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16. Abstract

Worldwide container demand has increased significantly over the past decade, due to growing international trade and the introduction of larger containerships on certain trade routes. The Texas Department of Transportation thus contracted the Center for Transportation Research at the University of Texas, Austin to examine containerized freight movements in Texas. The objective of this investigation was to gain a better understanding of how containers move across the state, what commodities are shipped in these containers, to what degree container shippers utilize the Texas-Mexico ports of entry, and to examine the potential for diverting containers from key highway corridors to rail. This report summarizes available information and data on the container sector and on container movements in and through Texas. A GIS platform (TransCAD) was used to map and display the available data. In the second phase of this study, the research team will examine the potential for diverting containerized traffic from Texas highway corridors to other modes, specifically rail.

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What We Know About Containerized Freight Movement in Texas

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1. Introduction

1.1 Introduction

Global trade has grown significantly in the past two decades and now a substantial share of non-bulk traffic moving between the main world markets moves in containers. Worldwide container traffic has increased significantly over the past decade, partly because it is required of transportation systems to move greater volumes of commodities at lower costs. In 2001, more than 18 million 20-foot equivalent units (TEUs) – the standard unit for counting containers – were handled at U.S. container ports compared to 13 million in 1995, representing an increase of 36 percent (U.S. Department of Transportation, 2003).

Within Texas, increasing container traffic has been driven by: Texas's competitive advantage within the national and global economy; trade with Mexico (especially container traffic between Mexico and the U.S. increased since the implementation of the North American Free Trade Agreement (NAFTA) in 1994), a growing U.S. economy during the 1990s, and growing trade with Latin America and Europe. The economy of Texas thus imports and exports substantial volumes of freight by container – through east coast, west coast, and gulf ports – as well as providing highway and rail corridors for containerized trade moving through Texas to origins and destinations outside the state.

Despite the widespread use of containers, relatively little is known about container movements within and across the State of Texas on various modes. One reason for the general lack of information about container movements is the limited container data available. Container movements by ship are tracked in great detail by the Port Import Export Reporting Service (PIERS), but detailed information on truck and rail container movements is either not collected or suppressed by government agencies for reasons of confidentiality. The Texas Department of Transportation's (TxDOT) first effort at understanding statewide container movements was Project 0-1833 "Infrastructure Impacts of Containerships (including Mega-Containerships) on the Texas Transportation System", which studied the characteristics of the maritime container industry.

In 2000, TxDOT contracted the Center for Transportation Research (CTR) at the University of Texas, Austin to analyze containerized freight movements in Texas. The objectives of the current study are to examine container flows in Texas, to display available data using a GIS platform, and to evaluate the potential for diverting containerized traffic from Texas's highway corridors to other modes. The first phase of this study, which culminated in this research report, aimed to gain a better understanding of containerized flows in Texas and to display their movements on the state's transportation system using a GIS platform. It is believed that an improved understanding of container flows in Texas would benefit TxDOT's transportation planners responsible for the future planning of transportation corridors and terminals. In the second phase of this project, the potential for diverting containerized traffic from Texas highway corridors to other modes under different scenarios will be investigated.

1.2 Organization of Report

This report is structured as follows. Chapter 2 provides a global perspective of the container sector and highlights the non-transportation aspects of the sector. Chapter 3 discusses maritime container flows through Texas's container ports and summarizes port infrastructure requirements, and plans to expand the container capacity of many of the State's ports. Chapter 4, 5, and 6 examines, analyzes and estimates container flows on the Texas road network, rail network, and barges, respectively. Chapter 7 discusses the GIS platform used to display container data and the embedded Fractional Mode Split Distribution Model selected to evaluate container mode split under various scenarios in the subsequent phase of this project. Finally, Chapter 8 highlights some of the report's main findings and conclusions.

2. Containers: A Global Perspective

2.1 Introduction

Container information and data can be grouped into mainly four categories for the purpose of this report. The first category relates to information on the container industry and includes data on container manufacturing, container types, and deployment. Information on these aspects of containerization can be found in specialized journals such as Containerisation International. The second category focuses on the steamship lines and the types of containerships transporting containers on world trade routes. Information on these activities are collected from a number of sources, including steamship company annual reports, countries registering containerships (like Panama), Lloyds Maritime Information Services, Ltd, and specialized journals such as Containerisation International. These sources cover routes, frequency of sailings, shipping companies, and data on the type of containerships being deployed on world trade routes. The third category addresses container movements through marine ports and border ports of entry. Such data are available from routine reports supplied by individual ports, or through research sponsored by ports and government agencies such as the Federal Highway Administration's Freight Analysis Framework study, the Maritime Administration of the U.S. Department of Transportation (U.S. DOT), and the Bureau Transportation Statistics (BTS). Finally the Journal of Commerce (JoC) PIERS data set provides a valuable (if expensive) source of port container information. The fourth category of information, relates to what could be termed surface operations, is rather weak. Although some container origin and destination data are available at the larger ports and through the PIERS data set, this category of information tends to be limited in terms of container movements by surface mode. An annotated bibliography on available container literature and a detailed review of available freight data sources are included in Appendix A and B, respectively.

The research team used secondary data (where available) and conducted primary research to gain a better understanding of the container sector and to learn more about container surface movements and container-on-barge (COB) operations. In the summer of 2002, the assistance of various stakeholders involved in containerized freight movements was sought. Questionnaires were developed for different stakeholder groups (i.e. freight forwarders, trucking companies, container leasing companies, ocean carriers, and railroads), which were used to extract information as to the significant origins and destinations of containerized movements in and through Texas, major highway corridors used, who owns the containers, container liability, the security risks, and what happens with a container at the end of its useful life (see Appendix D for questionnaires and Appendix E for a list of respondents). The specific survey method is given in Box 1.

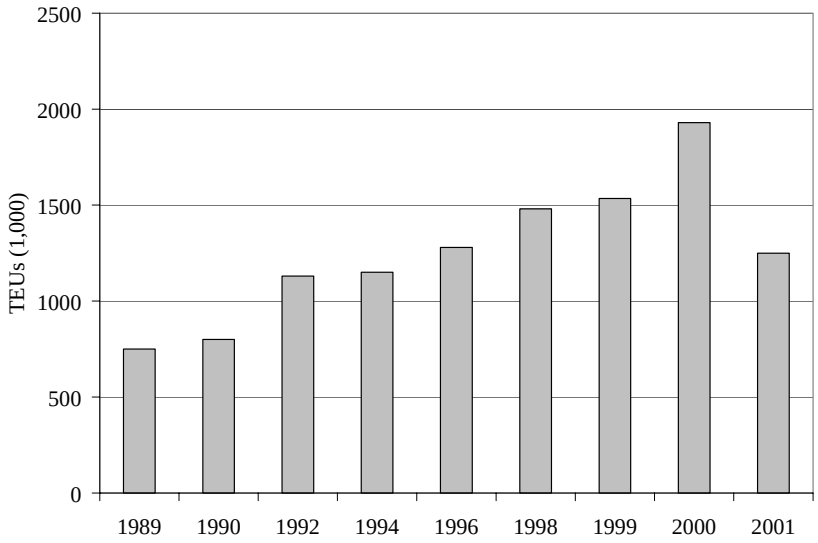
Box 1: Survey Method

Stakeholders were identified through existing contacts, a detailed literature review, and an Internet search. Companies were contacted and asked to identify a representative that could participate in the research. Once representatives were identified, an explanation of the study and a formal request to participate in a telephone interview was faxed to the representative. If the representative was willing to take part in a follow-up interview, a telephone meeting was scheduled and conducted at their convenience. This "cold calling" approach required 350 phone calls to secure and conduct 33 interviews. In total, three major ocean carriers, twelve trucking companies, nine freight forwarders, seven container leasing companies and two railroad companies were interviewed (see Appendix E for a list of companies interviewed).

The information provided in this chapter is based on both secondary and primary data collected as part of this research project. The chapter first examines the manufacture and ownership of containers, and then investigates the more specific operational characteristics in terms of liability, tracking, cost considerations, and information on containers as they are withdrawn from transportation use. Finally, the chapter identifies emerging problems associated with the repositioning of empty containers and the general challenge of improving security, together with inefficiencies and operational risks that were revealed both as part of the formal literature review and the individual stakeholder interviews.

2.2 Major Container Manufacturers

Demand for containers increased in the 1990s, fueled by a 7% per year growth in international trade and the introduction of large new containerships into the global shipping fleet. Figure 2.1 shows the total number of Twenty Equivalent Units (TEUs) manufactured globally between 1989 and 2001. It also shows that in the 10-year period following 1989, container production doubled (Harrison and Figliozzi, 2001). The ratio of containers to containership slots is always greater than one and the data in Figure 2.1 reflect both new (and larger) containerships entering service, as well as the growth in globally traded containerized commodities and the replacing of old boxes.



Source: Containerisation International Market Analysis

Figure 2.1 World Container Output

Container manufacturing is not a high-technology process and can be undertaken in industrializing nations. Manufacturing requires a modest production-line and three inputs: steel, wood (especially plywood), and labor. In the 1970s, container manufacturing moved from the Americas and Europe to India and the Far East. Containers were manufactured where the ships were built (South Korea), where labor was skilled yet inexpensive (India), or where raw materials were readily available (Indonesia). In the 1990s, however, China experienced spectacular economic growth and came to dominate container manufacturing. By 1995 China was supplying approximately 50% of the world container output - increasing to 82% by 2001 (Foxcroft, 1999).

Table 2.1 World Manufacture of Containers by Region ('000 TEUs)

	1998	**1999**	**2000**	**2001**
China	1,027	1,175	1,605	1,020
Other Asia	212	165	176	98
Europe	166	130	110	104
Americas	45	40	30	23
Other	30	25	9	5
Total	**1,480**	**1,535**	**1,930**	**1,250**

Source: Containerisation International Yearbook 2002

Table 2.1 gives a breakdown of container output by region for the period 1998 to 2001. China's supremacy in this market is attributable to an aggressive governmental policy, the concentration of Chinese producers, and access to the three inputs required for manufacturing containers: steel, plywood, and inexpensive labor. Also impacting the production of containers were the currency shocks experienced by many developing

nations in the late 1990s which weakened domestic economies and raised the prices for imported raw materials (typically in U.S. dollars) necessary for container production. It appears that China is likely to remain the major producer of containers in the near future.

While containers come in a variety of sizes and shapes the standard 20 ft and 40 ft containers—termed dry freight standard—dominate the market. Other variants, such as refrigerated containers, demand premium prices and can therefore be made outside China.

Table 2.2 Container Production by Type 2001

Type of Container	Percentage
Dry Freight Standard	81
Dry Freight Special	3
Integral Reefer	7
Tank	1
Swap body/Pallet-wide	5
U.S. Domestic 48 'and 53'	3
Total	**100**

Note: 2001 World Production was 1.25 Million TEU
Source: Containerisation International Yearbook 2001

Table 2.2 provides a breakdown of the different types of containers produced in 2001. The dry freight standard accounts for over 80% of production followed by refrigerated containers and swap body/pallet-wide variants. Refrigerated container designs have received a great deal of attention in recent years and are now built with small refrigeration units (or in some cases no units) and heavy insulation which, when loaded from cold stores, keep the cargo inert for the entire trip.

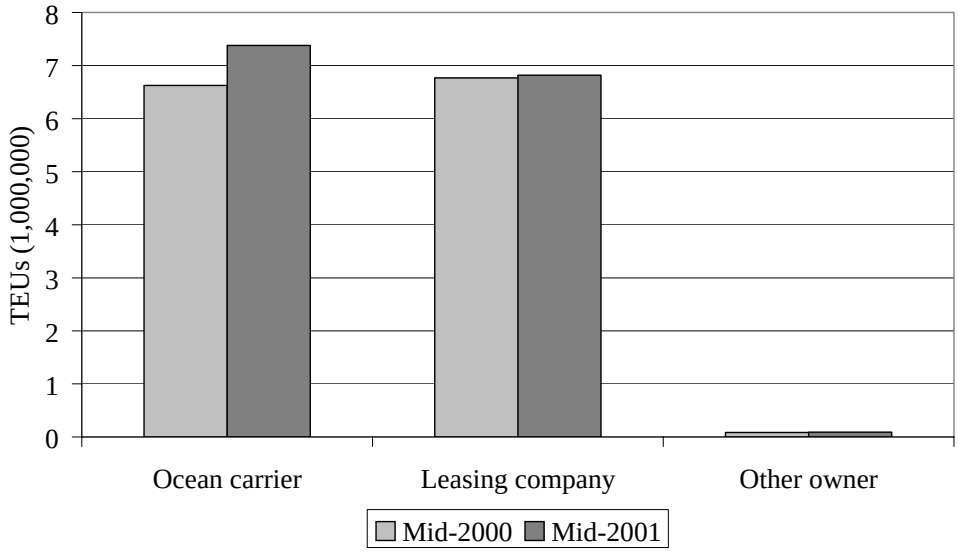
The post-2001 slow-down in both world economic activities and the deployment of new containerships suggests that container production is in the mature stage of its life cycle and a more stable production level, equating to scrappage rates, may prevail for the next several years. If this is indeed the case, total global production is likely to be in the range of 1.2 to 1.5 million TEUs, with much of it being manufactured in China.

The two leading Chinese container manufacturers are CIMC Group and Singamas Container Holdings. CIMC Group operates eight and Singamas Container Holdings operates four of the approximately thirty dry-freight manufacturing plants in China. In 2001, CIMC Group produced 670,000 TEUs or approximately 66% of China's container output (Foxcroft, 2002).

2.3 Global Container Ownership

The world's containers are primarily owned by two types of companies: ocean carriers and leasing companies (as shown in Figure 2.2). In mid-2001, ocean carriers owned approximately 7.4 million of the world's 15.1 million TEUs deployed, while leasing companies owned approximately 6.8 million TEUs. Between mid-2000 and mid-2001 the percentage of the world's TEUs owned by the ocean carriers increased from 47% to 49%. During the same time period the percentage of the world's TEUs owned by leasing companies decreased from 48% to 45%. The remainder of the world's container fleet –

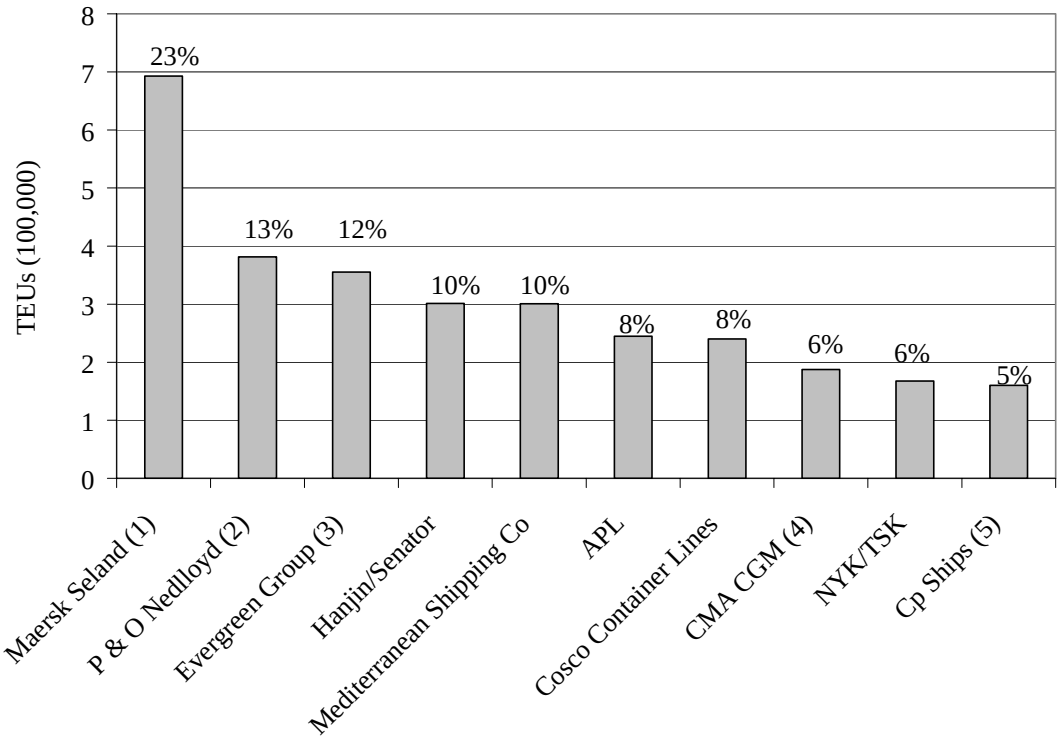
approximately 6% – are owned by other companies, such as trucking companies and major shippers (Foxcroft, 2002).



Source: Foxcroft, 2002

Figure 2.2 World Container Fleet by Main Owner (2000-2001)

The top five ocean carriers in terms of the number of TEUs deployed in 2001 are Maersk Sealand, P&O Nedlloyd, the Evergreen Group, Hanjin/Senator, and Mediterranean Shipping Company (see Figure 2.3). Maersk Sealand is the largest container service operator, with approximately 700,000 TEUs deployed in 2001. The second largest operator, P&O Nedloyd, deployed approximately 380,000 TEUs (Willmington, 2002).



Notes:
1. Includes the fleets of AP Moller subsidiaries Portlink & Safmarine
2. Includes the fleets of wholly-owned subsidiaries Farrell Lines & Mercosul Line
3. Includes the fleets of wholly-owned subsidiary Lloyd Triestino and affiliated Uniglory
4. Includes the fleets of wholly-owned subsidiaries ANL and Feeder Associated Systems
5. Comprises the fleets of ANZDL, Canmar, Cast, Contship, Lykes & TMM Lines

Source: Willmington, 2002

Figure 2.3 Top 10 Container Service Operators on the Basis of TEUs Deployed (November 1, 2001)

The top five container leasing companies in terms of fleet holding are TransAmerica Leasing, GESeaCo, the Textainer Group, Triton Container International, and the Interpool Group. These five companies hold more than 50% of the total 2001 fleet. TransAmerica Leasing and GESeaCo each hold more than one million TEUs. Table 2.3 summarizes the top ranking container leasing companies and their fleet holding for mid-2001 (Foxcroft, 2002). Competition among container lessors is influenced by lease rates, the availability and quality of equipment, and customer service (Sea Container LTD, 2001).

