow similar analysis for world shipping routes. These models then allow the user to determine the best route between two points based upon the lowest emission type, least time or least cost. The model does this based upon information supplied by the user and the emission settings within the model (The Laboratory for Environmental Computing and Decision Making (LECDM), 2008). For this analysis the default settings for GIFT/STEEM were used in the model for a comparative analysis. The specific settings for the model can be found in Appendix D.

GIFT: Limitations

For this type of comparative analysis, most default settings were adequate in most cases. However, there are some inherent limitations with the defaults of GIFT. The first limitation is with the estimation of time for each route. The time given by GIFT is only the time to traverse that particular route, not including detailed intermodal transfer times, bump yards for trains, breaks for truck drivers, etc. In an effort to make the results more realistic for intermodal-truck, ten hours has been added to the truck transport time for every eleven hours in transit. This is representative of the requirements for truck drivers by the Federal Motor Carrier Safety Administration (FMCSA) that limits actual drive time for a truck to eleven hours within a fourteen hour period before requiring ten hours of rest time (Federal Motor Carrier Safety Administration, 2010). Similarly for rail transportation, eight hours of time has been added for every sixteen hours of transport time to make the rail time closer to reality. This is following the requirement by the Federal Rail Administration that rail workers may work sixteen non-consecutive hours in a 24 hour period (Federal Railroad Administration, 2009). Although rail crews may be able to switch out in an long haul shipping situation, there are other delays, such as "bump yards" that are not included in this time estimate.

A second limitation of the GIFT model is the ability of GIFT to predict a per TEU cost for shipping over long distances. GIFT allows for a single value to be put in the cost attribute for a cost per mile per TEU. However, costs are highly variable in many situations. Additionally this constraint would assume that a 40' container is twice as expensive to ship at a 20' container when, in reality, the handling costs are similar, making the overall cost less than twice. The costs for the water portion of the shipping are detailed in Table 6.

Table 6 Sea Shipping Costs

Route	Container Size	Average Cost+	Cost Per Mile*
Singapore to U.S. East Coast	20'	$2,501	$0.18
	40'	$3,081	$0.28
Singapore to U.S. West Coast	20'	$1,730	$0.20
	40'	$2,100	$0.24
Shanghai to U.S. East Coast	20'	$3,101	$0.26
	40'	$3,621	$0.30
Shanghai to U.S. West Coast	20'	$2,220	$0.35
	40'	$2,620	$0.41

* Based upon 14130 average miles from Singapore to U.S. East Coast , 8632 Miles to U.S. West Coast. 11,881 miles from Shanghai to U.S. East Coast, 6,384 miles to U.S. West Coast

+ March 2010 cost, Dewry Publishing, 2010

The intermodal costs for rail and truck transportation are also quite variable and were estimated based upon conversation with a JB Hunt pricing representative and the use of the website "freightquotes.com." These costs are detailed in Table 7. Using these assumptions based upon mileage from GIFT to come up with approximations for operating costs. For all environmental aspects of the analysis, the GIFT defaults were used and can be found in Appendix D.

Table 7 Intermodal Shipping Costs

Route	Mode	Cost	Cost per Mile per TEU*
Los Angeles to Savannah	Rail	$2500	$0.53
Los Angeles to Savannah	Truck	$5250	$0.90
*Assumes 2,375 miles from Los Angeles to Savannah for 40' container			

Results

From the GIFT analysis and additional assumptions, the costs, emissions and time for each type of route can be estimated and from this some general conclusions can be drawn. In all three of our base cases, the all water route is the least expensive route on a per TEU basis. However, it takes on average ten days longer than intermodal ship and rail transport and thirteen days longer than intermodal ship and truck transportation. In all cases, trucking across the U.S. is the most expensive option and the shortest time option of the three mode choices. In the categories of energy, CO_2 and particulate matter intermodal shipping via ship and rail is the lowest of each of the three categories. Additionally, shipping using the rail intermodal option adds approximately two days to the transport time by these estimates. Tables 8 and 9 show an example of the results from the GIFT analysis. Additional results for all six case studies of routes are available in Appendix E.

Table 8 Singapore to Savannah GIFT Route Results

Singapore to Savannah							
	Transfer	Time (Days)	Energy BTUs	CO2 (gm/TEU)	PM10 (gm/TEU)	Operating Cost 20' ($US)	($US)
All Water	N/a	42.9	47,328,053	4,064,503	3,420	$2,583	$3,218
Intermodal (Water - Rail)	LA/LB	32.6	33,872,618	2,873,061	2,288	$2,913	$4,444
Intermodal (Water - Truck)	LA/LB	30.4	60,229,958	5,197,119	2,472	$3,852	$6,323

Table 9 Shanghai to New York GIFT Route Results

Shanghai to New York						
	Transfer	Time (Days)	Energy BTUs	CO2 (gm/TEU)	Operating Cost 20' ($US)	40' ($US)
All Water	N/a	37.3	41,163,319	4,785,900	3,224	3,787
Intermodal (Water - Rail)	LA/LB	26.8	27,104,247	2,284,701	$3,658	$5,465
Intermodal (Water - Truck)	LA/LB	24	56,212,684	4,854,600	$4,611	$7,371

Question Two Conclusions:

The analysis from question two indicates there are some tradeoffs to be made when determining the “best” shipping route from Asia to the United States East Coast. Although the all water route via the Panama Canal may be the cheapest option it is also the slowest option. If a shipper’s primary concern is cost, the all water route may be the best alternative. However, this is not a uniformly “better” alternative for all types of freight. Certain freight may require a faster shipping alternative which the shipper is willing to pay a higher cost for shipping. The best middle of the road alternative appears to be intermodal shipping by water to the West Coast and then by rail across the U.S. Additionally, this is the shipping method that uses the least energy and has the least emissions of particulate matter and carbon dioxide.

Chapter 6

QUESTION THREE: EFFECT ON PORT OPERATIONS

Question three focuses on the possible effects that a shift in freight patterns would cause on the operations at container terminals. From questions one and two, it seems most reasonable that the expected change will be larger TEU capacity ships visiting ports less frequently. To determine what a range of possible effects on port operations, a computerized model of a port was built and configured to examine the expected impact.

Methodology

For this portion of the analysis, a software package called "Process Simulator 2009" by the Pro-Model Company was used with Microsoft Visio to diagram a generalized model of a port's operations. This software is capable at looking at storage abilities, queue lengths, operating times and many other characteristics of a system. Initially, the Port of Wilmington was built as a test case of the model. After meeting with the Director of Operations at the Port of Wilmington, a realistic model of the port was built detailing Chiquita and Dole's containerized operations at the port of Wilmington. Figure 3 is a basic overview of the layout of the operational queuing model.

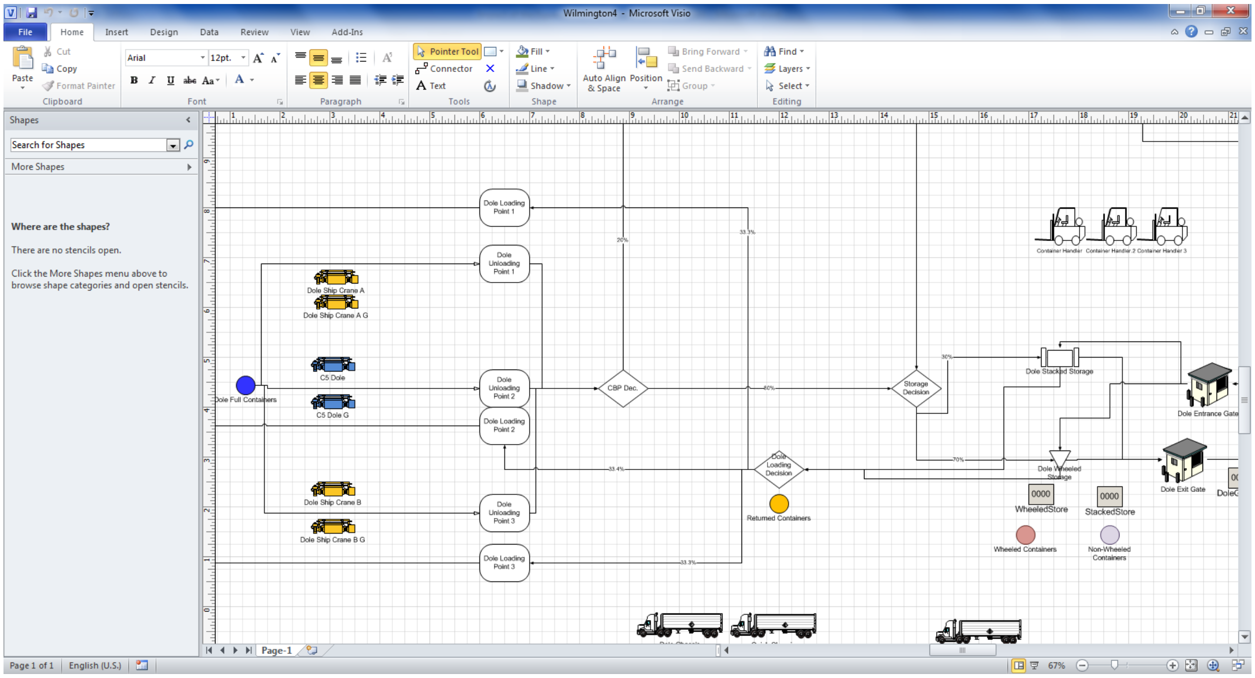

Figure 3 Port of Wilmington Container Operations Model

After this, a full day was spent at the Garden City Terminal of the Georgia Port Authority, meeting with managers and touring the facility to understand operations. From statistics provided and seeing the facility first hand, a generalized model was built that is realistic in terms of how the port operates. This model is essentially a queuing model to look at container throughput based upon varying schedules, container traffic, operation times and storage times. The model generalizes storage facilities and is limited to container operations. Additionally, it looks at containers in and out of the facility but does not detail movements within the container facility such as stacking, moving to inspection facilities and other inter-facility moves. Figure 4 is a basic overview of the layout of the model created for the Garden City Terminal. In reality, the model is animated and provides output such as queue times, throughout, storage usage, average time containers are in the system, etc.