Table 2.3 Top Ranking Container Leasing Companies and their Fleet Holding, Mid-2001

	Mid 2001 ('000 TEU)	% of Total
TransAmerica Leasing	1,075	15
GESeaCo	1,065	14
Textainer Group	965	13
Triton Cont International	910	12
Interpool Group	670	9
Florens Group	560	8
CASI-Container Applications Inc	405	5
Cronos Group	380	5
Gateway Container Corp	270	4
Capital Lease	230	3
Gold Container Corp	185	3
Amficon Container Leasing	70	1
Waterfront Leasing	60	1
Carlisle Leasing	56	1
United Container Systems	44	1
Other	435	6
Total	7,380	100
Operating Lease	6,820	

Source: Foxcroft, 2002

2.3.2 Container Leasing

In some circumstances it is more economical for carriers to lease containers to meet their business needs rather than to purchase containers. Container leasing provides for increased flexibility. Certain lease options allow a carrier to leave a container at the trip destination if no backhaul is found. This flexibility can save costs because the carrier does not have to incur the cost of repositioning the empty container. In periods of high demand, a carrier can lease additional containers as opposed to incurring the high capital cost of buying containers that might be redundant in periods of lower demand (Dupin, 2001).

Container leasing, however, tends to be more expensive than owning a container. It is estimated that the daily cost of a leased container is approximately 60 - 70 % higher than an owned container. Leasing is also less attractive in Africa, South America, and the Caribbean, since leasing companies do not have depots in these countries. Empty lease containers therefore have to be repositioned at a high cost to regions of higher demand (Dupin, 2001).

Repositioning of empty containers is a major expense for leasing companies. In areas of container surplus, such as New York, Miami, Rotterdam, and London, leasing companies have started to close their depots or to charge shippers a repositioning fee. TransAmerica, for example, decided to charge shippers a repositioning fee rather than to

close any of their 300 worldwide depots. The repositioning fee for a 40 ft container from New York to the Far East ranges from $800 to $1,000 (Dupin, 2001).

The majority of freight forwarders interviewed leased their containers from ocean carriers. A major benefit associated with leasing containers from ocean carriers is that the ocean carrier is responsible for repositioning the container. One freight forwarder interviewed claimed that the ocean rate was the same if the container was shipped-owned or shipped-leased. Only three trucking companies indicated that they own or lease containers. Most replied that they only move containers. A number of different lease options exist (see Box 2). The three trucking companies interviewed that leased containers preferred spot or term leases.

2.4 Container Liability

According to George Pezold, an attorney with Augellow, Pezold & Hirschmann in New York, container liability is transferred between the buyer and seller, and among carriers. Incoterms 2000 governs the terms of sale and the transfer of liability between the buyer and the seller for international goods. Among carriers, liability is determined by the contract of carriage – usually the Bill of Lading that specifies the terms of delivery, the carrier's tariff, and the applicable statutory law or international treaty (Personal Communication, 2002).

Box 2: Container Lease Options (Muller, 1999)

Various container lease options are available, ranging from short-term spot leases to long-term master leases.

Spot Lease

A spot lease is a short-term lease sometimes called a *trip lease*. The lease is for one or more containers for a short time period or for a specific trip or purpose. As a result of market conditions the prices for spot leases tend to fluctuate widely. Because of these fluctuations users should not depend on spot leases, although it is possible to get a low-priced spot lease by shopping around. Leasing companies, however, tend to minimize spot leases to ensure that they do not have too many un-leased containers in a low rate period.

Term Leases

A term lease is when a lessee needs a container for a prolonged period. This type of lease usually comes without any additional services from the lessor other than buying the container from the manufacturer and leasing it. Usually the lessee is responsible for repositioning the container.

Master Leases

Master leases are long-term leases also known as *pool management plans* or *full-service leases*. In the case of a master lease, the leasing company is responsible for managing the container fleet, which includes maintenance, repair, repositioning, and other services. Master leases are *"complicated involving a system of debits and credits relating to the condition of the containers at the time of interchange and service."*

The price of master leases fall when leasing companies compete with each other, especially during periods of light demand. The reduced price of the master leases can in some cases be lower than the cost associated with owning the container. Master leases have become popular with large U.S. container leasing companies for two reasons: customer acceptance and increased competition. Most of the freight forwarders and all the trucking companies interviewed, however, indicated that they did not enter into master leases.

2.4.1 Buyer/Seller Liability

Incoterms are standard trade definitions that are commonly used in international sales contracts. They represent an international agreement that specifies responsibility and the transfer of goods between the buyer and the seller. The International Chamber of Commerce created Incoterms – or International Commercial Terms – in 1936. Currently there are thirteen different Incoterms (Reynolds, 1999).

Several freight forwarders interviewed confirmed that insurance responsibility for the container and the cargo is governed by the Incoterms. Although there are thirteen different terms, the freight forwarders indicated that three of these terms are more commonly used: Free on Board (FOB), Cost Insurance and Freight (CIF), and Ex Works (EXW).

In a FOB transaction, the seller selects the freight forwarder to arrange for the movement of a container to the port or designated point of origin. Responsibility is transferred from the seller to the buyer when the container is discharged at the port or designated point of origin. Neither the buyer nor the seller is responsible for insurance, although it is in the interest of the buyer to purchase insurance. This Incoterm is one of the most often misused terms as it is often incorrectly used to describe an inland movement. Correctly used, it applies to a cargo movement by sea or inland waterway (Reynolds, 1999).

In a CIF transaction responsibility is transferred from the seller to the buyer once the container passes the ship's rail in the port of origin. In other words, the seller is responsible for any incidents occurring on the pier side of the rail, and the buyer is responsible for any incidents occurring on the shipside of the rail. Under this Incoterm, the seller is responsible for minimum insurance coverage (Reynolds, 1999).

An EXW transaction is one of the simplest and most basic shipping arrangements. The seller has minimum responsibility. In terms of this arrangement, the seller makes the container available for pickup at a stipulated place – usually the seller's factory or warehouse – and at an agreed time. Delivery is accomplished when the container is released to the buyer's freight forwarder. The buyer is responsible for making arrangements with a freight forwarder to obtain export clearance and for handling all other paperwork. Under this Incoterm, neither party is responsible for insurance. It is, however, in the interest of the buyer to obtain insurance, because even before transportation the seller has relinquished responsibility (Reynolds, 1999).

2.4.2 Carrier Liability

Bill of Lading

When a shipper hands over cargo to a railroad, water carrier, or trucking company, the carrier issues a Bill of Lading. The Bill of Lading is a contract of carriage between the shipper and carrier, but also serves as a receipt for the cargo. It includes a statement of the cargo's value, charges for transport, and a list of the carrier's conditions of carriage and liability. The Bill of Lading is also used as a document of ownership and can exchange hands several times during transit (Muller, 1999). Only one of the nine freight forwarders and two of the twelve trucking companies interviewed, mentioned that responsibility for the container is transferred from the ocean carrier to the surface carrier upon receipt of the original Bill of Lading.

Uniform Intermodal Interchange Agreement (UIIA)

The Uniform Intermodal Interchange Agreement (UIIA) is a standard industry contract among trucking, water, and rail carriers. It was designed to bring uniformity to the interchange process (UIIA Homepage, 2002), and to help inform the different carriers about their rights and financial responsibilities when equipment (i.e., containers, chassis, etc.) is transferred from one carrier to another (Mongelluzzo, 1996). Currently, approximately 5,400 motor carriers, 47 water carriers, 6 railroads and 1 leasing company recognize the UIIA. CSX Lines announced in April 2002 that the company will be converting from an in-house Intermodal Interchange Agreement to the UIIA which they

believe is "currently the most preferred, widely accepted, and subscribed to document used by equipment owners and equipment users" (CSX Lines, 2002).

The UIIA has helped clarify liability issues. Previously, trucking carriers were under the impression that they assume liability when collecting documentation on their way out of the marine or rail terminal. In terms of the UIIA, the trucking company assumes responsibility for their actions once they enter a marine or rail terminal (Mongelluzzo, 1996).

Insurance Liability for Ocean Carriers

The Carriage of Goods by Sea Act (Cogsa) governs the insurance liability of ocean carriers in the U.S. Congress passed Cogsa in 1936 to help level the playing field in international shipping. In an effort to protect shippers from ocean carriers, Cogsa set a maximum liability amount of $500 a package for cargo damage. Unfortunately, the word *package* was never defined. A package can thus be a single item that requires some preparation before transportation, such as a box, bundle, crate, or container. A container, therefore, could be subject to the $500 insurance limit even though there may be more packages inside the container. Despite many court rulings, it is still unclear whether a container is a *package* or not. Shippers are therefore advised to purchase additional insurance to cover packages inside the container (Muller, 1999). Three of the eight freight forwarders interviewed confirmed that the liability of ocean carriers is limited to $500 per container if lost at sea.

Both ocean carriers confirmed that they insure the container, but only one of the two insures the contents of the container. Half of the freight forwarders interviewed confirmed that the shipping lines insure the container, but insurance for the contents is the responsibility of either the seller or the buyer, depending on the Incoterms. Most of the trucking companies interviewed indicated that they insure both the container and the contents of the container.

2.5 Container Tracking

According to the container leasing companies interviewed, the container lessee is responsible for tracking the container during the lease period. The lessors arrange the delivery and collection point at the beginning and end of the lease period. The container depot, from which the container is collected or to which it is delivered, reports this information to the container leasing company.

Both the ocean carriers interviewed claimed to have sophisticated systems for tracking container movements. Several methods exist to track containers: through an internal system, the Internet, or a terminal Web site. About half of the freight forwarders interviewed relies on the tracking systems of the ocean carriers, although some did indicate to have internal systems that can track the containers from origin to destination.

Most of the trucking companies track containers through an in-house dispatch system and telephone communication with the driver. None of the trucking companies interviewed used a real-time GPS system.

2.6 Container Cost Considerations

A number of cost components are associated with containers, starting from the initial manufacturing costs, lease or ownership costs, carrier costs, dock and terminal handling charges, including lifting and moving the container, wharfage costs, and repositioning costs. Cost information is always difficult to obtain because of the proprietary nature of the information. Only orders of magnitude are revealed in telephone surveys. This section summarizes the limited cost information extracted during the surveys, as well as some estimates uncovered during the literature review. Box 3 illustrates the charges that are assessed on a coffee container arriving in Houston during August of 2001.

Box 3: Container Charges

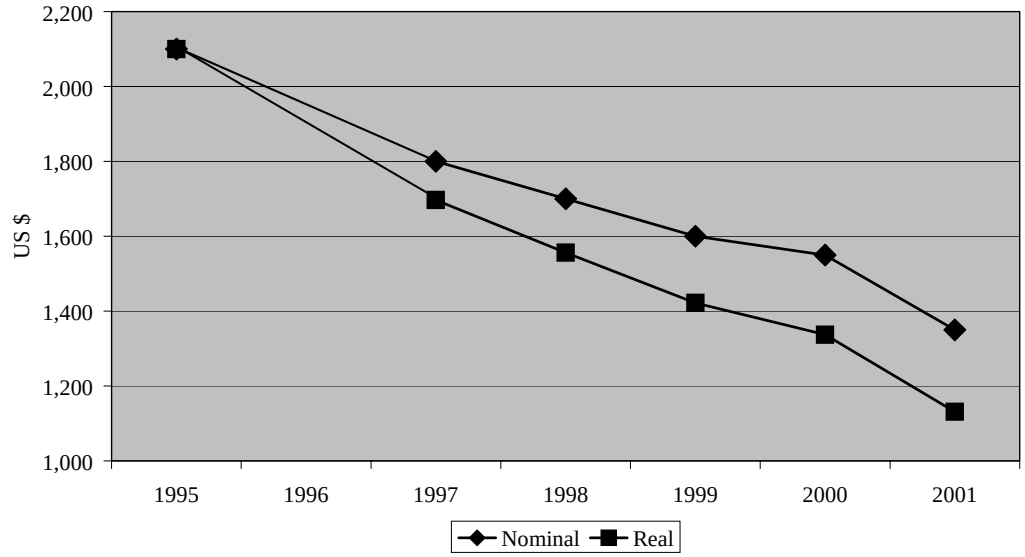
Boske and Cuttino (2002) listed the following charges that were assessed on a coffee container arriving at the port of Houston during August of 2001:

USDA charge	$10-25
FDA charge	$10-25
Customs entry	$75-150
Wharfage charged by Houston	$2.87 per metric ton
Sampling	$12 per sample plus airfreight
Inbound handling	$0.0775 per bag
Outbound handling	$0.0775 per bag
Weighing	$0.325 per bag
Reconditioning	$12 per bag
Cleaning	$0.0050 per pound
Blending	$0.0075 per pound
Palletizing	$0.0015 per pound
Storage	$0.31 per bag
Screening (on average after 15 days grace period)	$20 per unit
Fumigation of import container	$85 per unit
Segregation of damaged cargo	$0.75 per bag
Disposal of damaged coffee	$1 per bag

2.6.1 Manufacturing Costs/Selling Price

As previously noted, there are several cost components that influence the final price offered to those purchasing new containers. Dominating manufacturing input costs are those related to raw materials and labor. To this broad category of locationally sensitive costs must be added the proximity to customers – which impacts transportation costs – and the production costs at each facility. And because such facilities are spread throughout the world, the strength of the local currency relative to the U.S. dollar can also cause substantial fluctuations in both input costs and output prices. Finally, there is the market itself, and thus the interaction of global supply and demand for specific container types.

The dominance of China in the production of containers (see Section 2.2) underlines a danger of oversupply. It has been reported that the largest Chinese container manufacturers have container supply capacity exceeding 2 million containers per year—well over the total annual demand in any recent year (Foxcroft, 2000).



Note: Real price is adjusted with for a 3% inflation rate.
Source: Containerisation International Yearbook (1996-2002)

Figure 2.4 Average Ex-Works Shanghai TEU Price

If a chronic oversupply exists in any market, a fall in prices will follow (both in nominal and real terms). Figure 2.4 illustrates a dramatic reduction in the average price of containers (per TEU, Ex-Works Shanghai) since 1995, particularly in real terms. This potentially could have resulted in a slight reduction in the costs per TEU/mile on container routes, given the reduction in capital outlays. However, there are other important consequences. Of particular interest is the impact price reductions have on scrappage rates. A fall in new container prices is likely to shorten the operational life of containers. At a time when repositioning costs are increasing, containers may end up at destinations from where it is simply too expensive to move them to points where they can be loaded. As an example, the nominal sea rate for a TEU slot from Los Angeles to the Far East has on a number of occasions exceeded the cost of a new container purchased in Shanghai. For those shipping out of Shanghai or in that immediate region of Asia, it is thus potentially less costly to purchase a new container than to reposition one from a distant destination.

Actual costs for containers vary depending on the type of container and where and when it is purchased (Muller, 1999) but the trend is clearly demonstrated. Large volume customers may obtain substantial discounts based on volume and the timing of their purchase, which further complicates matters. However, an important consequence of the substantial fall in container prices is that a number of regions—particularly in the U.S. and Europe—are now faced with the additional cost of storing large numbers of empty containers while repositioning or scrapping policies are determined.

2.6.2 Leasing Costs

According to one of the container leasing respondents, ocean carriers pay $1 for a 20 ft, $1.85 for a 40 ft, and $2.40 for a 40 ft high cube container per day in an operating lease. In addition, if the container is moving from a high demand market to a low demand market, the ocean carrier might be charged a repositioning fee.

2.6.3 Terminal Handling Fees/Lift Costs

One of the respondents interviewed said that terminal handling fees – including loading the container at the port onto the container ship – ranged from $250 to $300. One of the ocean carriers reported that the container terminal handling and lifting fees at Houston amounts to approximately $275. Another respondent indicated that only to lift a container from the terminal onto the container ship amounted to $63.

According to one of the freight forwarders, terminal handling fees for exports are included in the lease rate, but for imports terminal handling fees are a separate line item. According to this freight forwarder, terminal handling fees vary according to the container's origin. For example, the terminal handling fee for a 20 ft container from Europe would be $400, and $500 for a 40 ft container. The terminal handling fee for a 20ft container from Brazil would be $415, and $550 for a 40 ft container. The terminal handling fee for a 20 ft container from the Middle East would be $390, and $650 for a 40 ft container.

2.6.4 Transfer Costs

Most of the freight forwarders interviewed did not know what it cost to transfer a container between modes. Half of the trucking companies and the freight forwarders reported that either transfer costs were included in the ocean carrier's lease rates or that there was no transfer cost. According to one of the container leasing companies, transfer costs vary between $15 at the depot to $150 to $180 at the port.

2.6.5 Demurrage Costs

One of the ocean carriers pointed out that for a refrigerated container a customer has only 3-5 days to collect, empty, and return the container. A customer is charged a ground rental or storage fee of approximately $350 per day after 3 days for a refrigerated container. In Houston, the ground rental or storage fee for a non-refrigerated container is $150 per day after 5 days. This fee makes the movement of containers by rail between the port and within the Texas Triangle problematic.

2.6.6 Repositioning Costs

Repositioning is becoming a costly activity. To reposition a container from the East Coast to Asia, including trucking and ocean freightage, can amount to more than $1,000. When you compare that to the cost of a brand new container – approximately $1,600 in China in 2000 – it is evident that repositioning can easily account for almost 63% of the value of a new container Ex-Works.

2.7 The End or an Afterlife

Based on the survey responses, the average life of a container is approximately 13 years. Most respondents indicated that a container lasts from 10-15 years. While a significant number of old, broken, and obsolete containers are scrapped at the end of their useful life, about 300,000-500,000 containers experience an afterlife. These containers are converted into storage space, offices, homes, malls, and even prisons (Muller, 1999).

2.7.1 Storage and Office Space

Used containers are most often converted into storage and office space. An entrepreneur in San Francisco lined up used containers, painted them, cut out the sides to make doors, and use them for storage space (Muller, 1999). The Mobile Storage Group converts containers into office space. Their Flexible Office System is made out of 20 ft containers that are equipped with interchangeable wall panels, windows, electrical outlets, lights, heat and air conditioning, white steel walls, and flooring. One benefit of a container office is that it has ground level access and therefore does not require stairs or expensive skirting board (The Mobile Storage Group, 2002).

2.7.2 Homes

Used shipping containers have been utilized for housing in places of housing shortages, such as South Africa. The Safmarine Group, one of South Africa's largest shipping companies, donated 4,500 used 20 ft containers and $4 million to convert them into homes. Three containers were joined together to create a 615 sq ft home that includes a bathroom, dining room, and kitchen. Windows, doors, insulation, electricity, running water, a sewage system, and a ventilation system are added and the container home is painted. The container home sells for $11,200, while a comparable home built with regular construction materials will sell for $16,000 (Brennan, 1997).

In the U.S., an earthquake in Guam inspired Mark O'Bryan to build houses from used shipping containers. He observed that unlike standard housing, the shipping containers used by the homeless were undamaged. He formed Habitat Systems and with the help of the Milwaukee School of Engineering convinced the Milwaukee Housing Authority to build the container housing project. The project consists of 20 two-bedroom duplexes. Each duplex is 640 sq ft. Clapboard sidings were added to the exterior to make the duplexes look like the typical Milwaukee home, (Berke, 1996).

2.7.3 Shopping Malls

In 1993, the Masakhane Container Mall was built from converted shipping containers in a black settlement in South Africa. The Masakhane Project, a non-profit development agency, did not have sufficient funds to build a permanent mall, but had the idea to use 8 ft by 20 ft ocean shipping containers and convert them into a mall (Keller, 1993).

Today, the mall is still operational and considered a success. It has twelve permanent tenants and an occupancy rate of approximately 60%. The twelve tenants comprise a liquor store, grocery store, butchery, fruit and vegetable shop, homemade confectionary, wheel and tire services, shoe repair, scrap metal buyers, a seamstress and clothing shop, a hair salon, phone center, and restaurant. The 40% space availability depresses rental rates,

which provides prospective entrepreneurs with the opportunity to start a business with extremely low overheads and in reasonable and secure premises. The mall is located on the main road between the industrial area and the larger communities – and thus easily accessible (Personal Communication with Richard Webster, 2002).

2.7.4 Jail Cells

Canning Vale Prison in Australia purchased twenty-four renovated containers to use as temporary prison cells to help alleviate overcrowding. The container cells came with a curtained window, shelves, carpet, and a TV (Le Grand, 1999).

2.8 Inefficiencies and risks

2.8.1 Empty Containers

Empty containers are piling up in some ports, such as the Port of New Jersey. Robert Ward, chief executive of GESeaCo, estimated that there are at least 100,000 empty containers in storage yards around the Port of New Jersey that belong to leasing companies and an additional 50,000 belonging to ocean carriers. Assuming that a 40 ft container sells for $2,600, Ward calculated that *"there is something like $200 million worth of containers in New Jersey doing nothing, and that is just leasing company containers. You can add half again as many shipping line containers."* Ward estimated that leasing companies have between 300,000 to 400,000 empty containers in storage yards in the U.S. (Dupin, 2000).

Statistics published by Drewry Shipping Consultants Ltd. on the number of empty containers handled as a percentage of port volume seems to confirm Ward's observation (see Table 2.4). In North America, between 20 - 22% of the total port volume is empty containers. This is comparable to statistics of 14% and 16% for Southeast Asia and South Asia, respectively. This seems to point to the imbalance in trade between North America and the Far East, as well as the high cost of repositioning empty containers (Brennan, 1999).

Table 2.4 Empty Containers as a Percentage of Port Volume

	1980	1985	1990	1995	1996	1997
North America	21.2	21.8	20.6	19.2	22.0	21.1
Western Europe	21.1	23.6	20.5	18.1	18.0	18.2
N. Europe	18.7	21.1	19.0	15.5	15.2	15.0
S. Europe	27.2	29.7	24.5	24.5	24.0	23.7
Far East	17.9	20.5	16.1	15.5	16.7	17.9
Southeast Asia	18.7	18.8	15.3	11.8	12.8	14.0
Middle East	38.3	33.9	27.1	26.1	26.9	27.3
Latin America	30.9	34.2	38.4	33.6	32.7	30.7
Caribbean/Cent. Amer.	31.3	32.4	39.8	37.3	34.9	31.4
S. American	29.1	38.6	35.1	25.6	27.7	28.9
Australia/Asia	20.0	21.1	20.3	18.5	20.0	18.3
South Asia	24.2	24.4	17.4	17.3	17.7	16.2
Africa	20.9	24.4	25.2	25.8	26.8	25.6
Eastern Europe	20.3	25.2	28.2	25.7	21.0	26.7

Source: Brennan, 1999

2.8.2 Fraud and Theft

Containers may facilitate the crimes of malefactors and forgers, because once a container is loaded and sealed, people tend to trust the paperwork – as the container is impermeable to sight. There are several types of container content fraud. The most frequent type of fraud is when the cargo in the container is different from the cargo listed on the manifest or Bill of Lading. A second general type of container fraud is misdescription. In some cases misdescription is the result of an honest mistake, but at other times cargo is misdescribed to evade higher freight costs, custom duties, or regulations concerning the shipment of hazardous waste (Dupin, 2001).

2.8.3 Security Risks

The perceptions of the respondents regarding whether containers present a security risk varied greatly. Almost all the container leasing companies felt that containers were not a security concern. One of the two container leasing companies that felt otherwise substantiated the perception that containers represent a security risk by citing that only 3% of all containers handled at ports are physically inspected.

About half of the trucking companies and half of the freight forwarders interviewed felt that containers were a security concern. About half of these respondents felt that technology could be used to address security concerns.

Both the ocean carriers interviewed indicated that containers were a security concern. One of the ocean carriers purchased an X-ray machine and randomly X-ray's approximately one-third of the containers handled, plus anything that seems suspicious.

A better understanding of the container sector, how containers move, and who is liable at what stage, is considered crucial in identifying the container freight transportation's vulnerability to security risks.

2.9 Concluding Remarks

Despite increasing containerization, a comprehensive literature review revealed that very little data is publicly available on containers and their movements within the U.S., particularly on the highway system. Telephone interviews with a number of transportation stakeholders involved in containerized freight movements also indicated that limited research is currently being undertaken in this area. This chapter summarizes available literature and information gathered from stakeholders on the global nature of containers, including construction, ownership, liability, tracking, costs, non-transportation end life uses, and inefficiencies and risks.

One important element not addressed by the surveys was the impact of new security measures being introduced by U.S. Customs and the Department of Homeland Security. The pre-filing of import information, particularly that of containers, will provide data for security tracking. Previously, data were collected for fiscal reasons – particularly the collection of taxes. The expanded view of the role of U.S. Customs will potentially result in the recording of the transport mode and the details of the trip – commodity, origin and destination, steamship company, crew, shipping agent, – meaning that there will be a more complete intermodal picture for each trip. This provides an exciting opportunity for transportation planners since such data will provide important insights into decisions on the part of the shippers and can be used to detail the entire supply chain in the U.S. and not just the port. It is therefore hoped that the Bureau of Transportation Statistics will be granted access to the data and be empowered to share the aggregated findings with federal and state transportation planners. The subsequent chapters of this report describe available and estimated container flow information by mode on the state's transportation system.

3. Texas Maritime Container Flows

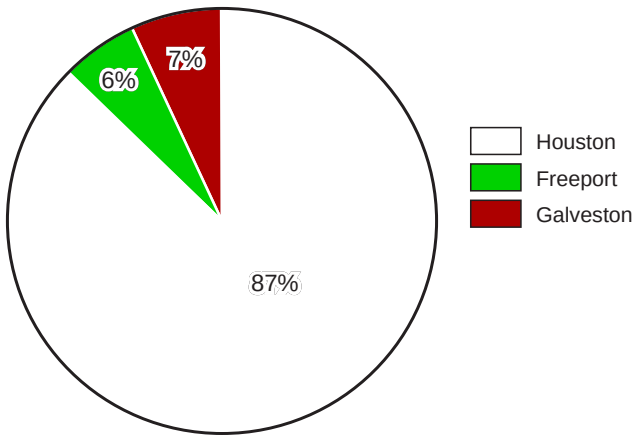
3.1 Introduction

Texas deepwater maritime ports handle substantial volumes of bulk products, dominated by chemical, petroleum, and agricultural commodities. In Texas only the Ports of Houston, Freeport, and Galveston ship and receive containers. Of these three ports, the Port of Houston is by far the largest container port, ranking 10th in North America (Containerisation International, 2002). The port's container business has not fallen substantially over the past 10 years, as has been the case at many other ports where steamship scheduling has dramatically altered business. Even as the U.S. economy slowed after 2000, Houston's containerized traffic has managed to keep growing. Container movements through Texas ports reflect the strength of the regional (but especially Texas) economy and are, in one sense, a barometer of the State's international trading performance.

This chapter describes container flows through Texas ports, the origins and destinations of containers handled at the Port of Houston, the various infrastructure elements of specific Texas ports, and planned container capacity expansion plans at various Texas's ports.

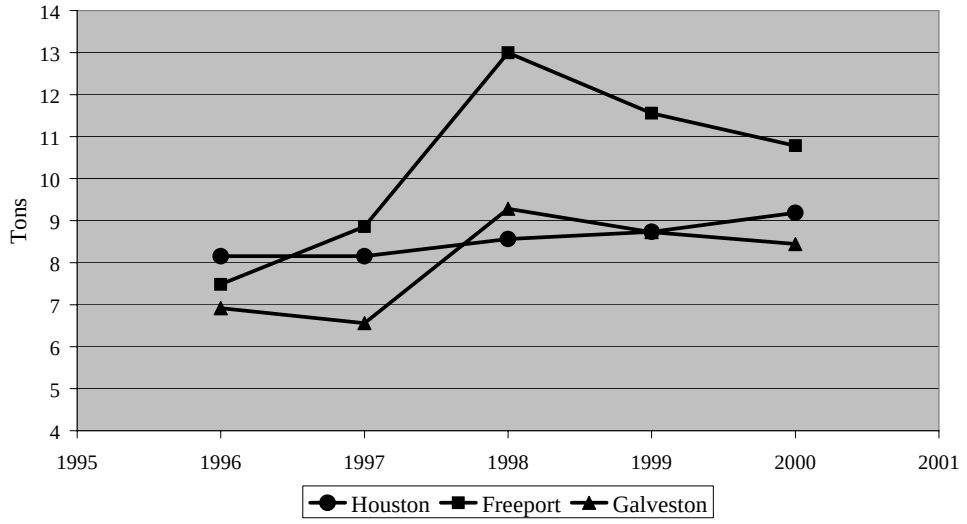
3.2 Texas's Container Ports

As indicated earlier, currently only the Ports of Houston, Freeport, and Galveston ship and receive containers in Texas, though others are trying to develop some of this business. Of the three, the Port of Houston is by far the largest container port; handling approximately 1.1 million TEUs or 87% of the total TEUs shipped and landed at Texas ports in 2000 (see Figure 3.1). In contrast, the Ports of Galveston and Freeport handled 7% and 6% of the total, respectively (Containerisation International Yearbook, 2001 and Personal Communications with the Port of Houston, May 2002).



Source: Containerization International (2001), and Personal Communication with the Port of Houston (May 2002)

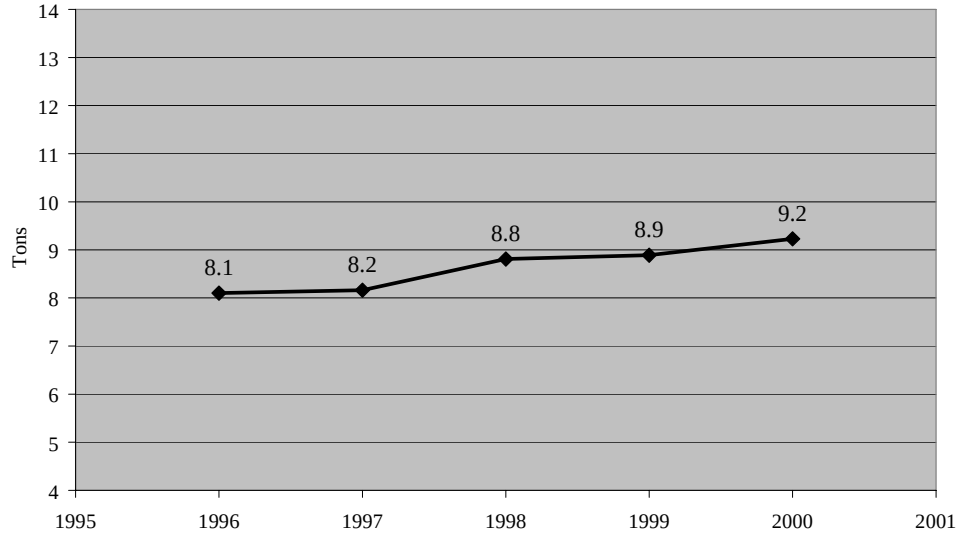
Figure 3.1 Number of TEUs Handled by Texas Ports (2000)



Source: Containerization International (2000), and Personal Communication with the Port of Houston (May 2002)

Figure 3.2 Average Container Weight

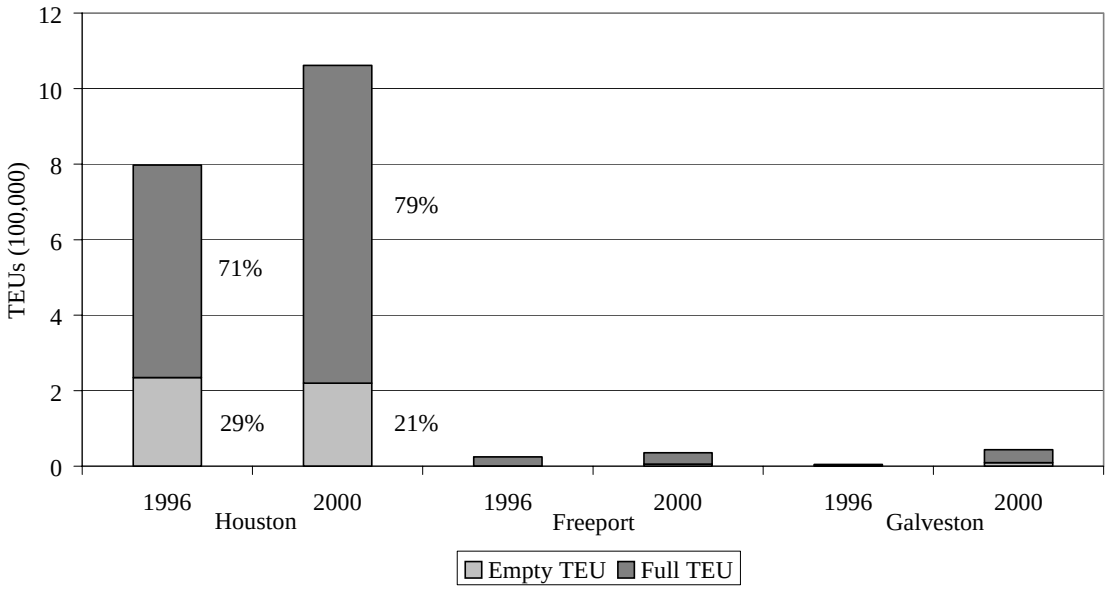
The average weight (in tons) of containers shipped and received at Texas container ports between 1996 and 2000 is displayed in Figure 3.2. As can be seen from this figure the average weight per container increased between 1996 and 2000, peaking in 1998 at both the Ports of Freeport and Galveston. This could be a reflection of the commodities moved, the size of the containers, and the number of empty containers moved.



Source: Containerization International (2000) and Personal Communication with the Port of Houston (May 2002)

Figure 3.3 Average Container Weight
(Average of Port of Houston, Port Freeport, and Port of Galveston)

The average container weight for all containers handled by the three Texas container ports is displayed in Figure 3.3. From 1996 to 2000 there has been a 1.1 ton increase in the average container weight. This could be attributable to better utilization of container capacity – fewer partially loaded containers – or a decrease in the number of empty containers handled. It has to be recognized that this statistic is dominated by the container situation at the Port of Houston.



Source: Containerization International (2000) and Personal Communication with the Port of Houston (May 2002)

Figure 3.4 Full and Empty Containers Handled by Texas Port

As is evident from Figure 3.4, which illustrates the number of empty and full containers (in TEUs) handled at Texas's containers ports, the number of empty containers handled at the Port of Houston decreased in both absolute and relative terms in 2000 compared to 1996. During this period, the number of empty containers as a percentage of total containers decreased from 29% to 21%. A reduction in the number of empty containers points potentially to improved utilization of existing container capacity with associated cost benefits.

Barbours Cut Terminal is currently the Port of Houston's only container terminal, although it is planning to build a second facility at Bayport, which would more than double its handling capacity. In terms of TEUs it is ranked as one of the top ten container handling facilities in the U.S. Not only is the terminal important to the Texas economy, but it also plays an important role in the Gulf of Mexico by handling more than 65% of containers traversing the Gulf of Mexico (www.portofhouston.com, 2003).

The effects of container movements on the Texas economy, more specifically on employment at the Port of Houston, can be seen in Table 3.1. The table shows the number of jobs by commodity and by commodity tonnage handled at the Port of Houston in 1997. Although it is clear that both the petroleum and liquid bulk industries employ a significant

number of people the number of jobs per ton for these commodities are much lower than for containers (Boske and Cuttino, 2001).

Table 3.1 Job Impacts by Commodity: Port of Houston (1997)

Commodity	Jobs/ Commodity	Jobs/ Thousand Tons
Petroleum	15,259	0.23
Liquid bulk	8,829	0.17
Containers	**5,711**	**0.75**
Steel	2,182	0.54
Dry bulk	1,783	0.07
Grain	1,455	0.33
Roll on/Roll off	1,234	13.77
Other breakbulk	644	0.96
Bagged cargoes	488	0.82
Autos	250	4.63
Lumber	239	0.81
Paper	168	0.41
Resin	109	1.86
Breakbulk cotton	66	0.44
Pulp	58	0.54

Source: Martin Associates, *The Local and Regional Economic Impacts of the Port of Houston* in Boske and Cuttino, 2001.