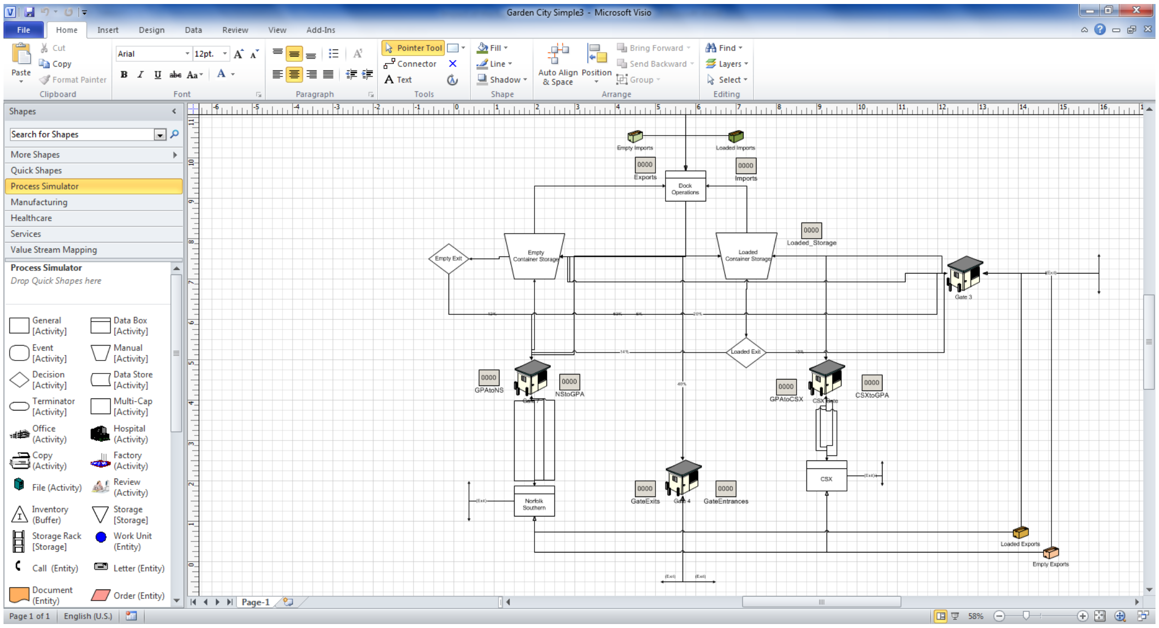

Figure 4 Garden City Terminal Container Operations Model

Model Scenarios

Base Case Model

A model of the existing operations of the Garden City Terminal was built that is similar to several months of actual operations, but does not replicate any specific recent month. The base case model is consistent with actual data provided by the Georgia Port Authority (GPA), for monthly container traffic throughput. The results of the model running for the base case are displayed in Table 10.

Table 10 Garden City Terminal - Base Model Container Totals

<table>
<tr><th colspan="2">Type</th><th>Containers</th></tr>
<tr><td colspan="2">Loaded Exports</td><td>47,341</td></tr>
<tr><td colspan="2">Empty Exports</td><td>21,622</td></tr>
<tr><td colspan="2">Empty Imports</td><td>13,302</td></tr>
<tr><td colspan="2">Loaded Imports</td><td>54,053</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="2">Intermodal Container Transfer Facility TO: Garden City Terminal</td><td>8,177</td></tr>
<tr><td colspan="2">Garden City Terminal TO: Intermodal Container Transfer Facility</td><td>13,015</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td rowspan="3">Empty Container Storage</td><td>Minimum</td><td>19,758</td></tr>
<tr><td>Average</td><td>20,908</td></tr>
<tr><td>Maximum</td><td>22,059</td></tr>
<tr><td rowspan="3">Loaded Container Storage</td><td>Minimum</td><td>7,731</td></tr>
<tr><td>Average</td><td>13,293</td></tr>
<tr><td>Maximum</td><td>17,900</td></tr>
</table>

Alternative One – Increase in container traffic

The first alternative model to the base case is doubling the containers handled by the Garden City Terminal. Presently, the Garden City Terminal handles about 2.7 Million TEUs annually and they estimate they have a maximum capacity of 6.5 Million TEUs (Mitchell, 2010). Although a jump this large may seem surprising, the Garden City Terminal is currently undergoing changes to better utilize their existing terminal facilities and to add a few new storage areas on property they already own. They are also able to increase their annual capacity by making operational changes such as stacking containers closer together and only allowing for one way traffic between stacks rather than two way traffic. In this scenario, the possibility of doubling the containers handled in a month is examined which is a sample of what doubling the annual throughput of the port may do to storage and output ability.

Alternative one has two additional options associated with it. For a predicted future increase in containerized traffic, the Georgia Port Authority is planning to add an additional gate for containerized trucks to use to access the port, referred to as "Gate eight." This additional gate is a gate of similar size to the other two gates already in use by the port for truck traffic and is modeled as having fifteen lanes for traffic. This comparison of the two options within alternative one yields information on the effect an additional gate will have given there will be an increase in containers though the port.

Alternative Two – Changing Freight Pattern

Presently the Garden City Terminal has a freight pattern that is relatively consistent from week to week, with Thursday and Friday being their largest shipping days; Nearly half of their containers arrive and depart the terminal via container ship on Thursday and Friday (Mitchell, 2010). Alternative two addresses a possible change in shipping schedules where in a two week period the first week has one-third of the two week volume and the second week has two-thirds of the two week volume. In both weeks Thursday and Friday each have one-quarter of the weekly volume and Monday, Tuesday and Wednesday each have one sixth of the weekly volume. This represents a possible shipping schedule that may occur if the expansion of the Panama Canal results in larger ships calling less often at individual ports.

Analysis

Alternative One – No Build "Gate Eight"

In the scenario that the Garden City Terminal doubles its annual container throughput but does not make any infrastructure upgrades through the addition of an additional gate, the throughput is increased. However, the throughput is limited by the availability of lanes for trucks bringing empty and loaded containers for export into the terminal. The results of this scenario are below in Table 11 with a comparison of increase to the base case before the doubled volume.

Table 11 Garden City Terminal Alternative One - No Build Container Traffic

Type		Containers	% Increase From Base
Loaded Exports		77,167	63.0%
Empty Exports		34,377	59.0%
Empty Imports		26,095	96.2%
Loaded Imports		105,517	95.2%
Intermodal Container Transfer Facility TO: Garden City Terminal		15,069	84.3%
Garden City Terminal TO: Intermodal Container Transfer Facility		22,482	72.7%
Empty Container Storage	Minimum	34,717	75.7%
	Average	36,786	75.9%
	Maximum	38,895	76.3%
Loaded Container Storage	Minimum	18,558	140.0%
	Average	28,120	111.5%
	Maximum	36,976	106.6%

Alternative One – Build "Gate Eight"

In the scenario that the Garden City Terminal doubles its annual container volume and builds an additional gate with fifteen lanes for container truck traffic, the terminal is able to increase its monthly container throughput for exports by an additional ten percent over the no build scenario. The results from this scenario are found below in Table 12.

Table 12 Garden City Terminal Alternative One - Build Gate Eight Container Traffic

Type		Containers	% Increase From Base	% Increase from No Build
Loaded Exports		85,499	80.6%	9.7%
Empty Exports		38,696	79.0%	11.2%
Empty Imports		26,022	95.6%	-0.3%
Loaded Imports		105,822	95.8%	0.3%
Intermodal Container Transfer Facility TO: Garden City Terminal		15,140	85.2%	0.5%
Garden City Terminal TO: Intermodal Container Transfer Facility		23,289	78.9%	3.5%
Empty Container Storage	Minimum	37,198	88.3%	6.7%
	Average	39,855	90.6%	7.7%
	Maximum	42,163	91.1%	7.8%
Loaded Container Storage	Minimum	23,480	203.7%	21.0%
	Average	35,173	164.6%	20.1%
	Maximum	46,230	158.3%	20.0%

Alternative Two – Changing Freight Schedule

A possible alternative shipping schedule with one third of the two week freight the first week and two thirds of the two week freight the second week leads to larger variability in the containers on site in a given time period. The largest change was seen in the number of loaded containers in storage. The high end of containers on site increased by fifteen percent while the low end decreased by thirteen percent Additionally, empty containers on site increased by two percent on the high end and decreased by two percent on the low end. The details from the analysis can be seen below in Table 13. This indicates, with a changed shipping schedule there will be a need to examine how containers are stored. This may cause the Georgia Port Authority to require shippers to deliver containers for export closer to their export day, so they will not have to be stored on site as long. Another possibility would be to expand the availability of storage on site to accommodate the larger influx of containers. However, in general, not all ports would be able to make that type of change.

Table 13 Garden City Terminal Alternate Shipping Schedule

Name	Value		
Loaded Exports	47521		
Empty Exports	21430		
Empty Imports	13167		
Loaded Imports	52726		
	Minimum	Average	Maximum
Empty Container Storage	19364	20824	22538
Percent Change	2.0%	0.4%	-2.1%
Loaded Container Storage	6866	13183	21059
Percent Change	12.6%	0.8%	15.0%
	Value		
NS to GPA	4416		
CSX to GPA	3895		
ICTF to GPA	8311		
GPA to NS	8129		
GPA to CSX	4648		
GPA to ICTF	12777		

Question Three Conclusions

Whether or not the Panama Canal increases the annual freight volume or other aspects about the Garden City Terminal cause an increase in container traffic, the model shows a change in storage requirements for the facility. The addition of “gate eight” appears to be a beneficial investment allowing greater container throughput for the terminal.

In the event a shift in freight causes an alternate shipping schedule due to larger ships calling on the ports less often, it is possible there may be an impact on how long containers can be stored on site prior to export and how many containers must be able to be stored at one time on the terminal. There are many possibilities for alternate schedules and only one alternative has been presented. It demonstrates some of the challenges the Garden City Terminal and other container ports may have to consider when planning for future operations.

Chapter 7

LIMITATIONS

There are several limitations that exist on the breadth of application of this research. The impact in this situation has only been analyzed for container traffic and does not consider changes in other types of commodities. Additionally, with the exception of the case study of Savannah's container port, it does not look at particular container terminals and their capacity to attract new clients to utilize their facilities. The choice of a shipper's receiving port is very complex and would require more research from an economical standpoint to determine where some of the more significant impacts may be felt.

Additionally, the cost component of the GIFT model is very weak and a detailed analysis of the costs associated with intermodal transfers and cost of shipping container would be beneficial. Some of the time analyses leave out certain components, such as bump yards for rail facilities and waiting time at the Panama Canal. A much more in depth model would be needed to take all of these possibilities into consideration, since they vary year to year, season to season and even day to day.

This research is primarily limited to putting some of the numbers behind the rhetoric that the expansion of the Panama Canal is going to cause huge freight shifts. It is meant to be a broad analysis to look as the range of possibilities of outcomes, not necessarily a specific prediction of future shipping trends. For a specific prediction, a significantly more complicated model would need to be considered and is outside the realm of this analysis.

Chapter 8

RECOMMENDATIONS FOR FUTURE RESEARCH

There are many areas still left completely unexplored. This research is limited to container ships and commodities routinely transported by container. However, containers are not the only type of freight utilizing the Panama Canal. Research into the impact the expansion may have on bulk commodities, roll on roll off freight (such as automobiles) and other types of ships that may now be able to transit the canal post expansion, such as military vessels, may be beneficial. There may be some significant impact to these other types of freight, but the Panama Canal is not the only major canal utilized by shipping vessels.

The Suez Canal currently is a major player in East Coast freight and possibly could become a competitor with the Panama Canal if shippers can save time, money or both by making better utilization of the Suez Canal. Research into the alternative of the Panama Canal vs. the Suez Canal to the U.S. East Coast and even possibly to the West Coast through the Suez and Panama Canal may be a beneficial area of research.

In both situations of the Panama Canal and the Suez Canal, the aspect of cost is an important decision factor in shipping route and method. The cost of shipping and the value of a commodity being shipped are important trade offs for the shipper. However, the cost of shipping a container varies widely based upon many factors. Research into predicting cost for shipping routes in some type of reliable way would be beneficial to the research of world shipping routes. This cost predictor needs to be based upon more than just distance shipped and would be an important contribution to the GIFT/STEEM freight model.

Chapter 9

CONCLUSIONS

There is no doubt that the Panama Canal expansion project will impact world-wide container shipping in some way. However, there is nothing to indicate that there will be a huge influx of container traffic to East Coast ports. Freight is local and does not travel significantly far from its port of origin, whether that origin is a container port or creation in the United States. Freight is imported near its ultimate destination and although there is some containerized freight transiting across the intermodal connection from West to East, it is not significant enough for a huge freight shift. It appears that the most likely initial impact will be larger ships calling on ports less often.

This will have an impact on cost, although it is unknown what that impact will be. It is likely cheaper to take the all water route to the East Coast, but a shipper must be willing to give up the longer time required to ship using this method. With the arrival of larger ships less often, ports will need to think about how they are going to change operations to accommodate a surge of containers in a shorter period of time. Some of the impacts may be altered by the marketing abilities of shipping facilitators, such as rail and truck companies vs. container terminals, competing for business and offering the best value based option for a particular shipment.

The most significant impact appears there will be more operational changes in how to manage the expected changes of future shipping patterns. Larger ships will have new operational requirements and will begin to replace smaller ships as it becomes more economically necessary to do so. To remain competitive in the container market, container facilities need to make changes to accommodate these larger vessels, especially the larger "jack of all trades" container ports. Some of the smaller niche container ports will likely remain unchanged by the canal expansion due to their specialized handling of certain freight and traditionally smaller vessels calling on these ports.

After 2014, the world shipping and routing market will definitely be different and there will be new trade-offs for all parties to consider. In any circumstance, economic demand and marketing forces will all be competing for the "best" route alternative. The Panama Canal will continue to have a major portion of the East Coast freight, but at some point, a new balance will be found between the expanded all water route and the intermodal land route from West to East.

DEFINITIONS

ACP: Panama Canal Authority (Autoridad del Canal)

Aframax: American Freight Rate Association Term for a tanker of approximately 80,000 - 105,000 dwt (Used in the Black Sea and North Sea)

Channel: Channel with steep sides that takes up most of a waterway

CFS: Commodity Flow Survey

DWT: Dead Weight Tons

EPA: Environmental Protection Agency

GIFT: Geospatial Intermodal Freight Transportation

Malaccamax: Vessel Exceeding 12,000 TEUS

MCT: Marine Container Terminals

MLW: Mean Low Water -Water Depth at low tide, referring to a channel depth in a harbor

NPX: New Panama-max. These are the newest class of ship that is the largest that will be able to fit through the canal after expansion in 2014.

Panamax Vessel: Designed to fit the chambers of the Panama Canal

PCMUS: Panama Canal Universal Measurement System 100 ft3 of cargo space or a 20' long container = 13 PCUMS tons.

Post-Panamax: Previously not able to fit through the canal generally able to move about 5,000 to 8,000 containers

Shallow Water Channel: in a large body of water and the channel depth is not much deeper than the water around it

STEEM: Ship Transportation Energy and Emissions Model

Super Post Panamax: Ship capability of transporting more than 9000 containers

Trenches: Trench channel has more sloped sides and is one part of a larger body of water

TEU: Twenty Foot Equivalent Unit is an inexact unit of cargo capacity used to describe the capacity of container ships. Based upon the volume of a 20-foot long shipping container

VPA: Virginia Port Authority

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APPENDIX A: NORTH AMERICAN CONTAINER TRAFFIC

(American Association of Port Authorities 2009)

TABLE 2
NORTH AMERICA CONTAINER TRAFFIC
2009 PORT RANKING BY TEUs

2009 Rank	Port (State/Province)	Country	2009	2008	Absolute Change	Percent Change	2008 Rank	2009 Rank	Port (State/Province)	Country	2009	2008	Absolute Change	Percent Change	2008 Rank
1	Los Angeles (CA)	United States	6,748,995	7,849,985	-1,100,990	-14.0%	1	26	Wilmington(DE)	United States	259,964	267,684	-7,720	-2.9%	25
2	Long Beach (CA)	United States	5,067,597	6,350,125	-1,282,528	-20.2%	2	27	New Orleans (LA)	United States	229,067	235,324	-6,257	-2.7%	29
3	New York/New Jersey	United States	4,561,527	5,265,058	-703,531	-13.4%	3	28	Wilmington (NC)	United States	225,176	196,040	29,136	14.9%	32
4	Savannah (GA)	United States	2,356,512	2,616,126	-259,614	-9.9%	4	29	Philadelphia (PA)	United States	222,900	255,994	-33,094	-12.9%	26
5	Metro Port Vancouver (BC)	Canada	2,152,468	2,492,107	-339,639	-13.6%	5	30	Palm Beach (FL) (fy)	United States	199,393	244,638	-45,245	-18.5%	28
6	Oakland (CA)	United States	2,050,030	2,236,244	-186,214	-8.3%	6	31	Gulfport (MS)	United States	198,900	214,074	-15,174	-7.1%	30
7	Houston (TX)	United States	1,797,198	1,795,320	1,878	0.1%	9	32	Boston (MA)	United States	187,094	208,626	-21,532	-10.3%	31
8	Hampton Roads (VA)	United States	1,745,228	2,083,278	-338,050	-16.2%	7	33	Portland (OR)	United States	174,203	245,459	-71,256	-29.0%	27
9	San Juan (PR) (fy)	United States	1,673,745	1,684,883	-11,138	-0.7%	11	34	Apra (GU) (fy)	United States	157,096	167,784	-10,688	-6.4%	34
10	Seattle (WA)	United States	1,584,596	1,704,492	-119,896	-7.0%	10	35	St. John's (NF)	Canada	119,405	118,020	1,385	1.2%	36
11	Tacoma (WA)	United States	1,545,853	1,861,352	-315,499	-16.9%	8	36	Kahului (HI) (fy)	United States	113,898	147,003	-33,105	-22.5%	35
12	Montreal (QU)	Canada	1,247,690	1,473,914	-226,224	-15.3%	13	37	Mobile (AL)	United States	112,270	114,439	-2,169	-1.9%	37
13	Charleston (SC)	United States	1,181,353	1,635,534	-454,181	-27.8%	12	38	Ensenada (BCA)	Mexico	110,952	110,423	529	0.5%	38
14	Manzanillo (COL)	Mexico	1,110,350	1,409,782	-299,432	-21.2%	14	39	Kawaihae (HI) (fy)	United States	103,383	97,591	5,792	5.9%	39
15	Honolulu (HI) (fy)	United States	1,049,420	1,124,388	-74,968	-6.7%	15	40	San Diego (CA)	United States	95,515	95,230	285	0.3%	40
16	Miami (FL) (fy)	United States	807,069	828,349	-21,280	-2.6%	17	41	Freeport (TX)	United States	74,466	71,900	2,566	3.6%	41
17	Port Everglades (FL) (fy)	United States	796,160	985,095	-188,935	-19.2%	16	42	Progreso (YUC)	Mexico	53,517	66,477	-12,960	-19.5%	42
18	Jacksonville (FL) (fy)	United States	**753,647**	697,494	56,153	8.1%	19	43	Hilo (HI) (FY)	United States	52,523	60,190	-7,667	-12.7%	43
19	Lázaro Cárdenas (MIC)	Mexico	585,449	524,791	60,658	11.6%	22	44	Tampa (FL) (fy)	United States	48,788	43,445	5,343	12.3%	48
20	Veracruz (VER)	Mexico	564,315	716,046	-151,731	-21.2%	18	45	Nawiliwili (HI) (FY)	United States	48,784	59,457	-10,673	-18.0%	44
21	Baltimore (MD) [1]	United States	525,296	612,877	-87,581	-14.3%	20	46	Saint John (NB)	Canada	44,382	49,240	-4,858	-9.9%	46
22	Altamira (TAM)	Mexico	400,968	436,119	-35,151	-8.1%	23	47	Panama City (FL)	United States	40,594	47,228	-6,634	-14.0%	47
23	Halifax (NS)	Canada	344,811	387,347	-42,536	-11.0%	24	48	Hueneme (CA)	United States	32,060	32,197	-137	-0.4%	49
24	Anchorage (AK)	United States	343,278	544,315	-201,037	-36.9%	21	49	Fernandina (FL)	United States	24,582	30,477	-5,895	-19.3%	50
25	Prince Rupert (BC)	Canada	265,225	181,894	83,331	45.8%	33	50	Richmond(VA)	United States	24,380	49,530	-25,150	-50.8%	45