3.3 Major Origins and Destinations

During the summer interviews, the participants indicated that most of the containers to and from the Port of Houston have an origin or destination in the Texas Triangle – Houston, Dallas, and Austin/San Antonio – which accounts for over 70% of the state gross domestic product (GDP). A limited number of containers originated or was destined for Laredo and El Paso. A significant number of the respondents – especially the trucking companies, freight forwarders, and container leasing companies – pointed out that most of the container movements are within the Houston area or within 100 miles from the Port of Houston. The latter was confirmed during an interview with a Port of Houston representative. The representative reported that approximately 56% of the containers handled at the port remain in Harris County, and that all were transported by truck. In total, the representative claimed that nearly 80% of the containers handled at the Port of Houston remained in Texas. The remaining 20% have out-of-state origins or destinations. Approximately 16% have an origin or destination in California and the remaining 4% have an origin or destination elsewhere in the U.S. These container movements have intermodal or rail potential.

In 2000, an origin/destination (O/D) survey of containerized cargo was conducted at Barbours Cut Terminal. URS performed the survey during normal business hours on March 7, 2000. Six surveyors were stationed at the four main gates (C1, C3, C5 and Maersk Sealand). This survey effort resulted in 944 surveys of which 377 and 261 were

completed for containers destined and originating at Barbours Cut Terminal, respectively. Relevant statistics from the survey data are illustrated in Tables 3.2 and 3.3 for containers destined and originating at Barbours Cut Terminal, respectively.

Table 3.2 Containers Destined for Barbours Cut Terminal

Origin	State	Count	Percent
Baytown	TX	12	3.18
Beaumont	TX	14	3.71
Bishop	TX	4	1.06
Corpus Christi	TX	6	1.59
Dallas	TX	25	6.63
Freeport	TX	11	2.92
Galveston	TX	10	2.65
Houston	TX	109	28.91
Houston (Budweiser)	TX	4	1.06
Houston (Galena Park)	TX	5	1.33
Houston (Lathrop)	TX	5	1.33
Houston (McCarty)	TX	16	4.24
Houston (Sheldon)	TX	5	1.33
Houston (Wallisville)	TX	5	1.33
La Porte	TX	11	2.92
Laredo	TX	4	1.06
Orange	TX	14	3.71
Passadena	TX	5	1.33
Santa Fe	TX	9	2.39
Settagast Terminal	TX	4	1.06
Texarkana	TX	4	1.06
Tulsa	OK	5	1.33
Louisiana	LA	15	3.98
Arkansas	AK	6	1.59
Other		69	18.30
Total		**377**	**100**

Source: URS report Barbours Cut Container Terminal Traffic County Program in Draft Environmental Impact Statement for the Port of Houston Authority's Proposed Bayport Container/Cruise Terminal, 2001.

As shown in Table 3.2, 40% of the 377 containers arriving at the Barbours Cut Terminal originated in Houston. Second, Dallas (part of the Texas Triangle) was a significant origin, accounting for almost 7% of the surveyed containers destined for Barbours Cut Terminal. Also, about 7 % of the surveyed containers originated out-of-state.

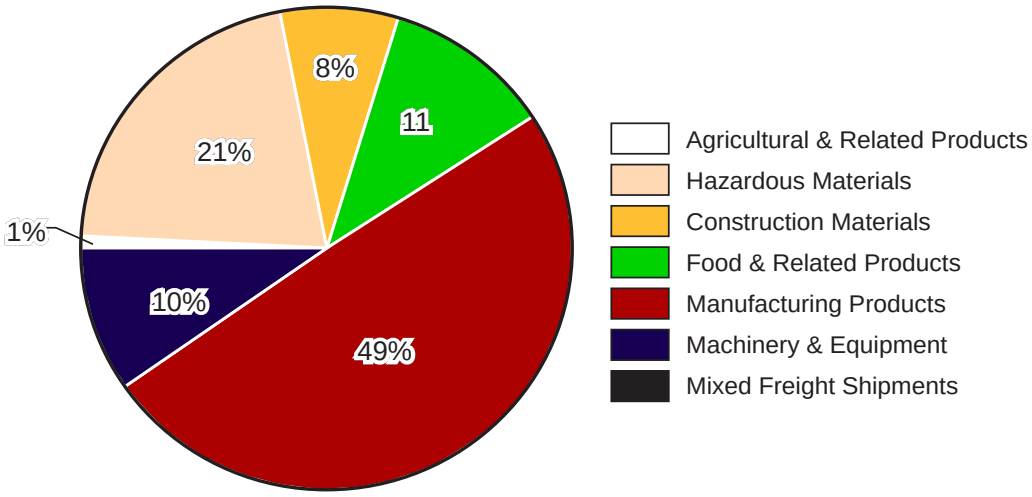
Table 3.3 Containers Originating at Barbours Cut Terminal

Destination	State	Responses	Percent
Baytown	TX	4	1.53
Beaumont	TX	3	1.15
Dallas	TX	27	10.34
El Paso	TX	13	4.98
Freeport	TX	3	1.15
Hidalgo	TX	4	1.53
Houston	TX	63	24.14
Houston (Broadway/B)	TX	7	2.68
Houston (Budweiser)	TX	3	1.15
Houston (Galena Park)	TX	4	1.53
Houston (McCarty)	TX	9	3.45
Houston (Wallisville)	TX	11	4.21
La Porte	TX	3	1.15
Laredo	TX	23	8.81
Orange	TX	12	4.60
Santa Fe	TX	11	4.21
Tyler	TX	5	1.92
Tulsa	OK	8	3.07
Louisiana	LA	5	1.92
Arkansas	AK	6	2.30
Other		37	14.18
Total		**261**	**100**

Source: URS report Barbours Cut Container Terminal Traffic County Program found in Draft Environmental Impact Statement for the Port of Houston Authority's Proposed Bayport Container/Cruise Terminal, 2001.

Approximately 37% of the 261 surveyed containers leaving the Barbours Cut Terminal were destined for Houston. Similar to the surveyed containers arriving at the Barbours Cut Terminal (see Table 3.2), Dallas was an important destination for containers originating at the Port of Houston. Also, approximately 7% of the containers originating at the Barbours Cut Terminal had an out-of-state destination.

The PIERS database contains information on vessels entering and leaving U.S. ports (see Appendix B for a description). The PIERS database captures information on international waterborne shipments entering or exiting U.S. ports based on manifest and weigh bill information (Cambridge Systematics, Inc., 1997, 1997). Some of the variables included in the database are: container number, commodity description, consignee name, consignee address, arrival date, Bill of Lading number, carrier name, port of discharge, weight, and harmonized commodity code. Data on containerized commodities were extracted from a complementary copy of the PIERS database (October to December 2000) provided to the research team by the Center for Ports and Waterways/TAMU Galveston.



Source: PIERS Database (October, November, and December 200)

Figure 3.5 Containerized Tonnage Arriving at the Port of Houston (October, November, and December 2000)

Figure 3.5 displays the percentage of containerized tonnage by commodity category arriving at the Port of Houston between October and December 2000. Manufactured products accounted for almost half (47%) of the total containerized tonnage, followed by hazardous materials (21%), and food and related products (11%). These three commodity groups represented approximately 80% of the total containerized tonnage. Agricultural and related products (1%) and construction materials (8%) together represented less than 10% of the total containerized tonnage.

3.4 Port Container Infrastructure

Bomba and Harrison (2000) identified the depth of the approach channel, the substantial land area required for container storage, and the cost of container cranes as three major cost components for container ports.

The depth of the approach channel is an important design aspect of any container port operation. Channel depth is important to all east coast U.S. ports since rivers drain from west to east and deposit alluvial material which must be regularly (and expensively) dredged. The majority of containerships calling at Gulf ports are Panamax class vessels that require a 40 feet navigable channel. Barbours Cut has such a channel, while the proposed ports at Bayport and Texas City have channel permits for 45 and 50 feet, respectively. A 50 feet channel provides access to the largest containership currently entering service, although only New York/New Jersey on the east coast has the container volume to justify a liner service with a ship of this size. Research for TxDOT suggests that when Gulf container volumes grow to a point that justifies this type of containership, it will call at either Freeport (Bahamas) or Panama City (Panama) and containers will be relayed on smaller ships to Gulf Coast ports.

Container ports also require substantial land area to house container cranes and to facilitate loading and unloading. There must also be adequate space to temporarily store containers after unloading them (Bomba and Harrison, 2000).

Container cranes are a costly investment for any container port. Cranes serving third-generation Post-Panamax ships cost between $5 and $8 million each (Bomba and Harrison, 2000). This section briefly summarizes the infrastructure available for container handling at Texas's ports.

Box 4: Container Moving Equipment

"*A number of different pieces of equipment are used to move containers about the storage and staging areas of a dock (before and after the containers are lifted from a ship). Commonly used pieces of equipment include a chassis system, straddle carriers, yard gantry cranes, forklift trucks, and container handlers…Chassis systems move containers from a port's staging area to its storage area. After lifting a container off a ship, cranes place the container on a trailer chassis (called the container chassis), which is hauled by a yard horse. A yard horse is basically a small, minimally equipped truck (e.g., small operator cab). After a container is placed on the chassis system, it can be hauled to its temporary storage location on the dock to be lifted and stored by another piece of container moving equipment, or it can simply be left on the chassis …"* (Bomba and Harrison, 2002)

3.4.1 Port of Houston

The Port of Houston's Barbours Cut Terminal is located on Morgan's Point on the northwest shore of Galveston Bay. The terminal has six 1,000 ft long container berths and a channel depth of 40 ft at mean low tide.

The terminal container storage area is approximately 250 acres with room for more than 23,400 grounded TEUs. There are also 532 reefer outlets and slots for more than 4,000 wheeled units.

The terminal has twelve container cranes, including six 40-ton and two 30-ton Portainers with an outreach range of 107-ft (outreach is measured from the edge of the wharf to the center of the load); two 50-ton Morris Post-Panamax shore cranes with an outreach of 127-ft; and two 50 ton IMPSA Post-Panamax cranes with a 127 ft outreach.

The terminal is served by many yard cranes, including six 30-ton Paceco cranes, two 30-ton Peiner cranes, four 40-ton Morris Cranes, eight 40-ton Bardellas cranes; and six 40-ton Noell cranes. Other cranes at the terminal, include five 30,000 lb top lifters for handling empty containers, a mobile crane with 82-ton capacity, and three 40-ton load handling machines.

Finally twenty-eight heavy-duty yard tractors and 100 heavy-duty yard chassis are available for rent. Special heavy-lift equipment is also available for rent from private firms.

The terminal has a computerized inventory control system, a nearby vehicle import processing system, a fireboat, and 24-hour security (www.portofhouston.com and Personal Communications with Port of Houston March 5, 2003).

Box 5: Planned Landside Access Projects

The Port of Houston has several project plans to improve land access at the port. These projects are aimed at improving access for both truck and cars by adding additional lanes, building direct connectors, and widening existing roads. Some of these projects are highlighted below:

- The addition of a second turn lane from the Highway 146 feeder to Barbours Cut Boulevard should ease congestion, idling, and emissions. At this time there is only a single turn lane onto Barbours Cut Boulevard from the State Highway 146 feeder road. This is a problem because most of the traffic exiting Highway 146 from the north and onto this feeder road is turning onto Barbours Cut Boulevard. This traffic causes major backups, which results in unnecessary idling and the associated emissions from thousands of idling vehicles daily. Construction is scheduled to begin in 2004 at an estimated cost of $1 million.
- Widening of Broadway into a four-lane roadway between Barbours Cut Boulevard and North "L" Street will increase safety and reduce bottlenecks. Currently Broadway is a two-lane road that is too narrow to handle the existing traffic. Construction is scheduled to begin in 2004 at an estimated cost of $2 million.
- The building of a direct connector between southbound State Highway 146 and EB Port Road will help reduce delays and waiting times for both cars and trucks at the intersection. Currently southbound traffic from State Highway 146 must yield to rail before proceeding east bound on Port Road. To accommodate the Bayport Facility's projected traffic volume the direct connector will have two lanes and be approximately 1,750 ft long. Construction is scheduled to begin in 2004 at an estimated cost of $7.9 million.
- The building of a direct connector from westbound Port Road turning onto northbound State Highway 146 will eliminate the need to wait for rail at the intersection. This direct connector will be one lane and approximately 80 ft long. The structure should significantly reduce delay and wait time for both cars and trucks at this intersection. Reducing waiting times should result in a decrease in air emissions and truck/car interactions. Construction is scheduled to begin in 2005 at an estimated cost of $3.1 million (Port of Houston: Port Access Projects, 2003).

3.4.2 Port Freeport

Port Freeport operates on 186 acres of developed land, with an additional 7,723 acres of undeveloped land available. The port has five operating berths and a channel depth of 45 ft. The port also has a 70 ft deep sinkhole, which would easily facilitate a mega-container ship. Port Freeport has a state-of-the-art Gottwald 280 Crane to handle containers. The at-hook lifting capacity of this crane is 110 tons. The Gottwald 280 Crane is mobile and has an automated 20 ft and 40-ft correcting spreader, which is used to handle various types of cargo including containers (www.portfreeport.com).

3.4.3 Port of Galveston

The East End Container Terminal is located at the Port of Galveston and leased by the Port of Houston. The terminal operates on 38 acres and has a minimum channel depth of 40 ft. The container terminal has two berths, three rail-mounted container wharf cranes, one rubber-tired gantry crane, thirty-one terminal tractors, nine port packers (container top-handlers), twenty-two yard trailers, fifty-six reefer plugs, and one 440 volt three-phase mobile generator (www.portofhouston.com).

3.5 Container Port Expansion Plans

All Texas's container ports are looking to expand to meet the expected increase in container demand. Barbours Cut Terminal is currently handling 1.2 million TEUs but is looking for various ways to manage and increase existing capacity.

The proposed Bayport Terminal and Texas City International Terminal (see below) are expected to handle as many or possibly exceed the number of TEUs currently handled at Barbours Cut Terminal. Combined the foreseen number of TEUs handled at these three terminals would be in the range of the Port of New York/New Jersey (3.6 million TEUs) (Containerization International Yearbook, 2001). In addition, even ports such as Corpus Christi that have not traditionally handled containers have plans to build container-handling facilities. Some of these container expansion plans are discussed in the sections below.

3.5.1 Barbours Cut Terminal

According to the Port of Houston Authority a lack of expansion space has made further development of Barbours Cut Terminal impossible. The Port has thus begun a $52 million project to improve traffic flow and terminal efficiency in an effort to increase capacity. The leased terminal at the Port of Galveston (described in Section 3.4.3) is considered a temporary solution (Hensel Jr., 2001).

3.5.2 Bayport Terminal

The Houston Port Authority recognized the need to increase its container capacity to prevent the loss of container business to other ports in Texas. The foreseen solution is to build a new container terminal – Bayport – at a cost of $1.2 billion (1998 dollars). The new development will be located 5 miles south of Barbours Cut Terminal on land owned by the Port Authority. The terminal already has an industrialized channel (Schaeffer, 2001). The Port Authority has applied for a development permit from the Army Corps of Engineers. The Corps is in the process of finalizing the Environmental Impact Statement (Draft Environmental Impact Statement, 2001).

3.5.3 Texas City International Terminal

Given increased container growth, Barbours Cut Terminal reaching capacity, and Bayport's environmental dispute with local residents, Texas City identified an opportunity to diversify commodities handled at the port. Traditionally the Port's been very dependent on the oil industry (www.abam.com/News/Texas_City.htm).

Texas City has proposed Shoal Point as a possible site for a container handling facility. Shoal Point, partially owned by Texas City, is a 1,000 acre island created by dredged soil 15 miles from the Gulf of Mexico and 40 miles southeast of downtown Houston (Hensel Jr., 2001).

A partnership between Stevedoring Services of America and Americana Ships was formed to explore the possibility of constructing a large container terminal. Although the Port of Houston has previously declared this site to be "unbuildable," Texas City believes that by using an aggressive wick drain system in combination with surcharge, the site would be ready to build within one year. Plans call for the facility to include 6,000 ft of marginal wharf, approximately 400 acres of yard, and 3.8 miles of industrial road to connect to the existing highway system at an estimated construction cost of $400 million. The location of the site has another important characteristic. It lies close to the Gulf of Mexico and Texas City has a permit to dredge to 50 ft which would enable it to serve the largest current containership in service – the so-called *mega-containership* (www.abam.com/News/Texas_City.htm).

3.5.4 La Quinta Trade Gateway

The Port of Corpus Christi plans to develop a containerized marine terminal, named the La Quinta Trade Gateway. It is believed that the La Quinta Trade Gateway would be competitive with other facilities like Houston-Galveston, New Orleans, Tampico-Altamira, and Veracruz. The Port forecasts container demand of between 220,000 and 660,000 TEUs by 2005, assuming a market penetration rate between 10% and 30% (Port of Corpus Christi, 2001). Hensel Jr. (2001) however forecasted a more conservative container throughput of 100,000 TEUs by 2005.

3.6 Concluding Remarks

The chapter examined the role of Texas's ports in facilitating the movement of containers in and through Texas. In 2001, the Port of Houston handled the majority of containers – 87% of the total containers shipped and landed at Texas ports. The chapter summarizes available information on container origins and destinations handled at Barbours Cut Terminal, available information on containerized commodity tonnages, and container infrastructure at Texas's ports. Combining the number of TEUs handled at the Port of Houston's Barbours Cut Terminal with the expected number of TEUs handled at the proposed Bayport Terminal and the proposed Texas City International Terminal, the resulting number of TEUs handled would place the container capacity of these three terminals in the range of the container capacity at the Port of New York/New Jersey (3.6 million TEU) (Containerization International, 2001). It will naturally be a number of years before the demand for such facilities will, however, materialize. An important consequence of adding two large container facilities along the southeastern edge of the Houston Ship Channel would be the resultant increase in container flows on a limited portion of the state transportation system. Since most of the current inter-city container movements to and from the Port of Houston are made by truck, TxDOT with its responsibility for highways should take notice. The subject of truck container movements in Texas is the subject of Chapter 4.