[1] Baltimore data for Maryland Port Administration (MPA) facilities only. Abbreviations: TEU= Twenty-foot Equivalent unit. fy = Fiscal year. *Reported figures represent total loaded and empty containers and include those moving in domestic and foreign trade.* Sources: AAPA survey;; Secretaria de Comunicaciones y Transporte, Coordinación General de Puertos y Marina Mercante (México); various websites.

Figure 5 North American Container Traffic

APPENDIX B: RATIO OF CONTAINERIZED FREIGHT

This represents an estimate to the ratio of containerized freight to bulk freight for the Port of Los Angeles Harbor, CA. "C" represents a type of commodity shipped as containerized freight and "B" represents bulk cargo. In the event a type of commodity may be shipped by both a judgment was made as to the type of shipment for the majority of that type. Values in the chart represent short tons.

Source: (Waterborne Commerce Statistics Center (WCSC) 2010)

Table 14 Ratio of Containerized Freight to Bulk Freight for the Port of Los Angeles Harbor, CA

	Foreign				
	All Traffic Directions	Receipts	Shipments	Intraport	Type (C or B)
All Commodities	57,340,976	40,466,058	16,874,918	0	
Total Coal	5,375	3,537	1,838	0	
Subtotal Coal	5,375	3,537	1,838	0	
1100 Coal & Lignite	5,197	3,537	1,660	0	B
1200 Coal Coke	178	0	178	0	B
Total Petroleum and Petroleum Products	8,774,009	7,912,395	861,614	0	
Subtotal Crude Petroleum	1,588,637	1,588,637	0	0	
2100 Crude Petroleum	1,588,637	1,588,637	0	0	B
Subtotal Petroleum Products	7,185,372	6,323,758	861,614	0	
2211 Gasoline	3,157,163	3,097,672	59,491	0	B
2221 Kerosene	1,417,496	1,417,428	68	0	B
2330 Distillate Fuel Oil	1,776,685	1,408,747	367,938	0	B
2340 Residual Fuel Oil	142,548	123,577	18,971	0	B
2350 Lube Oil & Greases	10,712	504	10,208	0	C
2410 Petro. Jelly & Waxes	24,441	22,983	1,458	0	C
2429 Naphtha & Solvents	384,136	250,540	133,596	0	C
2430 Asphalt, Tar & Pitch	28,019	749	27,270	0	C
2540 Petroleum Coke	241,686	875	240,811	0	B
2640 Hydrocarbon & Petrol Gases, Liquefied and Gaseous	2,486	683	1,803	0	B
2990 Petro. Products NEC	0	0	0	0	B
Total Chemicals and Related Products	4,855,241	2,031,117	2,824,124	0	
Subtotal Fertilizers	54,087	11,565	42,522	0	
3110 Nitrogenous Fert.	1,905	1,744	161	0	C

Table 14 Cont.

3120 Phosphatic Fert.	106	7	99	0	C
3130 Potassic Fert.	3,423	616	2,807	0	C
3190 Fert. & Mixes NEC	48,653	9,198	39,455	0	C
Subtotal Other Chemicals and Related Products	4,801,154	2,019,552	2,781,602	0	
3211 Acyclic Hydrocarbons	75,574	67,085	8,489	0	C
3212 Benzene & Toluene	26,136	24,708	1,428	0	C
3219 Other Hydrocarbons	58,746	33,350	25,396	0	C
3220 Alcohols	176,732	102,070	74,662	0	C
3230 Carboxylic Acids	140,172	90,639	49,533	0	C
3240 Nitrogen Func. Comp.	235,982	64,823	171,159	0	C
3250 Organo - Inorg. Comp.	134,371	55,485	78,886	0	C
3260 Organic Comp. NEC	145,665	43,960	101,705	0	C
3271 Sulphur (Liquid)	0	0	0	0	C
3272 Sulphuric Acid	4,975	4,415	560	0	C
3273 Ammonia	1,400	457	943	0	C
3274 Sodium Hydroxide	203,438	195,530	7,908	0	C
3275 Inorg. Elem., Oxides, & Halogen Salts	314130	81356	232774	0	C
3276 Metallic Salts	504,158	73,519	430,639	0	C
3279 Inorganic Chem. NEC	59,101	9,241	49,860	0	C
3281 Radioactive Material	3,942	1,849	2,093	0	C
3282 Pigments & Paints	97,652	67,493	30,159	0	C
3283 Coloring Mat. NEC	22,976	13,615	9,361	0	C
3284 Medicines	82,693	43,839	38,854	0	C
3285 Perfumes & Cleansers	187,984	91,215	96,769	0	C
3286 Plastics	1,656,588	568,904	1,087,684	0	C
3291 Pesticides	31,327	19,272	12,055	0	C
3292 Starches, Gluten, Glue	134,667	55,692	78,975	0	C
3293 Explosives	65,978	65,322	656	0	C
3297 Chemical Additives	121,787	9,020	112,767	0	C
3298 Wood & Resin Chem.	5,696	5,191	505	0	C
3299 Chem. Products NEC	309,284	231,502	77,782	0	C
Total Crude Materials, Inedible Except Fuels	4,338,507	707,754	3,630,753	0	
Subtotal Forest Products, Wood and Chips	519,715	353,190	166,525	0	
4110 Rubber & Gums	75,191	73,297	1,894	0	C
4150 Fuel Wood	3,383	3,232	151	0	C
4161 Wood Chips	251	177	74	0	C
4170 Wood in the Rough	104,991	15,491	89,500	0	C
4189 Lumber	293,879	226,494	67,385	0	C
4190 Forest Products NEC	42,020	34,499	7,521	0	C
Subtotal Pulp and Waste Paper	1,724,295	36,725	1,687,570	0	
4225 Pulp & Waste Paper	1,724,295	36,725	1,687,570	0	B

Table 14 Cont.

Subtotal Soil, Sand, Gravel, Rock and Stone	260,844	246,012	14,832	0	
4310 Building Stone	135,940	134,418	1,522	0	B
4322 Limestone	4,520	4,083	437	0	B
4323 Gypsum	33,706	29,033	4,673	0	B
4327 Phosphate Rock	38	38	0	0	B
4331 Sand & Gravel	86,640	78,440	8,200	0	B
4333 Dredged Material	0	0	0	0	B
4335 Waterway Improv. Mat	0	0	0	0	B
4338 Soil & Fill Dirt	0	0	0	0	B
Subtotal Iron Ore and Scrap	1,379,572	8,040	1,371,532	0	
4410 Iron Ore	216	216	0	0	B
4420 Iron & Steel Scrap	1,379,356	7,824	1,371,532	0	B
Subtotal Marine Shells	2,314	1,414	900	0	
4515 Marine Shells	2,314	1,414	900	0	B
Subtotal Non-Ferrous Ores and Scrap	149,618	27,905	121,713	0	
4630 Copper Ore	12	11	1	0	B
4650 Aluminum Ore	11,280	3,801	7,479	0	B
4670 Manganese Ore	1,437	76	1,361	0	B
4680 Non-Ferrous Scrap	131,902	23,253	108,649	0	B
4690 Non-Ferrous Ores NEC	4,987	764	4,223	0	B
Subtotal Sulphur, Clay and Salt	232,509	15,299	217,210	0	
4741 Sulphur, (Dry)	197,682	697	196,985	0	B
4782 Clay & Refrac. Mat.	34,827	14,602	20,225	0	B
4783 Salt	0	0	0	0	B
Subtotal Slag	250	250	0	0	
4860 Slag	250	250	0	0	B
Subtotal Other Non-Metal. Min.	69,390	18,919	50,471	0	
4900 Non-Metal. Min. NEC	69,390	18,919	50,471	0	B
Total Primary Manufactured Goods	10,658,363	8,830,860	1,827,503	0	
Subtotal Paper Products	1,127,792	808,125	319,667	0	
5110 Newsprint	29,601	29,111	490	0	C
5120 Paper & Paperboard	635,500	411,084	224,416	0	C
5190 Paper Products NEC	462,691	367,930	94,761	0	C
Subtotal Lime, Cement and Glass	2,104,516	2,001,665	102,851	0	
5210 Lime	255	12	243	0	B
5220 Cement & Concrete	984,020	982,473	1,547	0	B
5240 Glass & Glass Prod.	335,862	273,554	62,308	0	C
5290 Misc. Mineral Prod.	784,379	745,626	38,753	0	C
Subtotal Primary Iron and Steel Products	3,010,689	2,894,695	115,994	0	
5312 Pig Iron	29,248	28,243	1,005	0	C
5315 Ferro Alloys	18,963	18,162	801	0	C

Table 14 Cont.

5320 I&S Primary Forms	1,723,612	1,659,752	63,860	0	C
5330 I&S Plates & Sheets	166,640	159,911	6,729	0	C
5360 I&S Bars & Shapes	386,243	378,088	8,155	0	C
5370 I&S Pipe & Tube	587,622	556,474	31,148	0	C
5390 Primary I&S NEC	98,361	94,065	4,296	0	C
Subtotal Primary Non-Ferrous Metal Products	4,152,039	2,873,191	1,278,848	0	
5421 Copper	61,830	49,842	11,988	0	C
5422 Aluminum	160,144	136,636	23,508	0	C
5429 Smelted Prod. NEC	1,089,561	35,074	1,054,487	0	C
5480 Fab. Metal Products	2,840,504	2,651,639	188,865	0	C
Subtotal Primary Wood Products; Veneer	263,327	253,184	10,143	0	
5540 Primary Wood Prod.	263,327	253,184	10,143	0	C
Total Food and Farm Products	8,598,930	2,984,027	5,614,903	0	
Subtotal Fish	512,617	461,645	50,972	0	
6134 Fish (Not Shellfish)	213,638	176,716	36,922	0	C
6136 Shellfish	298,979	284,929	14,050	0	C
Subtotal Grain	899,855	163,185	736,670	0	
6241 Wheat	10,831	446	10,385	0	B
6344 Corn	724,165	3,175	720,990	0	B
6442 Rice	162,773	159,167	3,606	0	B
6443 Barley & Rye	1,085	297	788	0	B
6445 Oats	304	0	304	0	B
6447 Sorghum Grains	697	100	597	0	B
Subtotal Oilseeds	995,302	26,253	969,049	0	
6521 Peanuts	2,532	1,005	1,527	0	B
6522 Soybeans	910,070	17,064	893,006	0	B
6534 Flaxseed	135	88	47	0	B
6590 Oilseeds NEC	82,565	8,096	74,469	0	B
Subtotal Vegetable Products	718,548	262,576	455,972	0	
6653 Vegetable Oils	59,997	18,244	41,753	0	B
6654 Vegetables & Prod.	658,551	244,332	414,219	0	B
Subtotal Processed Grain and Animal Feed	1,284,675	70,163	1,214,512	0	
6746 Wheat Flour	5,014	3,010	2,004	0	B
6747 Grain Mill Products	259,062	48,449	210,613	0	B
6781 Hay & Fodder	558,371	452	557,919	0	B
6782 Animal Feed, Prep.	462,228	18,252	443,976	0	B
Subtotal Other Agricultural Products	4,187,933	2,000,205	2,187,728	0	
6811 Meat, Fresh, Frozen	280,783	123,811	156,972	0	C
6817 Meat, Prepared	26,115	3,353	22,762	0	C
6822 Dairy Products	54,844	9,172	45,672	0	C
6835 Fish, Prepared	85,678	84,654	1,024	0	C

Table 14 Cont.

6838 Tallow, Animal Oils	19,418	4,079	15,339	0	C
6839 Animals & Prod. NEC	295,483	18,768	276,715	0	C
6856 Bananas & Plantains	9,195	8,784	411	0	C
6857 Fruit & Nuts NEC	729,373	441,256	288,117	0	C
6858 Fruit Juices	507,979	464,831	43,148	0	C
6861 Sugar	3,777	3,323	454	0	C
6865 Molasses	95	95	0	0	C
6871 Coffee	151,519	117,063	34,456	0	C
6872 Cocoa Beans	11,928	10,667	1,261	0	C
6885 Alcoholic Beverages	389,418	307,211	82,207	0	C
6887 Groceries	0	0	0	0	C
6888 Water & Ice	67,448	64,328	3,120	0	C
6889 Food Products NEC	520,497	298,212	222,285	0	C
6891 Tobacco & Products	20,189	2,056	18,133	0	C
6893 Cotton	840,523	7,029	833,494	0	C
6894 Natural Fibers NEC	10,703	9,193	1,510	0	C
6899 Farm Products NEC	162,968	22,320	140,648	0	C
Total all Manufactured Equipment, Machinery	18,785,557	17,007,979	1,777,578	0	
Subtotal Manufactured Equipment, Machinery and Products	18,785,557	17,007,979	1,777,578	0	
7110 Machinery (Not Elec)	1,794,777	1,485,170	309,607	0	C
7120 Electrical Machinery	3,477,979	3,281,093	196,886	0	C
7210 Vehicles & Parts	2,036,338	1,752,636	283,702	0	C
7220 Aircraft & Parts	9,688	4,623	5,065	0	C
7230 Ships & Boats	12,004	8,287	3,717	0	B
7300 Ordnance & Access.	6,919	5,548	1,371	0	C
7400 Manufac. Wood Prod.	303,002	281,006	21,996	0	C
7500 Textile Products	2,907,583	2,684,385	223,198	0	C
7600 Rubber & Plastic Pr.	2,171,568	1,708,335	463,233	0	C
7800 Empty Containers	0	0	0	0	C
7900 Manufac. Prod. NEC	6,065,699	5,796,896	268,803	0	C
Total Waste and Scrap NEC	0	0	0	0	
Subtotal Waste and Scrap NEC	0	0	0	0	
8900 Waste and Scrap NEC	0	0	0	0	C
Total Unknown or Not Elsewhere Classified	1,324,994	988,389	336,605	0	
Subtotal Unknown or Not Elsewhere Clsfd	1,324,994	988,389	336,605	0	
9900 Unknown or NEC	1,324,994	988,389	336,605	0	C