4. Truck Container Flows

4.1 Introduction

Trucks are a key element in the movement of containers, since they are almost always used for the first and last legs of a container trip. Conventional cost analysis suggests that truck trips become less competitive, when compared to rail, once trip distances exceed 500 to 600 miles in length. Some evidence, however, suggests that a number of U.S. container trips exceed this amount. According to the National Industrial Transportation League and the Intermodal Association of North America, intermodal shipping accounted for 15% of all truckload traffic moving 500 miles (800 km) or more in 1994 (Pennington, undated). However, as indicated in earlier sections of this report, the public availability of data on truck container movements in the U.S. is scarce, and even more so on truck container movements in Texas.

Three databases containing container data are available to provide some insight into container movements: Bureau of Transportation Statistics (BTS) Transborder Freight Database, BTS Container Border Crossing Database[1], and the Federal Highway Administration's Freight Analysis Framework State Commodity Flow Database (see Appendix B for a detailed review of available freight data sources). The Transborder Freight Database provides total and containerized tonnage, as well as total and containerized values, for freight moving from Mexico into the U.S. The Container Border Crossing Database (extracted from the U.S. Customs data) estimates the number of containers entering the U.S. from Mexico. For the truck mode the database captures the total number of trucks, the number of trucks with loaded containers, and the number of trucks with empty containers entering the U.S. from Mexico. In terms of the third database, the Federal Highway Administration has removed all data related to container movements on Texas's highways from the State Commodity Flow Database.

In addition, the research team learnt that the Reebie TRANSEARCH Freight Database applies conversion factors to estimated commodity tonnage data to obtain containerized tonnage data. Their "quick" conversion factor to estimate trucked containers is 15.8 tons per container (for railroads the conversion factor is 17.5 tons per container) (Personal Communication with Reebie Associates, 2003).

4.2 Benefits of Shipping by Truck

4.2.1 Trucking Rates

In 1992, a study on inland transportation of marine containers found that trucks were always the lowest-cost mode for movements up to 400 miles, and usually the lowest-cost

[1] BTS does not endorse the use of the data on numbers of loaded and empty containers for detailed analysis because each border entry point employs a different method to estimate the number of containers. Although the data are not standardized, they are the only such data available and provide a general indication of the number of containers crossing into the U.S. and more specifically into Texas across the Mexico-Texas border.

mode for movements between 400 and 700 miles (The Container Transportation Chain, 1992). Trucking rate information is considered proprietary, because it impacts competitiveness but can be estimated by either (a) aggregating trucking costs, or (b) collecting base rates through a survey. Base rates can be lowered in a number of ways, principally through the shipment of higher volumes. However, collected base rates can provide a basis for comparative analysis to derive differentials between alternative modal services.

Truck and rail rates charged for a container movement between Houston and El Paso – separated by approximately 740 miles – were obtained through Web and phone inquires, and although not representative, they provide a perspective on different rates charged. As seen in Table 4.1, the Rail Carrier A rate is significantly lower than the truck rates and the Rail Carrier B rates for both the 20 ft and 40 ft containers. The rail representative interviewed pointed out that these are "ramp-to-ramp" rail rates. It is necessary to add two additional charges – local drayage and equipment per diem when comparing these rates with truck rates. Local drayage is the transport of the container from its origin to the rail terminal, or from the rail terminal to its final destination. According to the rail representative the average cost of local drayage (within the city) would be between $100 and $125. The equipment per diem is charged as long as the container is not in the possession of the railroad. According to the rail representative this charge is usually incurred for 4 days: $15 per day – 2 days at the origin side and 2 days at the destination side. The objective of this fee is to deter companies from using the container as storage (Web Inquiries and Personal Communications, February 2003).

Table 4.1 Truck/Rail Rates: Houston to El Paso

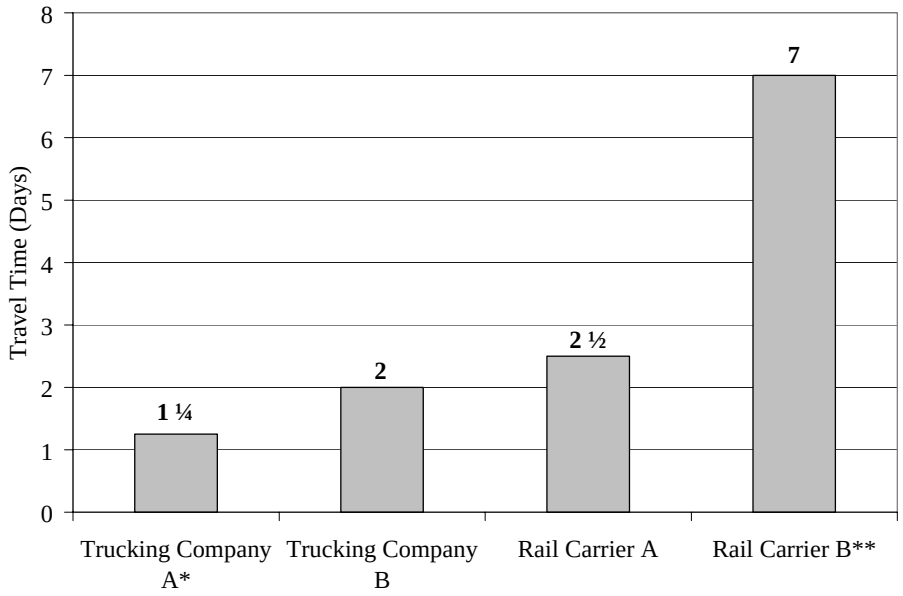
	Container Size	Ramp-to Ramp Rate	Drayage + Per Diem	Total Cost
Trucking Company A*	20ft	$1,066		$1,066
	40ft	$1,066		$1,066
Trucking Company B**	20ft	$2,200		$2,200
	40ft	$2,200		$2,200
Rail Carrier A	20ft	$659	$310	$969
	40ft	$775	$310	$1,085
Rail Carrier B	20ft	$962	$310	$1,272
	40ft	$995	$310	$1,305

* These containers would have to be reloaded into a 48 ft or 53 ft dry van.
** This rate includes a mandatory backhaul.
Source: Web Inquires and Personal Communications, February 2003

When local drayage and the equipment per diem charges are included in the rail carriers' ramp-to-ramp rate (the total cost), Trucking Company A's rates are lower than that of Rail Carrier A for a 40 foot container, and lower than Rail Carrier B's for both the 20 ft and 40 ft containers.

4.2.2 Travel Time

Trucks generally provide a faster door-to-door travel time compared to rail. Truck and rail travel times between Houston and El Paso were also obtained through Web and phone inquires. As seen in Figure 4.1, both trucking companies were able to move containers faster to El Paso than both rail carriers. Similar to the rail rates the rail travel times are only "ramp-to-ramp" times and thus additional time must be added for local drayage (Web Inquiries and Personal Communications, February 2003).



* These containers would have to be reloaded into a 48 ft or 53 ft dry container.

** In the case of this rail carrier, a direct service is not provided between Houston and El Paso. A container traveling from Houston will be moved out-of-state and transferred to another train destined for El Paso.

Source: Web Inquires and Personal Communications, February 17-21, 2003

Figure 4.1 Travel Times: Houston to El Paso

4.2.3 Quality of Service

Anderson Consulting and the University of Pretoria found that for all modes of transport the most important quality of service factors were (in order of importance):

- on-time delivery,
- reliability,
- damage-free delivery,
- ability to expedite, and
- flexibility in scheduling.

The trucking mode traditionally has been able to provide a superior service compared to rail in terms of these requirements. In recent years however, Class 1 rail companies have started to guarantee more competitive delivery times (see Chapter 5), perhaps reflecting growing relationships with the trucking industry. It, however, remains difficult for the railroads to compete with trucking companies in terms of flexibility, and ability to expedite shipments (Pretorius and Sallie, 1994).

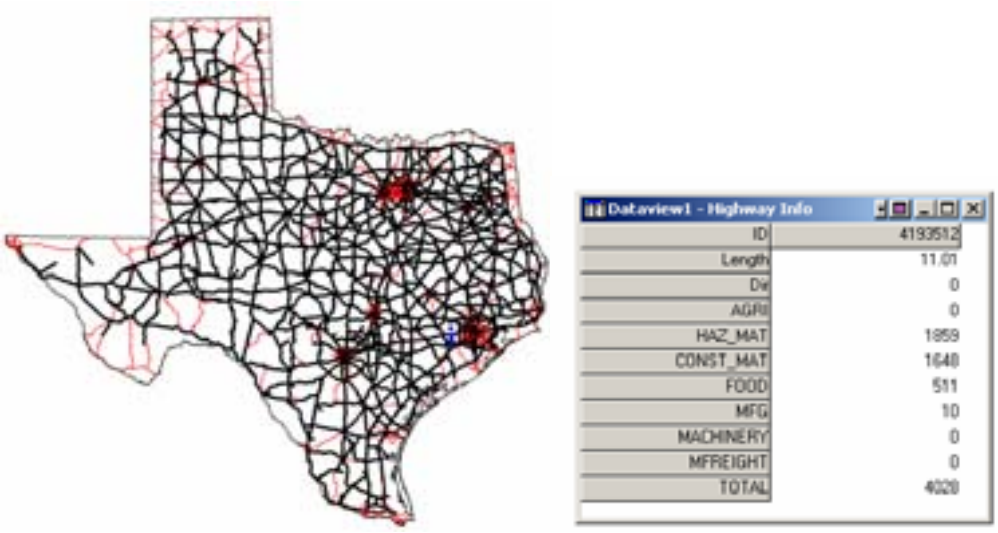
4.3 Containerized Truck Flows

Currently there is no public database for truck container movements similar to the Rail Waybill Sample. Accordingly, the 1996 Reebie TRANSEARCH Freight Database was used to estimate container movements on the Texas network. This database contains information on road and rail tonnages by commodity for: (a) Texas county-to-county movements, (b) movements with either an origin or destination in Texas destined for or originating out-of-state, and (c) through Texas movements. Commodities are classified at the two-digit Standard Transportation Commodity Code (STCC). The research team aggregated these commodities into seven groups (see Appendix F for more details):

- agricultural and related products,
- hazardous materials,
- construction materials,
- food and related products,
- manufacturing products,
- machinery and equipment, and
- mixed freight shipments.

To estimate truck and rail container tonnages, a conversion factor was developed based on the percentage of containerized tonnage[2] captured in the BTS Transborder Surface Freight Database (see Appendix B for a description of the database). This factor was applied to the 1996 Reebie TRANSEARCH Freight Database to convert the commodity tonnages to container-commodity tonnages moved by road and rail. The next step was to convert the container commodity tonnages to container flows. Rail tonnage moved in containers was converted to number of containers, using a conversion factor developed using the Rail Waybill Sample (see Appendix G). Unfortunately, there is no database similar to the Rail Waybill Sample for truck movements that could be used to estimate a similar conversion factor for truck container flows. The tonnage moved in containers by truck was converted to numbers of containers, using the conversion factor of 15.8 tons provided by Reebie Associates (see Appendix G). These container flows were then assigned to the Texas network using an all-or-nothing traffic assignment distribution (see Figure 4.2).

[2] This conversion factor was calculated by dividing the containerized commodity tonnage by the total commodity tonnage, both captured in the Transborder Surface Freight Database.



Source: Reebie TRANSEARCH Freight Database, 1996

Figure 4.2 Estimated Truck Container Flows Based on Reebie TRANSEARCH Freight Database

The trucking companies interviewed were asked which types of roadway they use: interstates, major highways, local roads, or county roads. All but one respondent said that they mostly use the interstate system. The one exception said that when the average container delivery was within 100 miles of an intermodal rail terminal, most of those 100 miles were driven on the major highways. And when containers are collected from, or taken to intermodal rail yards, most of the trip is over local or county roads.[3]

4.3.2 Port Truck Container Flows To/From Port of Houston

A 1986 study on inland transportation of marine containers found that "*motor carriers transport the vast majority of containers for distances up to 500 miles from the port facilities*" and that "*even for movements of greater distances motor carriers compete vigorously with railroads for many inland container shipments (particularly those moving to and from East Coast ports).*" The study analyzed the movement of inbound and outbound containers handled by Sea-Land in 1984 at Port Elizabeth, New Jersey. It was found that 72% of the inbound containers terminated within 100 miles, and 82% within 400

[3] The Texas Road Network consists of:

- 3,234 miles of interstate roadways, representing 6.97% of the total US interstate system (www.fhwa.dot.gov/ohim/hbs/tx.htm),
- 15,034 miles of National Highway System, which is 13.15% of the total National Highway System in the U.S. (www.fhwa.dot.gov/ohim/hbs/tx.htm),
- 40,991 miles farm-to-market roads (TxDOT pocket guide),
- 6,526 miles of frontage roads (TxDOT pocket guide),
- 78,671 miles of city streets,
- 142,357 miles of county streets,
- 142 miles of toll roads, and
- 610 miles of off-county roads.

miles. In the case of the outbound containers 74% terminated within 100 miles and 90% within 400 miles. These findings were supported by the Port Authority of New York and New Jersey, who estimated that about 80% of all container traffic originated or terminated within 150 miles of the port (The Container Transportation Chain, 1992).

In addition, the study analyzed a randomly selected sample of 5,000 inbound and outbound containers handled by Sea-Land in the first half of 1986 at Port Elizabeth, New Jersey. The analysis revealed that: 86% of the containers originated or terminated within 400 miles of the port, all transported by truck; 8% traveled between 400 and 700 miles, of which 90% were transported by truck; and the final 6% moved more than 700 miles, of which only 6% were carried by truck (The Container Transportation Chain, 1992).

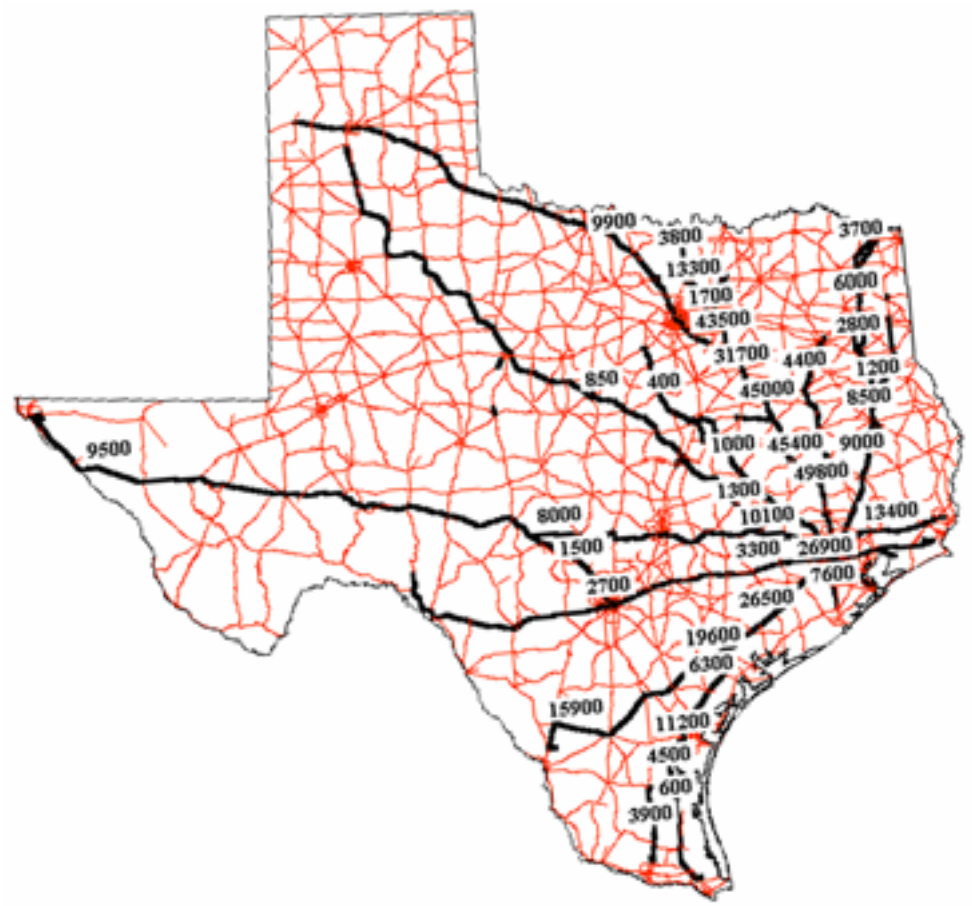
During the stakeholder interviews, the trucking companies' were asked if a substantial share of their container movements had either an origin or a destination at a port. All twelve companies reported that a substantial share of their container movements had either an origin or a destination at a port. Six of the twelve trucking companies moved containers within the Texas Triangle.[4] The other six reported that they operated throughout the U.S. (4), Latin and South America (1), and mostly in Texas (1).

A representative at Barbours Cut Terminal provided information on the number of containers transported by truck in 2000 – based on gate interchange information at the port. The number of gate interchanges (322,244) provides an estimate of the total number of containers moved in and out of the terminal. The representative advised the authors to assume that half of the containers were inbound and half were outbound. There are seasonal variations in the inbound and outbound movement of containers, but the representative felt that on average the annual inbound and outbound movements are balanced (Personal Commutation with the Port of Houston, 2003).

An origin/destination matrix (O/D matrix) was created using the number of gate interchanges and the container O/D information obtained from the URS study, referenced in Chapter 3 (see Appendix H). The O/D matrix was converted into an input table in the GIS platform (discussed in Chapter 6).

The GIS platform (TransCAD) was used to visually display container flows from the Port of Houston on the Texas Network. The result is illustrated in Figure 4.3.

[4] The Texas Triangle is made up of Houston, Dallas, and San Antonio. Three interstates I-10, I-35, and I-45 are the boundaries of the triangle. The Texas Triangle accounts for over 70% of the state GDP.