APPENDIX C: CFS FREIGHT CONTAINER MOVEMENT

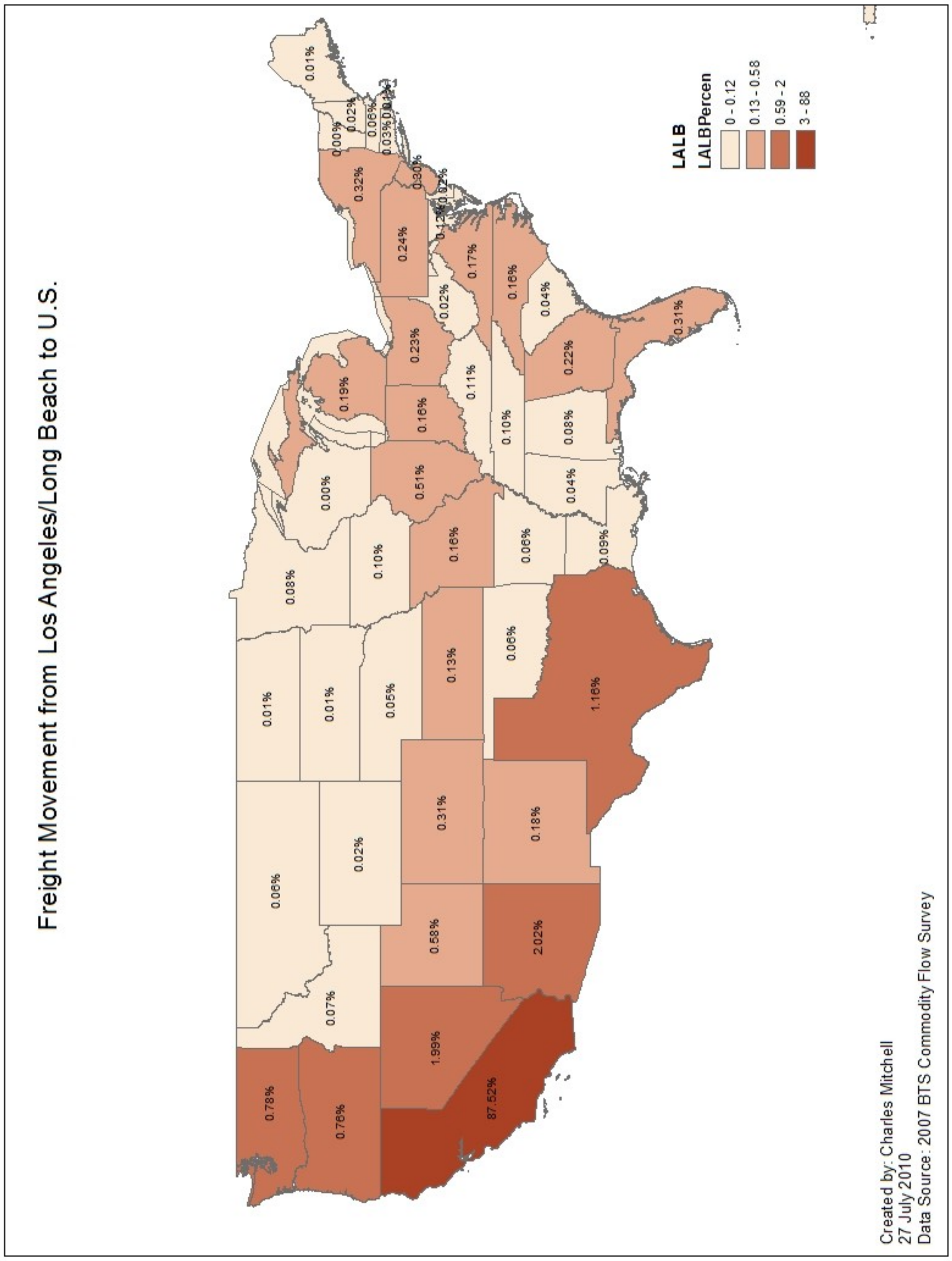

Figure 6 Los Angeles & Long Beach California Freight Movement

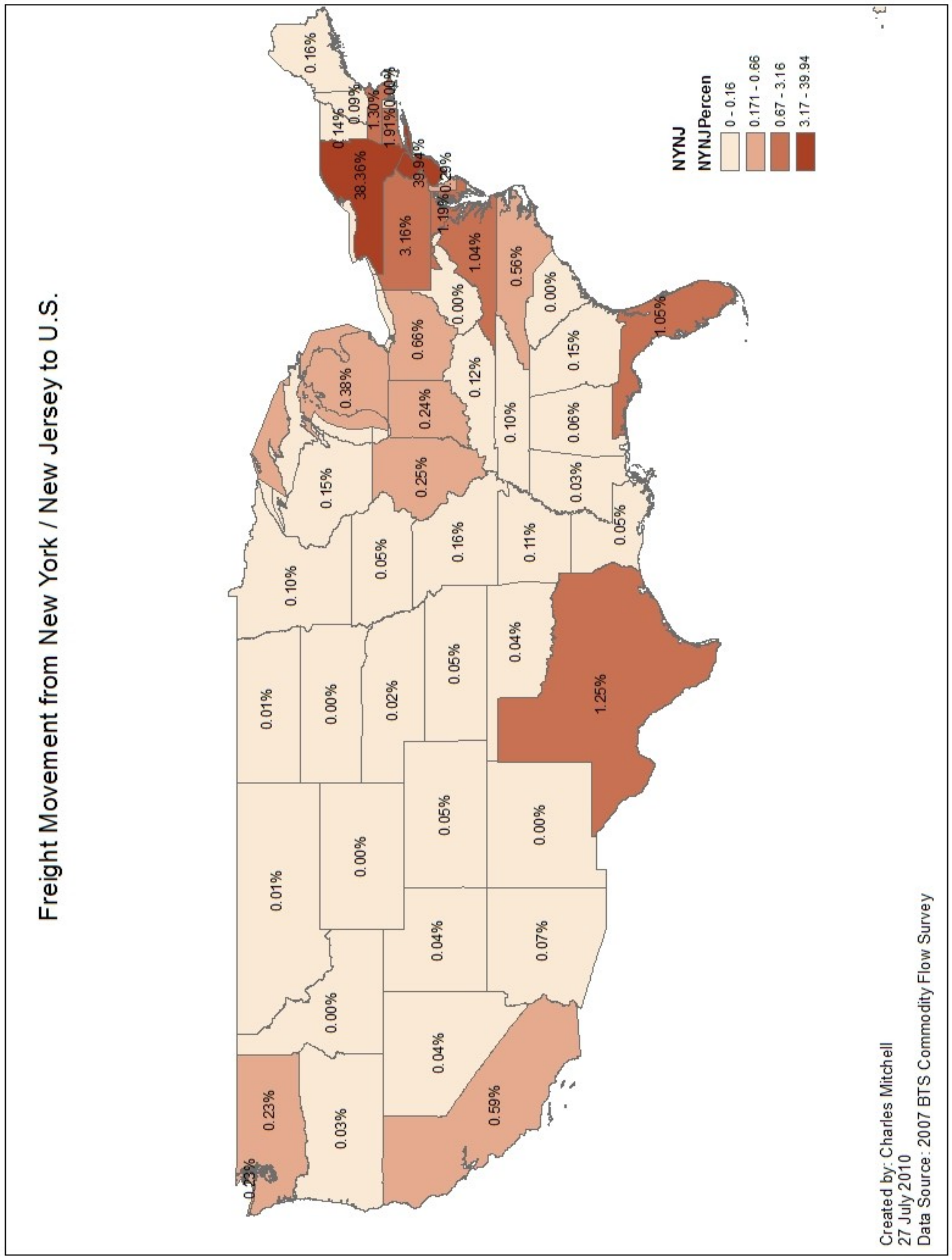

Figure 7 New York & New Jersey Freight Movement

APPENDIX D: GIFT SETTINGS

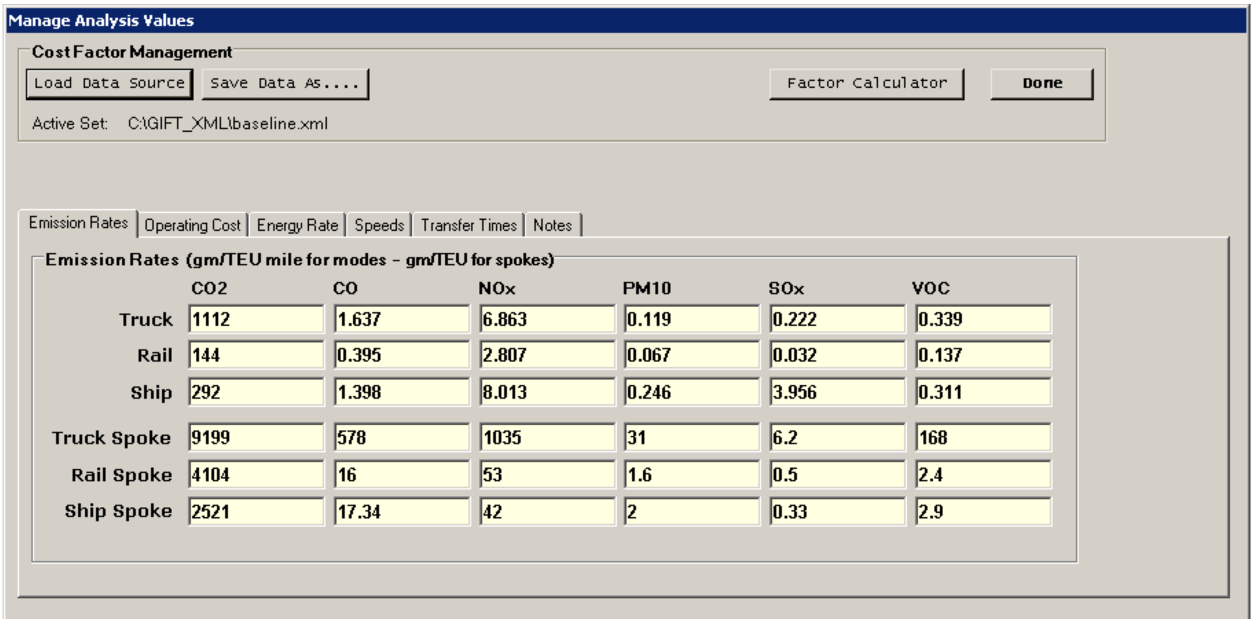

Figure 8 GIFT Emission Rates

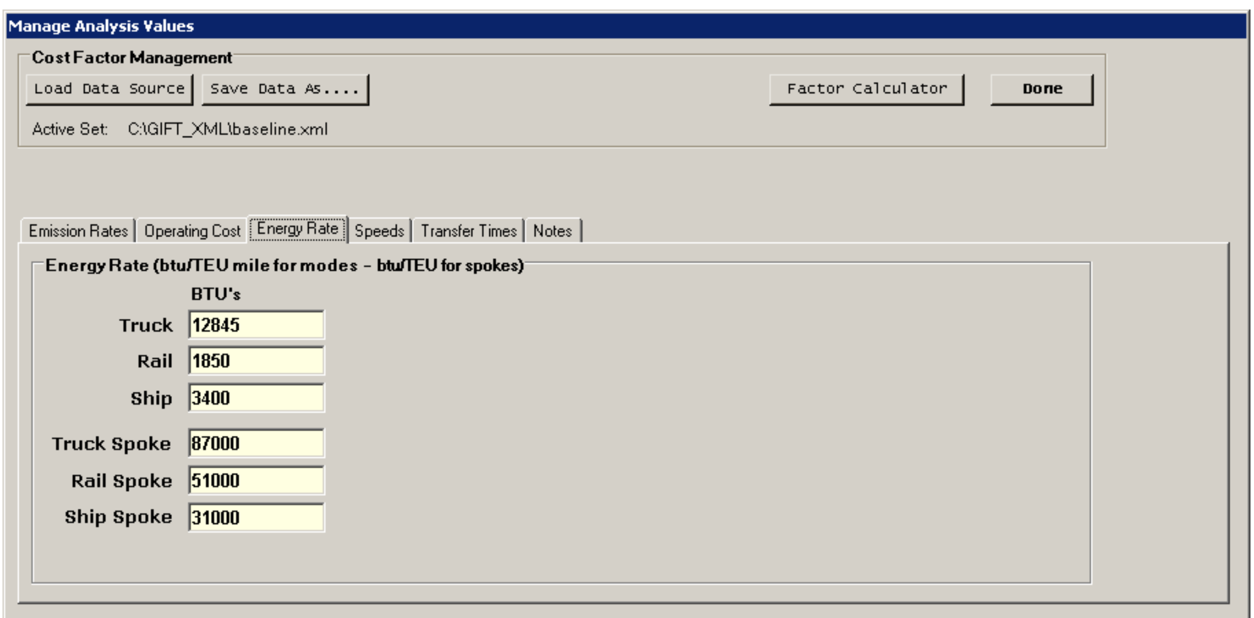

Figure 9 GIFT Default Energy Rates

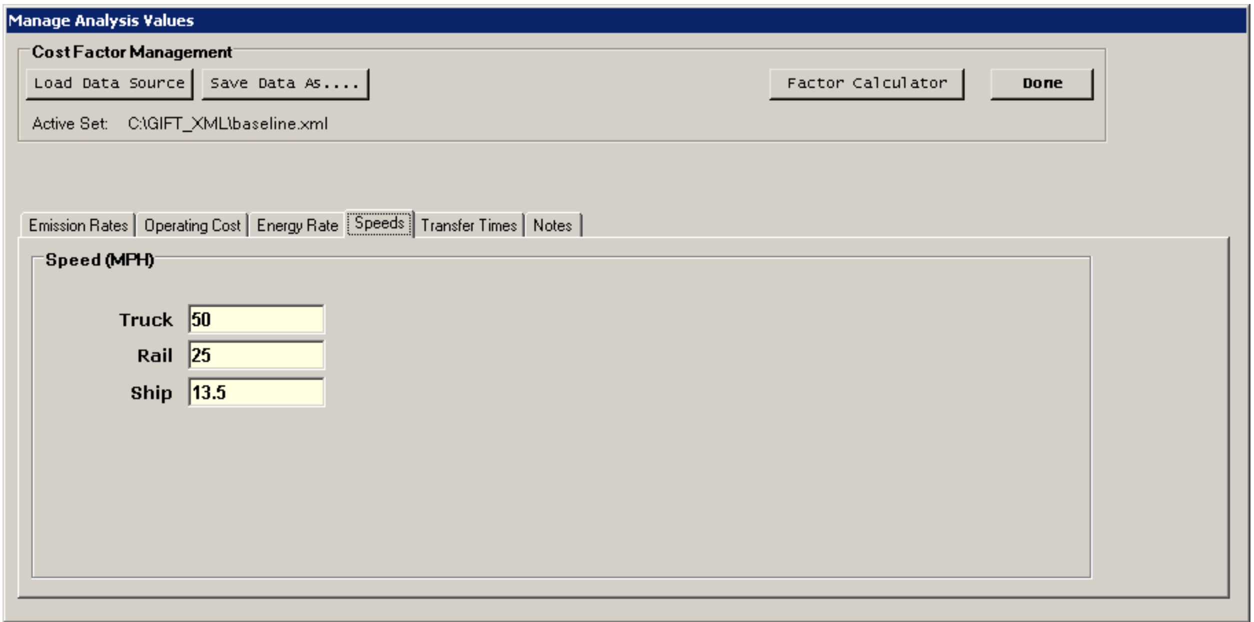

Figure 10 GIFT Default Speed Settings

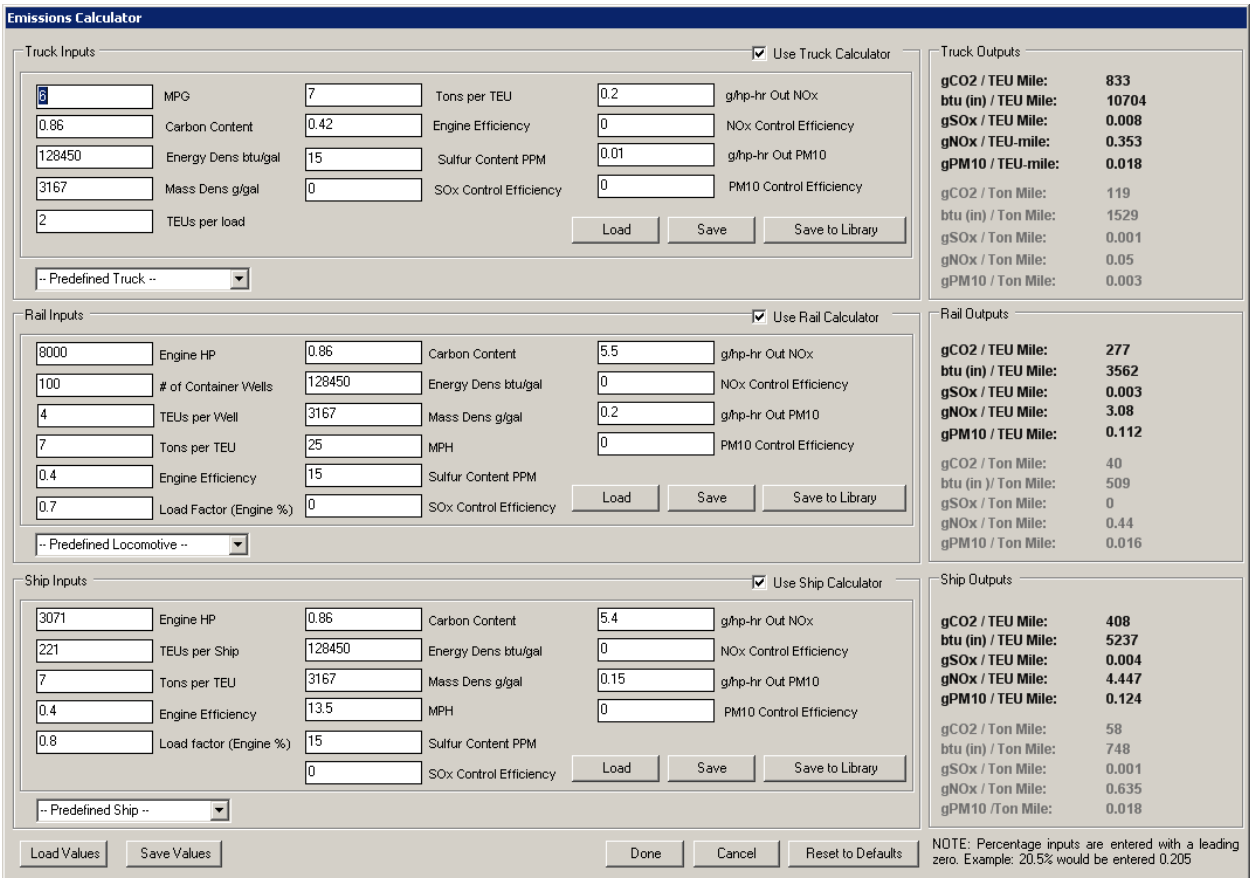

Figure 11 GIFT Emissions Calculator

APPENDIX E: GIFT RESULTS

Table 15 GIFT Results Asia to Savannah

To Savannah

Tiawan to Savannah				
	Transfer	Time	Energy	CO2
		(Days)	BTUs	(gm/TEU)
All Water	N/a	37.1	40,943,600	3,516,191
Intermodal (Water - Rail)	LA/LB	26.8	27,544,170	2,329,559
Intermodal (Water - Truck)	LA/LB	24.4	52,864,421	4,567,307

Singapore to Savannah							
	Transfer	Time	Energy	CO2	PM10	Operating Cost	
		(Days)	BTUs	(gm/TEU)	(gm/TEU)	20' ($US)	($US)
All Water	N/a	42.9	47,328,053	4,064,503	3,420	$2,583	$3,218
Intermodal (Water - Rail)	LA/LB	32.6	33,872,618	2,873,061	2,288	$2,913	$4,444
Intermodal (Water - Truck)	LA/LB	30.4	60,229,958	5,197,119	2,472	$3,852	$6,323

Shanghai to Savannah						
	Transfer	Time	Energy	CO2	Operating Cost	
		(Days)	BTUs	(gm/TEU)	20' ($US)	($US)
All Water	N/a	36	39,687,411	3,408,307	$3,112	$3,657
Intermodal (Water - Rail)	LA/LB	25.6	26,229,796	2,216,635	$3,422	$4,992
Intermodal (Water - Truck)	LA/LB	23.3	50,667,243	4,374,530	$4,227	$6,602

Table 16 GIFT Results: Asia to New York

To New York

Tiawan to New York

	Transfer	Time (Days)	Energy BTUs	CO2 (gm/TEU)
All Water	N/a	38.5	42,475,513	3,647,756
Intermodal (Water - Rail)	LA/LB	28	57,534,814	2,397,624
Intermodal (Water - Truck)	LA/LB	25.2	28,418,621	4,968,149

Singapore to New York

	Transfer	Time (Days)	Energy BTUs	CO2 (gm/TEU)	PM10 (gm/TEU)	Operating Cost 20' ($US)	Operating Cost 40' ($US)
All Water	N/a	44.3	48,803,961	4,191,257	3,528	$2,661	$3,314
Intermodal (Water - Rail)	LA/LB	33.8	34,744,890	2,940,897	2,319	$3,150	$4,919
Intermodal (Water - Truck)	LA/LB	31.4	63,853,327	5,510,796	2,505	$4,103	$6,825

Shanghai to New York

	Transfer	Time (Days)	Energy BTUs	CO2 (gm/TEU)		Operating Cost 20' ($US)	Operating Cost 40' ($US)
All Water	N/a	37.3	41,163,319	47,859		3,224	3,787
Intermodal (Water - Rail)	LA/LB	26.8	27,104,247	2,284,701		$3,658	$5,465
Intermodal (Water - Truck)	LA/LB	24	56,212,684	4,854,600		$4,611	$7,371