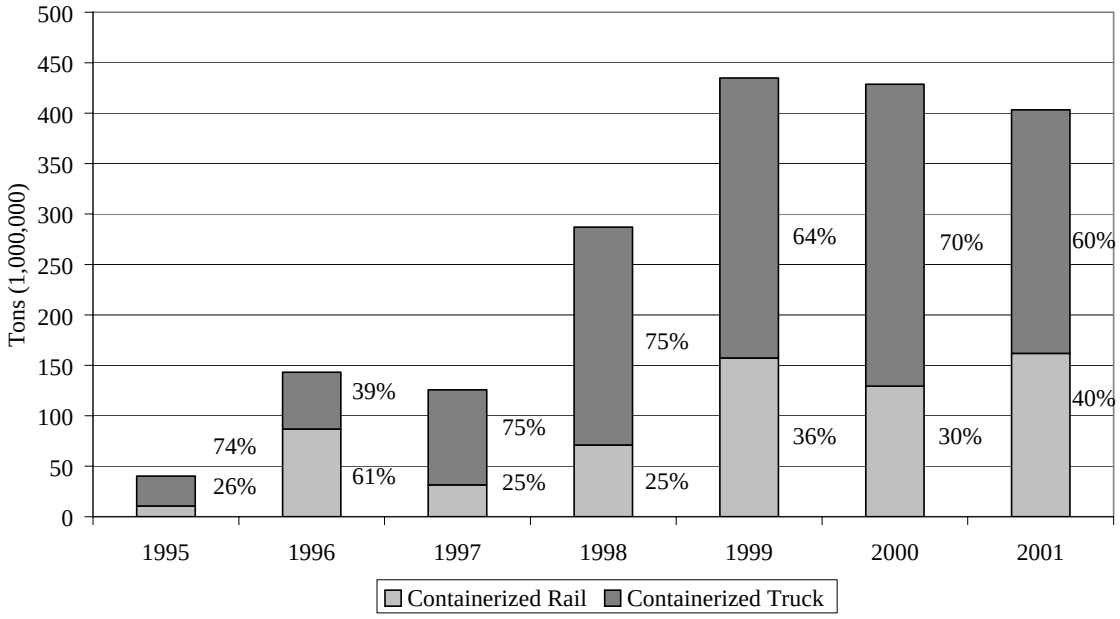
Source: URS survey, 2000 and Personal Communication, Port of Houston, 2003

Figure 4.3 Estimated Container Flows to/from Barbours Cut Terminal (2000)

4.3.3 Truck Container Flows Crossing: Texas - Mexico Border

The BTS Transborder Freight Database has twelve different tables, of which two contain information on containers: Table 9 – Imports from Mexico with Commodity and Selected Geographic Detail, and Table 11 – Imports from Mexico with Geographic Detail. Using Table 9, commodity, tonnage, and value of containerized freight by mode could be determined for containerized imports from Mexico. Using Table 11, border port of entry, tonnage, and value of containerized freight but no commodity information could be obtained.

The BTS Transborder Freight Database was used to derive container tonnage and value (for imports) crossing the Texas-Mexico Border. The analyses revealed that most of the container tonnage entering the U.S. from Mexico crosses the Texas-Mexico border – approximately 70% of the truck container tonnage and 80% of the rail container tonnage.



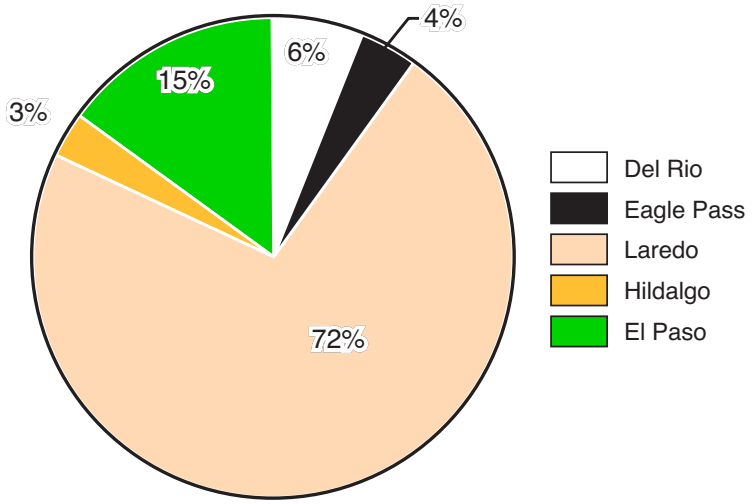
Source: Transborder Surface Freight Data

Figure 4.4 Containerized Tonnage Crossing the Texas-Mexico Border (Northbound Movements)

Figure 4.4 summarizes the modal split for northbound containerized tonnage crossing the Texas-Mexico border. It is clear from this figure that truck transport dominates rail in the movement of containerized imports. This is true for all years except 1996 when rail transported more containerized tonnage than truck.

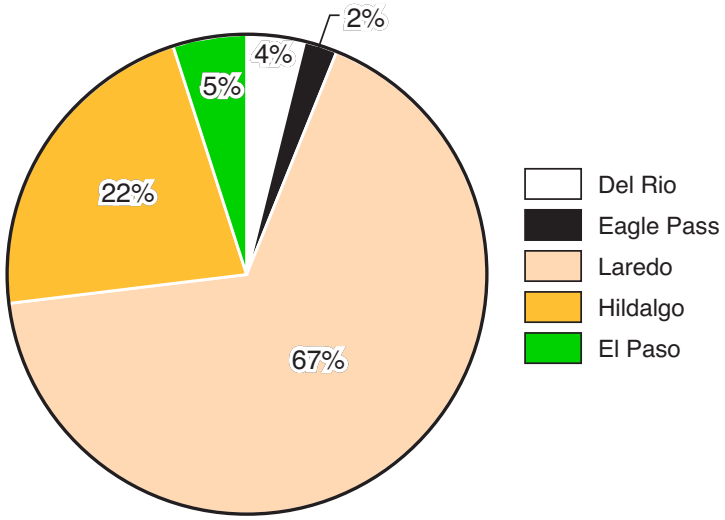
Between 1995 and 2001, trucks transported on average 173 million containerized tons per year or 65% of the total containerized tonnage. During the same time period, rail transported on average 93 million containerized tons per year or 35% of the total containerized tonnage. It should be remembered, however, that some containers loaded close to the border – in Nuevo Laredo, for example – might be trucked across the border to Union Pacific's intermodal terminal 12 miles north on IH-35 for onward movement through Texas. Not all containers trucked across the border thus end up on the Texas's Highway system.

The Transborder Database contains only information on the number of containers entering into the U.S. through the Texas border entry points of Brownsville, Del Rio, Eagle Pass, Laredo, Hildago, Rio Grande City, Progresso, Roma, El Paso, Presidio, and Fabens. Of these, five border points of entry reported significant container movements: Laredo, Del Rio, Eagle Pass, Hildago, and El Paso.



Source: Transborder Surface Freight Data

Figure 4.5 Containerized Value Crossing the Mexico-Texas Border (2001)



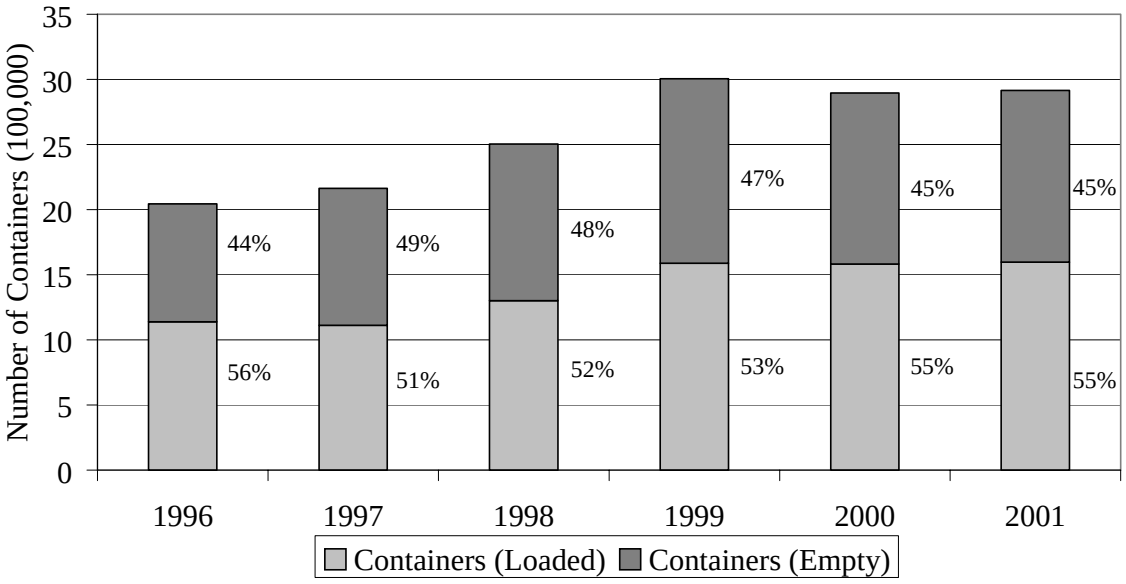
Source: Transborder Surface Freight Data

Figure 4.6 Containerized Tonnage Crossing the Mexico-Texas Border (2001)

As is evident from Figures 4.5 and 4.6, most of the containerized tonnage (67%) and value (72%) entering Texas from Mexico passes through Laredo. Mexico's principal highways, toll roads and railroad lines to Monterrey connect to I-35 and two major U.S. railroad lines at Laredo, making it an important gateway for U.S.-Mexico trade.

Interestingly, the commodities crossing Hildago appear to be relatively low in value, but high in weight. Commodities crossing El Paso, on the other hand, appear to be relatively low in tonnage, but high in value. This is consistent with the variation in assembly or *maquiladora* industries along the border. El Paso, for example, is a well-known gateway for automotive electronic components produced in Juarez.

The Container Border Crossing Database contains estimates of the number of loaded and empty containers entering the U.S. from Mexico (see Figure 4.7). Some concerns have been expressed about the accuracy of these counts when comparing the number of container crossings among border ports of entry, because different methods were used by each port to estimate the number of containers. Assuming that these methods were, however, consistently used between 1996 and 2001, the data provide valuable insights into changes in the numbers of container crossings between 1996 and 2001.



Source: Container Crossing US-Mexico Border Data

Figure 4.7 Container Crossing Data Texas-Mexico Border

From Figure 4.7, it can be shown that the total number of containers crossing the Texas-Mexico border has increased by 45% between 1996 and 2001. It is also evident that the number of empty container crossings as a percentage of total container crossings has been decreasing since 1997.

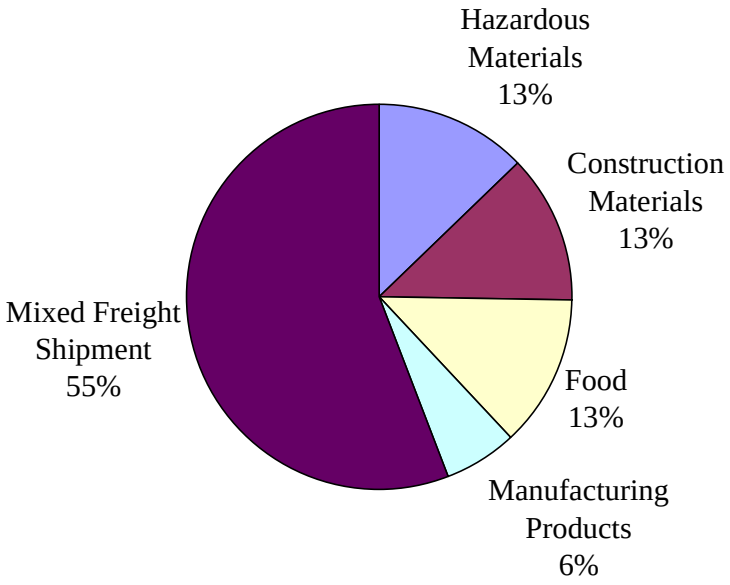
4.3.4 Truck Container Flows Generated at Intermodal Facilities

During the stakeholder interviews, the trucking companies were asked if a substantial share of their container movements had either an origin or a destination at a rail intermodal yard. Ten of the twelve trucking companies indicated that a substantial share of containers had either an origin or a destination at a rail intermodal yard. One of the companies said all their containers are destined for a rail intermodal yard. One of the largest intermodal facilities in Texas is at Alliance, north of Fort Worth. Alliance is a 9,600-acre inland port development with an industrial airport, two rail lines, an intermodal center, and access to an extensive highway system including IH-35W. The intermodal facility is privately operated but owned by Burlington Northern Santa Fe. It is the fifth largest facility in their

system performing approximately 460,000 lifts per year (Alliance Intermodal Facility Fact Sheet). Container traffic generated at these facilities is discussed in detail in Chapter 5.

4.4 Containerized Commodities

The Reebie TRANSEARCH Freight Database contains commodity information. The procedure to estimate container commodity flows from the Reebie TRANSEARCH Freight Database was discussed in Section 4.3. The results are displayed in Figure 4.8.

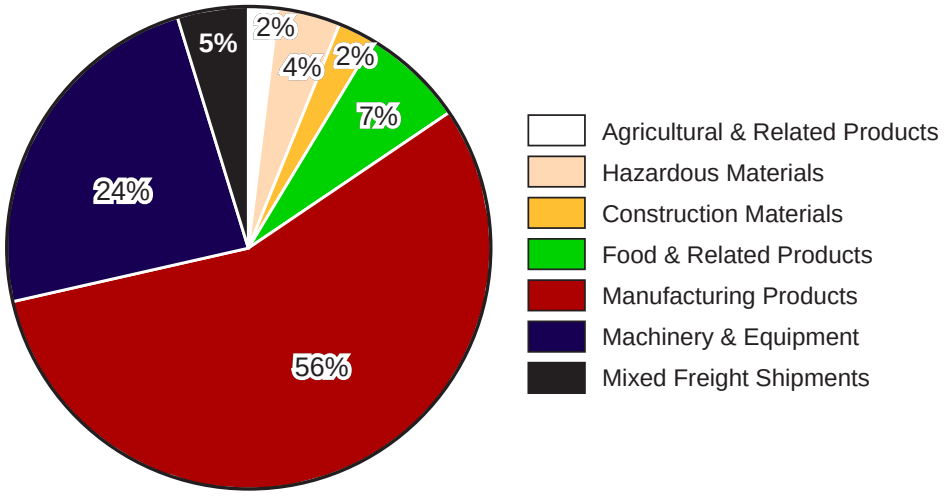


Source: Reebie TRANSEARCH Freight Database (1996)

Figure 4.8 Estimated Number of Containers

As is evident from Figure 4.8, in terms of number of containers, mixed freight shipment represents a significant share (55%) of the containers on the Texas road network. Hazardous materials (13%), construction materials (13%), and food and related products (13%), together represent 39% of the containers on the Texas road network. Manufactured products represent 6% of the number of containers. Empty containers are also being moved – as part of global and regional repositioning – on the state's highway system. It is likely, however, that trip distances are not significant as Schneider Logistics indicated that empty containers are moved by rail whenever possible.

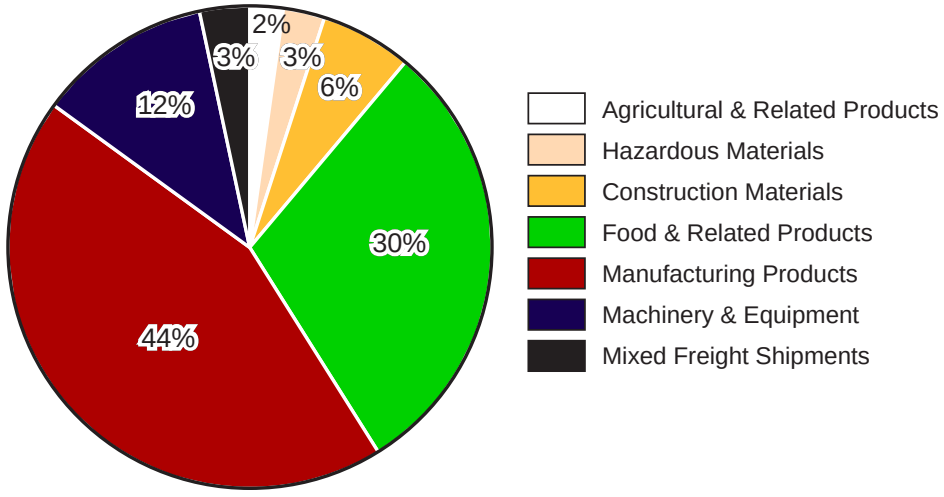
As discussed in Section 4.3.3, the Transborder Surface Freight Database (Table 9) contains information on containerized commodities (tonnage and value) for imports from Mexico into the U.S. Commodity information is available in terms of the Harmonized Tariff Schedule of the U.S. at the two-digit level. The commodity information was aggregated into seven categories (see Appendix F).



Source: Transborder Surface Freight Database

Figure 4.9 Containerized Value Crossing the Mexico-U.S. Border (2001)

In terms of value, containerized manufactured products represent a significant share (56%) of containerized imports crossing the Mexico-U.S. border. In addition, machinery and equipment represent 24% of the containerized value crossing the border. Manufactured products and machinery and equipment represent 80% of the containerized value crossing the border. On the other hand, agricultural and related products, and construction materials account for a small percentage (2%) of containerized imports (see Figure 4.9).



Source: Transborder Database

Figure 4.10 Containerized Tonnage Crossing the Mexico – U.S. Border (2001)

In terms of containerized tonnage, containerized manufactured products represent 44% of containerized imports crossing the Mexico-U.S. border. Food and related products

accounted for 30% of the containerized tonnage crossing the border in 2001. Manufactured products and food and related products represent 74% of the containerized tonnage crossing the border. Agricultural and related products and hazardous materials account for a small percentage of containerized import tonnage (see Figure 4.10).

4.5 Concluding Remarks

Although there is little publicly available data on the movement of containers by truck in Texas, this chapter summarized and estimated containerized truck flows and commodities in Texas from available data, including data received from the Port of Houston, extracted from the BTS databases, and from the 1996 Reebie TRANSEARCH Freight Database purchased by TxDOT.