APPENDIX F: GEORGIA PORT AUTHORITY MODEL RESULTS CONTAINERS IN STORAGE

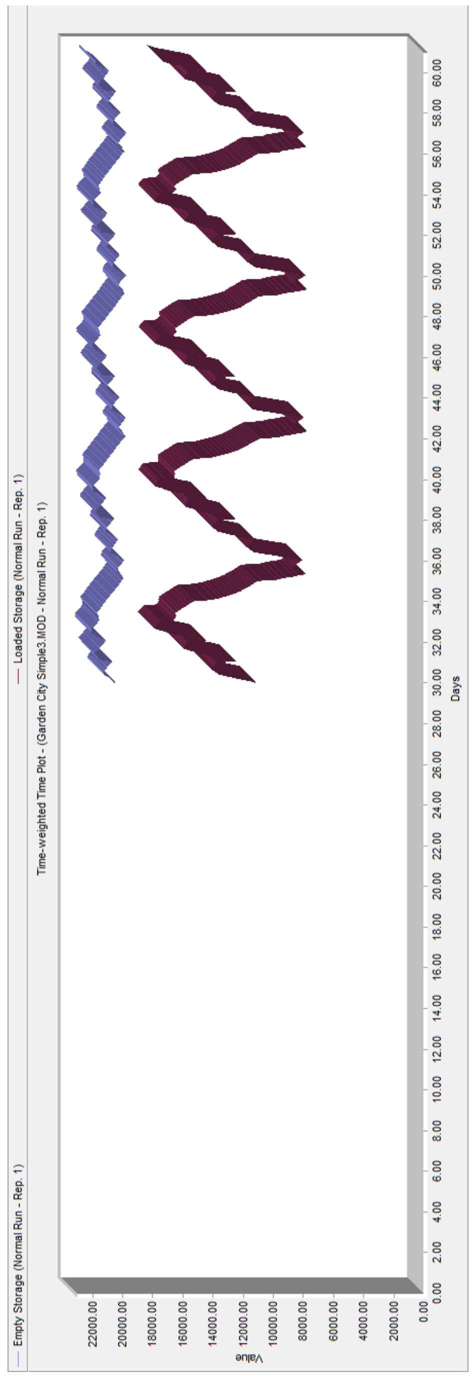

Figure 12 Base Case Containers in Storage Garden City Terminal

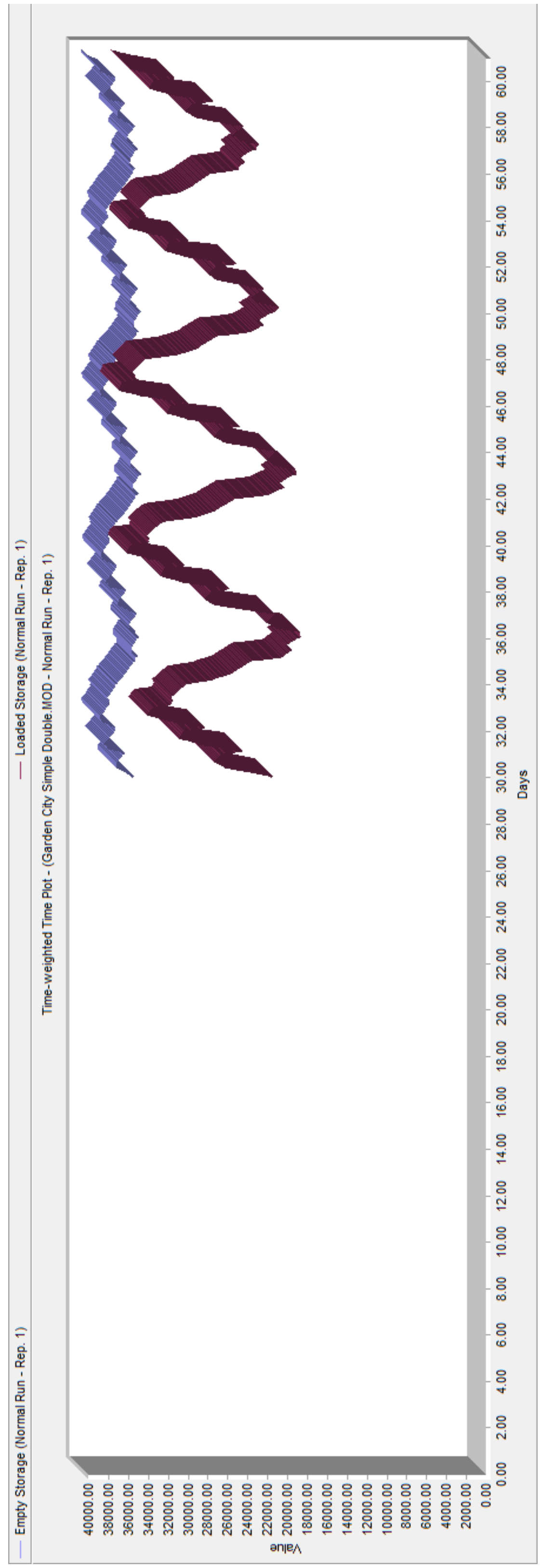

Figure 13 Double Annual Freight Containers in Storage: No Gate 8

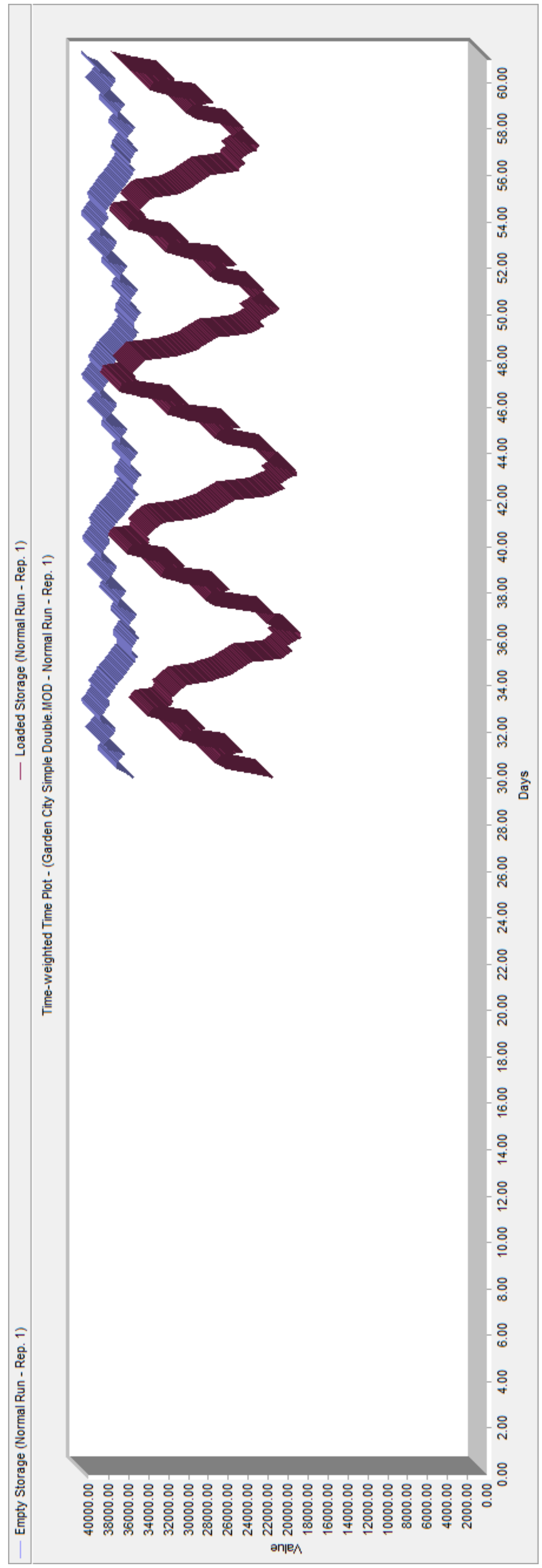

Figure 14 Double Annual Freight Containers in Storage with Gate 8

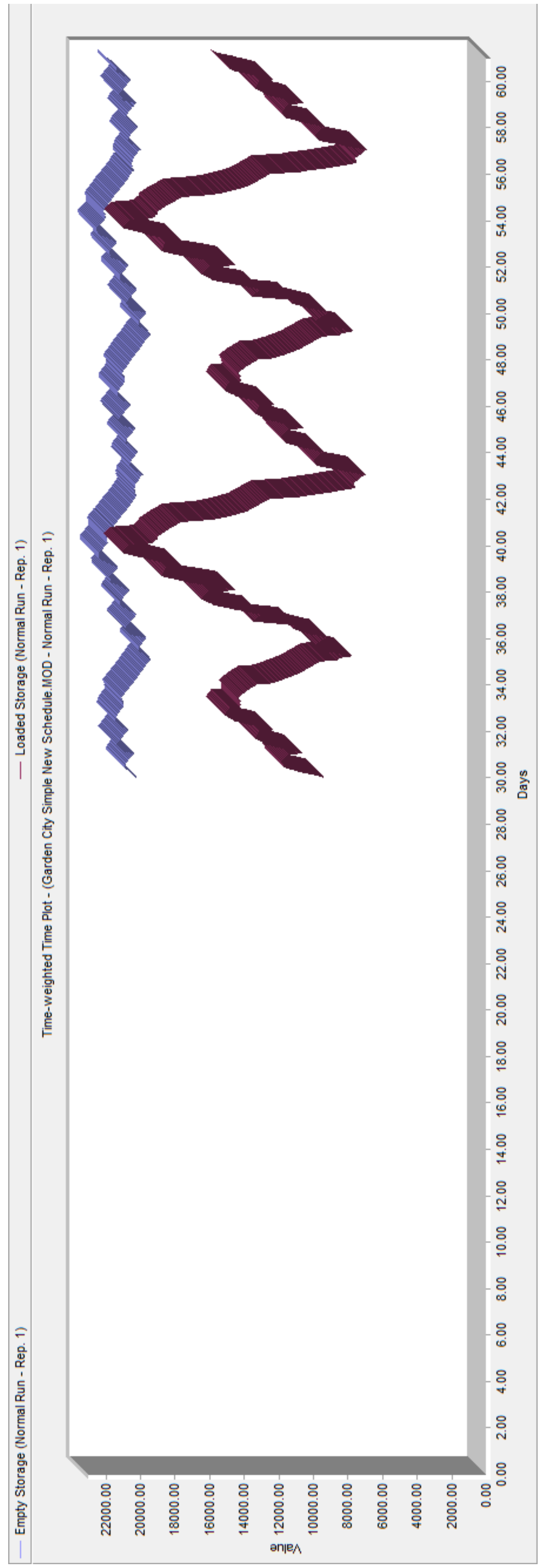

Figure 15 Alternate Shipping Schedule Containers in Storage