The chapter also highlighted the benefits of moving containers by truck in terms of total cost and time. Although rail rates between Houston and El Paso were significantly lower than truck rates, when local drayage and equipment per diem were included the total cost was greater. This is in accordance with rates quoted by a representative of BNSF at the 2003 TRB annual meeting where he claimed that the differential in favor of trucks was around $80 per trip between Houston and Dallas-Fort Worth. Also, the study showed that within Texas, trucks provided a faster service compared to rail. Conversion factors calculated from the TransBorder Surface Freight Database were applied to the 1996 Reebie TRANSEARCH Freight Database to estimate truck container tonnage, number of containers, and containerized commodities. Additional data were used to examine truck container flows to and from the Port of Houston and container flows, commodities, and tonnages crossing the Texas-Mexico border ports of entry. Rail provides a crucial contribution to moving containers through the nation and provides a potential alternative to trucking within Texas. This is addressed in Chapter 5.

5. Rail Container Flows

5.1 Introduction

Movement of containers by rail is an important method of providing for long-distance freight transportation in and through the state of Texas. Due to Texas's key geographic location on both international and transcontinental trade routes, a large portion of the nation's freight traffic, moving by either rail or truck, passes through or terminates within its borders. In the year 2000, intermodal trains were responsible for transporting 199 million tons over 421 billion ton-miles at the national level – the equivalent of 16.2 billion truck vehicle miles traveled (AASHTO, 2002). As freight demand grows to almost twice what it is now over the next 20 years, the use of containerized freight movement by rail will also continue to increase to meet this demand. Without container movement by rail, highway congestion and maintenance costs will escalate as even more freight moves by truck.

Intermodal container movement has been one of the fastest growing business sectors within the railroad industry over the past several years. A recent report conducted for the Association of American Railroads projected that rail intermodal movement, which includes Trailer on Flat Car (TOFC), Container on Flat Car (COFC), and Double Stack COFC train types will likely overtake coal transport as the largest revenue source for any single type of rail movement at some point during the 2003 calendar year (Dupin, 2002). Much of this gain has occurred as a result of improvements over the last 20 years in both rail infrastructure and specialized rolling stock. These changes support intermodal innovations such as allowing double-stack container trains to operate throughout the state, often moving hundreds of containers simultaneously as part of a single train.

5.2 Benefits of Shipping by Rail

5.2.1 Highway User Benefits: Reduced Congestion and Maintenance Cost Reduction

Container movement by rail has many potential public benefits over truck movement. One of the most often cited benefits is the role that rail can play in taking large numbers of trucks off the highway, thereby reducing highway congestion in urban areas and along high traffic-density trade corridors. By moving long-distance freight from the highway to rail rights-of-way, more existing highway capacity is left for use for personal travel in automobiles and light trucks and for local delivery of goods. While not every freight commodity is conducive to being shipped by container, those that are can often be transported for most of their total movement by rail just as efficiently as by truck. This can have enormous financial, traffic safety, social, and environmental benefits. On average, one double-stack container train can move the equivalent of 280 trucks, thereby increasing highway capacity by approximately 1,100 automobiles (Association of American Railroads, 2003). In fact, other train types carrying non-intermodal cargo are capable of removing as many as 500 trucks per train (Association of American Railroads, 2003).

While relieving congestion, such a reduction in the numbers of trucks using the highway system could also greatly reduce the costs of long-term highway maintenance. The expenses associated with truck damage to highway infrastructure are staggering. The current maximum weight allowed for trucks on Texas highways, without a special permit, is 80,000 pounds. Previous research in this area has shown that the impact of one truck loaded to this weight does the same amount of damage to the underlying roadway structure as approximately 9,600 automobiles (Wilson, 1998). As shown in Table 5.1, the marginal costs associated with each mile of truck travel at this weight, when all costs are accounted for, are approximately 19.9¢ per mile per truck in rural areas and approximately 69.6¢ per mile per truck in urban areas.

Table 5.1 Marginal Costs of 80 kip 5-Axle Truck Traffic on Highways

Cost Category	Marginal Costs (2000 $)	
	Rural Trucking ($/mile)	Urban Trucking ($/mile)
Congestion	0.0223	0.2006
Collision	0.0088	0.0115
Pollution	0.0385	0.0449
Noise	0.0019	0.0304
Pavement	0.1270	0.4090

Source: FHWA, Addendum to the 1997 Federal Highway Cost Allocation Study Final Report, 2000.

Although few individual container trucks approach this 80,000 lb weight limit, the damage inflicted by repetitive truck loadings at lower weights can rapidly accumulate—continuously generating pavement, environmental, and social costs.

Costs to the public sector in the road maintenance, congestion, and collision categories can be reduced or avoided by using rail to transport containerized freight. The ability to handle multiple containers on each rail car and to move many such railcars using the locomotive power of one train magnifies this rail benefit. By developing policies that encourage rail transport, the public sector is also implicitly fostering needed reinvestment by the railroad companies into improving the performance and capabilities of the rail system. Public dollars that would have been spent on roadway reconstruction and rehabilitation may be put to work elsewhere.

5.2.2 Energy and Environmental

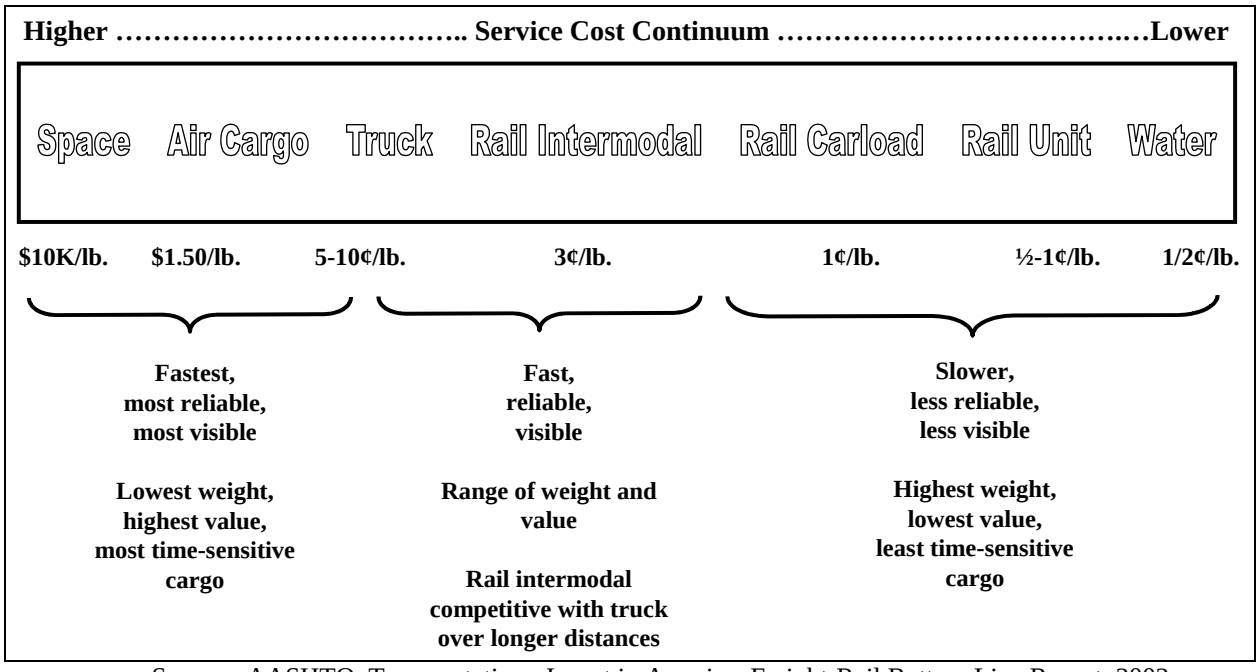
In addition to its highway preservation benefits, rail transportation has several energy use and environmental advantages over highway transportation. According to the numbers from the Association of American Railroads (AAR), freight railroads increased fuel efficiency 72 percent from 1980 to 2002 and are now at least three time more fuel efficient than trucks. As a result of such fuel efficiency, shifting even a small percentage of highway freight to rail could potentially save the nation millions of gallons of fuel each year (Association of American Railroads, 2003).

Movement of containers by rail transportation also has the advantage of being more environmentally friendly than movement by truck. The Environmental Protection Agency

(EPA) reports on transportation-related pollution that only 9% of NOx emissions and 4% of particulate emissions are attributed to rail transportation, even though rail moves over 40% of the intercity freight on a ton-mile basis (Association of American Railroads, 2003). The intermodal percentage of this freight reduces emissions by consolidating large numbers of trucks into single train movements with a net reduction in overall emissions.

5.2.3 Reduced Shipper Cost

Intermodal rail movement fills an important niche in the freight transportation industry by providing a cost-effective alternative to long-distance trucking while providing many of the same benefits since trucks often are responsible for delivery at each end. Intermodal rail also tends to carry the more valuable commodities within the rail transport segment as shown in Figure 5.1.



Source: AASHTO, Transportation: Invest in America, Freight-Rail Bottom Line Report, 2002.

Figure 5.1 Freight Transportation Service Spectrum

5.3 Deficiencies of Intermodal Shipping by Rail

5.3.1 Lack of Door-to-Door Delivery

The intermodal rail system represents a fixed network of rail lines traveling between major intermodal facilities, thus providing a service that rarely connects the origin or destination locations. Direct connections to port terminals are an exception, but the vast majority of intermodal movements by rail require the use of truck to handle the movement from the origin and to the destination with rail handling the middle, long-haul component.

Several factors contribute to the current situation, including the concentration of intermodal activities at fewer, larger facilities. This allows the railroads to focus their resources and improve efficiency at fewer locations and on fewer connecting lanes. Also contributing is the development of the highway system. Industrial areas have increasingly developed along the highway system, and not necessarily along the rail network, to provide better access for truck shipments.

5.3.2 Service Levels

The two major concerns for shippers are reliability and transit time. Railroad operations have historically lagged behind trucks in both these categories, including intermodal operations. Today, intermodal represents one of the fastest growing markets for the railroads, and has prompted the railroads to find ways of providing truck-competitive intermodal service. Working closely together by providing seamless interchanges, the railroads have begun providing guaranteed "on-time" intermodal services. These money-back guarantees have resulted in higher service levels that have significantly reduced transcontinental transit times. A list of some of these services that include Texas markets appears later in this chapter.

5.3.3 Capacity and Capital Investment Concerns

Between 1980 and 1999, rail intermodal ton-miles grew 98%, and it is expected that international container trade will double over the next decade (Phillips, 2001). These numbers indicate significant intermodal activity by the railroads but also raise concerns over the rail system's ability to handle the increased traffic levels. This concern also translates to an already congested highway network.

Concerns over the ability to handle increased intermodal levels exist in both the intermodal facilities and rail network. Many rail terminals exist within densely developed city centers, where little room exists for expansion. These intermodal facilities, often coexisting with other yard activities, have short intermodal tracks that require a train to be broken over several lines and limited space for truck and chassis parking and storage. Newer intermodal facilities have more room for intermodal activities but may be located outside the urban area, further from industrial developments. The number and lengths of sidings, level of signaling, and overpass clearance heights regulate the types and sizes of intermodal trains traveling across the rail network.

5.4 Overview of the Texas Rail System

Texas has one of the most extensive freight rail networks in the U.S. Texas consistently ranked in the top five states for the rail industry in many categories. For example, Texas ranks first in total length of track, second in the number of railroad companies, and first in railroad employment (Association of American Railroads, 2003). In 2000, the AAR listed 44 railroads operating in Texas with a total of 10,749 miles of track over which a single railroad operates. When the additional 3,257 miles over which more than one railroad operates through a trackage right agreement is added, railroad companies provide a total of 14,006 miles of rail service in the state.

The federal Surface Transportation Board (STB) classifies railroad companies into three categories according to their gross annual operating revenues. The earnings limits for

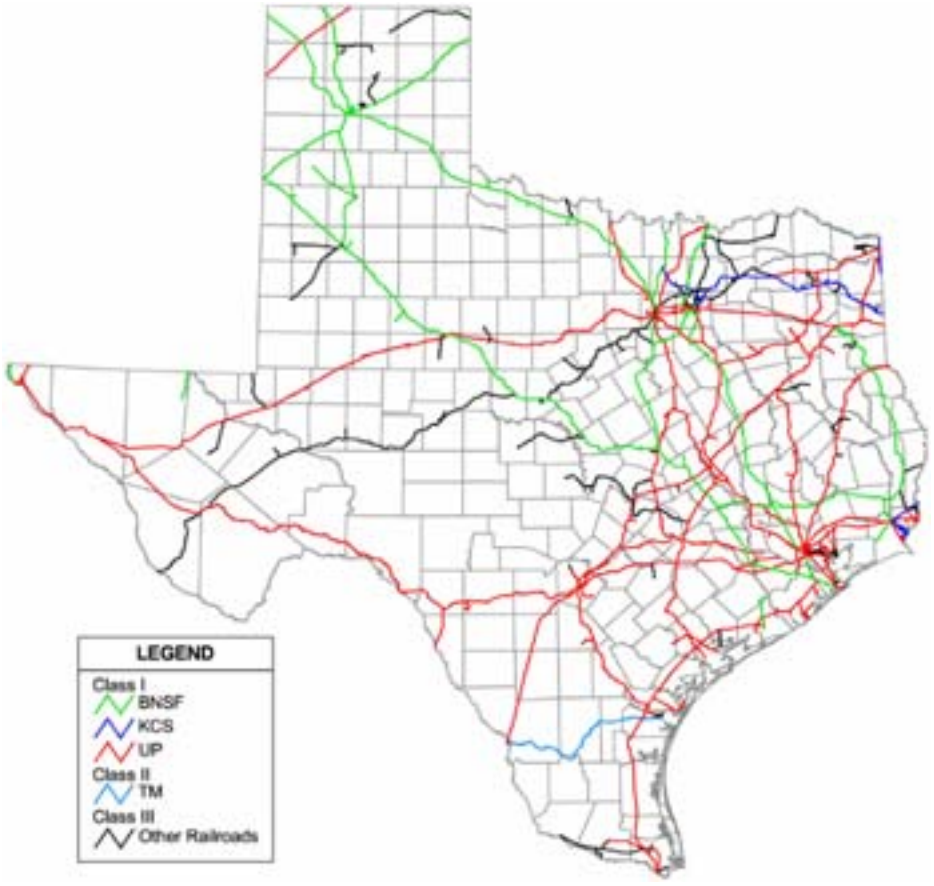
each class were set in 1991 and are adjusted annually for inflation. The limits below list the 1991 base limits with the year 2000 (i.e. adjusted for inflation) limits in parentheses.

Class I —gross annual operating revenues of $250 million or more ($256.4 million),

Class II—gross annual operating revenues between $20 million and $250 million ($20.5 million and $256.4 million), and

Class III—gross annual operating revenues of less than $20 million ($20.5 million).

Generally, under STB classification, Class II carriers are referred to as regional railroads and Class III carriers are called shortlines. Figure 5.2 displays the railroads operating in Texas.



Source: Texas Transportation Institute

Figure 5.2 Texas State Rail Network

Texas is currently served by three Class I railroad companies—the Union Pacific Railroad (UP), the Burlington Northern Santa Fe (BNSF), and the Kansas City Southern Railway (KCS). The only Class II railroad in the state at this time is the Texas Mexican Railway (TM), which owns the line between Laredo and Corpus Christi and operates via trackage rights between Corpus Christi and Beaumont. The remainder of the state's railroad companies is categorized as Class III railroads. Table 5.2 summarizes the number of freight railroads and the miles operated, including trackage rights, in terms of the different railroad classifications in Texas.

Table 5.2 Freight Railroads Operating in Texas (2000)

Railroad Classification	Number of Freight Railroads	Miles Operated (Including Trackage Rights)
Class I	3	11,377
Class II	1	544
Class III	40	2,085
Totals	**44**	**14,006**

Source: Railroad Statistics by State, Freight Railroads Operating in Texas, 2000, www.aar.org.

As shown graphically in Figure 5.2 and numerically in Table 5.2, the major Class I railroads operate the majority of the track mileage in the state. The smaller Class III operators, however, outnumber the Class I railroads. The Class II and III railroads, often referred to as shortlines, are generally short haul, providing linkages between two Class I carriers or between a Class I railroad and local customers. Shortlines serve this function in the intermodal system. For example, a Class III or switching railroad may move a container from a rural industrial park to the nearest Class I interchange point for transloading and movement across the state via rail.

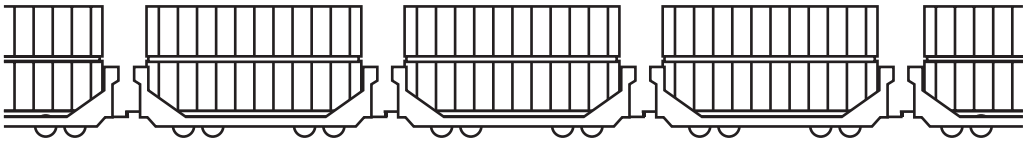
5.5 Rail Intermodal Services

5.5.1 Rail Intermodal Equipment

The majority of intermodal movements by rail consist of either TOFC or COFC services. TOFC generally refers to the movement of highway trailers and containers mounted on chassis on rail flatcars. The movement of intermodal containers on rail flatcars represents the COFC service. The implementation of specially designed railcars to handle stacked containers refers to double-stack COFC services. These specially developed railcars, which have the platform depressed below the top of the wheels, typically consist of five-car units, often with shared bogies between each interior car. Figure 5.3 demonstrates these rail intermodal technologies.

Trailers on Flatcar (TOFC)

Containers on Flatcar (COFC)



Double-stack Units (each five cars long — holding 10 containers)

Source: U.S. DOT, The Comprehensive Truck Size and Weight Study Final Report, Vol. 2 Chap. 4, p. IV-35, 2000.

Figure 5.3 Types of Rail Intermodal Equipment

As previously stated, intermodal is the fastest growing market for the railroads and is highly competitive. To become more competitive with trucks, the major railroads operating in Canada, the U.S., and Mexico are working to improve services by forming marketing alliances. These intermodal services are domestic, those that remain in the U.S., or international, and those that cross to or from Canada and/or Mexico. The following two sections provide a listing of these intermodal services by the U.S. railroads serving Texas. Some of the services may be directed to TOFC movements, but the majority relate to COFC movements.

5.5.2 Domestic Intermodal Services

All three Class I railroads operating in Texas offer intermodal services across the U.S. Under each railroad is the service name and the railroads involved in the service. The services listed may not represent the full host of intermodal services provided by each railroad. Table 5.3 provides a listing of railroad abbreviations used throughout the intermodal services sections.

Table 5.3 Railroad Company Abbreviations

BNSF – Burlington Northern Santa Fe	KCS – Kansas City Southern
CN – Canadian National	NS – Norfolk Southern
CP – Canadian Pacific	TFM – Transportacion Ferroviaria Mexicana
CSX – CSX Transportation	TM – Texas Mexican
FXE – Ferrocarril Mexicano SA De CV	UP – Union Pacific

- Kansas City Southern Railway (Kansas City Southern Railway , 2003)
  - Meridian Speedway Connections
    - BNSF from Dallas to the West Coast
    - NS from Meridian to the East Coast
- Burlington Northern Santa Fe Railway (Burlington Northern Santa Fe Railway, 2003)
  - Guaranteed On-Time Intermodal Product
    - 13 Major Markets linked by 39 lanes
  - Coast-to-Coast
    - BNSF-NS: San Bernardino, CA to Harrisburg, PA
- Union Pacific Railroad (Union Pacific Railroad, 2002)
  - Blue Streak
    - UP-NS: Los Angeles, CA to Atlanta, GA

5.5.3 International Intermodal Services

Five of the eight U.S.-Mexico railroad border crossings are located in Texas as listed below:

- San Ysidro, California
- Calexico, California
- Nogales, Arizona
- El Paso, Texas
- Presidio, Texas
- Eagle Pass, Texas
- Laredo, Texas
- Brownsville, Texas

Laredo represents the most significant crossing in terms of total tonnage and intermodal activity. El Paso is the other border crossing in Texas with major intermodal terminals. The following is a list of international intermodal services provided by the Class I railroads operating in Texas. All the services represent intermodal activity servicing Canada, the U.S., and Mexico.

- Kansas City Southern Railway (Kansas City Southern Railway, 2001)
  - NAFTA Express
    - Canada – CN; U.S. – KCS, TM; Mexico – TFM
- Burlington Northern Santa Fe Railway (Burlington Northern Santa Fe Railway, 2003)
  - Mexi~Modal
    - Canada – CN; U.S. – CSX, BNSF; Mexico – TFM, FXE
- Union Pacific Railroad (Union Pacific Railroad, 2003)
  - Transborder
    - Ramp-to-Ramp through Laredo and El Paso
    - Canada – CN, CP; U.S. – UP, NS, CSX; Mexico – TFM, FXE
- Passport
  - Ramp-to-Door/Door-to-Ramp over Laredo, where rail in U.S. and truck in Mexico

- Canada – CN, CP; U.S. – UP, NS, CSX

5.6 Major Intermodal Facilities

Class I railroads have a variety of facilities located around the state, including major intermodal terminal yards which are used for loading, storing, and switching containers and intermodal equipment. Most major intermodal facilities are located in one of three areas—in major urban centers of the state where large quantities of goods are produced and consumed, along the Texas Gulf Coast for marshalling of containers to and from port facilities, and near the international gateways along the U.S.-Mexico border.

Table 5.4 shows the Class I railroad connections to intermodal facilities in Texas. The facilities for KCS include the ones for TM. The connections with the ports along Texas's Gulf Coast represent the locations where considerable port-rail container exchanges occur. The most significant port-rail connection in Texas is the Port of Houston's Barbours Cut Terminal. Barbours Cut reported the movement of 48,570 containers in 2002 (Schiefelbein, 2003). Intermodal facilities at the international gateways also represent the locations where noteworthy intermodal activities occur.

Table 5.4 Major Class I Intermodal Facility Locations in Texas

Facility	UP	BNSF	KCS
Intermodal Yards	▪ Dallas (2) ▪ El Paso ▪ Houston (2) ▪ Laredo ▪ San Antonio (2)	▪ Amarillo ▪ El Paso ▪ Fort Worth ▪ Houston	▪ Dallas ▪ Laredo (TM) ▪ Port Arthur
Port Access	▪ Beaumont/Port Arthur ▪ Corpus Christi ▪ Houston	▪ Beaumont/Port Arthur ▪ Corpus Christi ▪ Houston	▪ Beaumont/Port Arthur
International Gateways	▪ El Paso ▪ Laredo	▪ El Paso	▪ Laredo (TM)

The following sections provide details of the major intermodal terminals in Houston, Dallas-Fort Worth, and Laredo.

5.6.1 Houston

Houston possesses three intermodal facilities serving the metropolitan area and one dedicated to serving the Port of Houston's Barbours Cut Terminal.

- Englewood Intermodal Yard – UP (Fryer, 2002)
  - Facility – 5 working tracks approximately 2,400 ft in length; 100-acre ramp
  - Activity – 18,000 lifts per month; Mainly used for east-west traffic; Ability to run 8,000 ft double-stack trains to West Coast (approximately 250 containers)
    - Unit Types – 99% containers

- Settegast Intermodal Yard – UP (Fryer, 2002)
  - Facility – 6 working tracks, including 2 new tracks constructed after the merger;
  - Activity – 10,000 lifts per month; Mainly used for north-south traffic
  - Unit Types – 70% containers
- Houston (Pearland) Intermodal Yard – BNSF (Seaman , 2002)
  - Facility – 4 working tracks, including 2 single-sided and 2 double-sided; 83-acre ramp
  - Activity – 10,000 to 12,000 lifts per month; 131,156 projected lifts for 2002; 98% on-time release; Ability to create 9,000 ft long trains consisting of approximately 275 units
  - Unit Types – 96% containers
- Barbours Cut Terminal (Port of Houston Authority , 2003)
  - Facility – 4 working tracks approximately 2,700 ft in length and 5 storage tracks; 42.1-acre ramp

5.6.2 Dallas-Fort Worth

The Dallas-Fort Worth area is a major junction of intermodal activity in the U.S. Not only are there four major intermodal facilities, but several of the intermodal services listed above either originate or pass through the region.

- Mesquite – UP (Marler , 2002)
  - Facility – 4 working tracks approximately 5,000 ft in length; 130-acre ramp; $26 million expansion in 1998; Automated gate system
  - Activity – 16,000 to 17,000 lifts per month (800 to 900 lifts per day)
- Miller – UP (Marler , 2002)
  - Facility – 6 working tracks approximately 1,200 ft in length; 68-acre ramp
  - Activity – 14,000 to 15,000 lifts per month
- Dallas – KCS (Kansas City Southern Industries, 2002)
  - Facility – 80-acre ramp; 3 overhead cranes; storage for 1024 trailers and containers
  - Activity – 120,000+ annual lift capacity
- Alliance – BNSF (HNTB Corporation , 1999)
  - Facility – 281-acre facility; 5 overhead cranes; 2064 parking spaces
  - Activity – 353,420 actual lifts in 1997
  - Unit Types – 65% containers

5.6.3 Laredo

Laredo experiences the highest levels of intermodal activities along the Texas-Mexico border. Two intermodal facilities one owned by UP and one by TM are dedicated to intermodal activities at the border. Both have recently undergone significant capital improvement projects to handle the increasing intermodal traffic.

- Port Laredo – UP (Roop, 2001)
  - Facility – 25 total tracks; 50 acre-ramp
  - Activity – 130,000 annual lift capacity

- Serrano Yard – TM (Roop, 2001)
  - Facility – Involved in recent four-phase $42.5 million rehabilitation project to upgrade the line from Corpus Christi to Laredo, including expanding the intermodal track capacity at Serrano Yard from 2 tracks to 5.

5.7 Rural Rail Transportation Districts

The intermodal facilities around the state were privately developed by the railroads or jointly developed with the Texas ports. Otherwise, very little public involvement has existed in the development of intermodal facilities. One government entity existing in Texas that could influence increased intermodal facility development is Rural Rail Transportation Districts (RRTDs). Consisting of one or more counties, RRTDs act as economic tools for the development of rail services, including owning and constructing rail lines and promoting rail service. Over 20 RRTDs are located around the state, including counties along the Texas Gulf Coast, Texas-Mexico border, and in and around major metropolitan areas.

5.8 Rail Container Movements and Flows Within Texas

The Carload Waybill Sample (Waybill) was used in evaluating the commodity flow movements of intermodal containers by Texas railroads. Although only a sample of the total rail activity in the state, the Waybill data set represents the most detailed railroad information available for public planning. Residing in two forms, a more generalized nationwide database and highly detailed, confidential statewide databases, the Waybill data provides for detailed analyses of intermodal movements in Texas along with the distinction between TOFC and COFC units. By using the more detailed confidential Waybill dataset for this analysis, the commodity movement information obtained includes county-level and railroad-specific details.

In the development of the model for this project, TxDOT provided the 1996 Reebie TRANSEARCH Freight Database, and the research team will soon implement the 1998 Reebie data set. The Waybill data provided in this section corresponds to the model data sets, the 1996 and 1998 Reebie TRANSEARCH Freight Databases, and provides support for the model development. The following sections describe the intermodal and container specific movements presented in the Waybill data sets.

5.9 Intermodal Units Originating and Terminating in Texas

This section evaluates the container and trailer share of intermodal shipments in Texas for 1996 and 1998. As demonstrated in Table 5.5, containers represent approximately two-thirds of all the intermodal movements in Texas. This number is slightly higher for the shipments originating in Texas, where containers represented 68.8 percent of the intermodal units in 1998. However, for both the originating and terminating intermodal shipments, the container share increased over the two-year period, with the terminating shipments experiencing the greatest change.

Table 5.5 Percentage of Containers and Trailers in Texas

Units						
	Originate		**Terminate**		**Total**	
Year	**Container**	**Trailer**	**Container**	**Trailer**	**Container**	**Trailer**
1996	64.5	35.5	58.6	41.4	61.0	39.0
1998	68.8	31.2	63.6	36.4	65.8	34.2
Tons						
	Originate		**Terminate**		**Total**	
Year	**Container**	**Trailer**	**Container**	**Trailer**	**Container**	**Trailer**
1996	62.6	37.4	52.9	47.1	57.7	42.2
1998	67.5	32.5	60.7	39.3	63.8	36.2

Table 5.6 shows the container movements shipped to, from, and within Texas. The overall container levels increased by nine percent from 1996 to 1998, including 15.2% in the number of units and 26.9% in the amount of tons terminating in the state. Originating container units experienced moderate growth levels of 6.2%. Intermodal container movements originating and also terminating in Texas represent minor quantities and decreased by over 30% during 1996 - 1998.

Table 5.6 Containers Originating and Terminating in Texas

Units				
Year	**Originate**	**Terminate**	**Intra-Texas**	**Total**
1996	306,616	294,051	21,500	622,167
1998	325,484	338,848	14,600	678,932
Difference	18,868	44,797	-6,900	56,765
%Diff	6.2	15.2	-32.1	9.1
Tons				
Year	**Originate**	**Terminate**	**Intra-Texas**	**Total**
1996	4,705,864	3,863,648	181,960	8,751,472
1998	4,881,864	4,901,720	137,360	9,920,944
Difference	176,000	1,038,072	-44,600	1,169,472
%Diff	3.7	26.9	-24.5	13.4

The following section further details the container movements in Texas, including the states interchanging with Texas, the commodities transported in containers, the railroads moving containers in Texas, and the container movements passing through Texas.

5.10 State Level Container Movements by Rail

Texas originated 328,000 containers in 1996 and 340,000 containers in 1998. Table 5.7 provides the states where the originating containers terminated. California accepted the greatest number of containers from Texas, almost double the quantity of the second-highest

state, Illinois. Together, California and Illinois were the destination for over 236,000 containers in 1996 and 275,000 containers in 1998, representing 72% and 81% of all containers originating in Texas, respectively.

Table 5.7 Texas to Destination States for Container Movements

Destination State	1996		1998	
	Units	Tons	Units	Tons
Arizona	920	13,760	960	14,040
Arkansas	0	0	1,240	13,680
California	148,416	2,678,744	182,960	2,935,000
Colorado	2,480	35,760	2,680	41,760
Florida	1,160	19,640	2,600	42,280
Georgia	12,040	185,320	11,600	161,280
Illinois	87,960	940,080	92,360	1,179,040
Kansas	3,360	50,720	2,880	40,520
Kentucky	280	5,600	40	800
Louisiana	18,200	346,040	7,280	129,400
Maryland	0	0	40	600
Massachusetts	480	7,200	480	7,200
Michigan	4,600	50,480	520	9,200
Minnesota	0	0	80	1,720
Missouri	4,080	64,480	1,920	25,600
Nebraska	280	2,600	0	0
New Jersey	1,480	22,200	3,240	48,480
New York	360	5,400	240	4,560
North Carolina	2,240	38,760	680	8,200
North Dakota	40	520	0	0
Ohio	480	5,120	720	6,400
Oklahoma	200	840	0	0
Oregon	1,880	35,560	2,640	52,200
Pennsylvania	1,840	27,200	2,720	40,440
South Carolina	1,560	28,960	1,080	19,280
Tennessee	8,640	77,600	1,520	19,040
Texas	21,500	181,960	14,600	137,360
Utah	280	4,200	484	8,224
Virginia	40	720	40	200
Washington	3,320	58,360	4,480	72,720

For the 315,551 containers in 1996 and the 353,448 containers in 1998 terminating in Texas, California and Illinois again represent the major interchange states, as shown in Table 5.8. Combined, both states originated 73% and 82% of all the containers terminating in Texas in 1996 and 1998. As demonstrated in Tables 5.7 and 5.8, containers originating

and also terminating in Texas represent the third highest level of activity with 21,500 units and 14,600 units in 1996 and 1998, respectively.

Table 5.8 Originating States to Texas for Container Movements

Originating State	1996		1998	
	Units	Tons	Units	Tons
Arizona	640	6,040	920	14,360
Arkansas	40	200	688	9,120
California	130,851	1,751,808	182,360	2,653,760
Colorado	2,080	30,720	1,360	18,920
Florida	640	15,320	1,120	12,840
Georgia	11,840	146,920	10,400	127,240
Illinois	99,320	1,213,320	107,320	1,540,680
Iowa	0	0	40	880
Kansas	2,120	31,400	2,000	23,840
Kentucky	0	0	40	520
Louisiana	14,600	234,360	7,560	120,400
Maine	0	0	80	360
Maryland	0	0	120	1,720
Massachusetts	1,280	17,520	1,200	16,840
Michigan	4,520	57,120	2,080	23,120
Minnesota	680	14,560	560	11,440
Mississippi	40	880	80	600
Missouri	5,560	75,720	4,160	66,560
Nebraska	400	3,920	0	0
Nevada	0	0	40	920
New Jersey	1,800	29,560	1,480	24,000
New Mexico	0	0	40	160
New York	440	7,560	440	8,280
North Carolina	1,240	13,000	0	0
Ohio	320	3,480	640	8,760
Oklahoma	400	3,600	80	320
Oregon	2,120	33,560	3,040	57,280
Pennsylvania	1,880	31,040	2,560	42,640
South Carolina	880	13,560	600	10,960
Tennessee	7,360	87,360	2,800	24,680
Texas	21,500	181,960	14,600	137,360
Utah	280	2,000	240	3,280
Virginia	200	1,480	40	120
Washington	2,520	37,640	4,760	77,120

Table 5.9 shows the commodities transported in containers for 1996 and 1998 originating and terminating activities. The two major groups are Commodity Group 7, Mixed Freight Shipments, and Commodity Group 5, Manufactured Products.

Table 5.9 Commodities Transported by Container

Originating					
Commodity Group	**Commodity Group Name**	**1996**		**1998**	
		Units	**Tons**	**Units**	**Tons**
1	Agricultural & Related Products	3,640	77,880	2,080	37,040
2	Hazardous Materials	15,224	300,900	14,644	287,504
3	Construction Materials	1,320	20,240	1,920	24,400
4	Food & Related Products	8,892	180,040	5,760	118,200
5	Manufacturing Products	47,420	514,360	37,600	503,560
6	Machinery & Equipment	2,920	37,720	3,680	43,760
7	Mixed Freight Shipments	248,700	3,756,684	274,400	4,004,760
Terminating					
Commodity Group	**Commodity Group Name**	**1996**		**1998**	
		Units	**Tons**	**Units**	**Tons**
1	Agricultural & Related Products	2,360	54,760	3,120	69,520
2	Hazardous Materials	4,720	81,920	6,560	126,160
3	Construction Materials	1,160	18,240	2,440	40,080
4	Food & Related Products	13,440	260,680	12,400	259,840
5	Manufacturing Products	79,228	839,756	73,280	1,023,000
6	Machinery & Equipment	2,120	34,440	1,640	23,840
7	Mixed Freight Shipments	212,523	2,755,812	254,008	3,496,640

The railroads originating or terminating containers in Texas are listed in Table 5.10. Approximately 65% of the container movements is transported by UP, with BNSF transporting approximately 30%. The other Class I railroad operating in Texas, KCS, transports approximately five percent of the containers originating or terminating in Texas. Norfolk Southern (NS) is a Class I railroad operating over the majority of the Eastern U.S. and most likely appears in the data set due to marketing agreements with the Texas railroads. In such an agreement, NS representatives actively acquire contracts to move containers and work with another railroad to originate or terminate the container.

Mergers in the mid-1990s created what are now BNSF and UP. The 1996 Waybill database, and in some instances reported within the 1998 Waybill database, the railroads appear as they were prior to the mergers. To perform the multiyear analysis, the railroad data was consolidated into the current railroad company.

Table 5.10 Railroads Transporting Containers in Texas

Originating								
Railroad	**1996**				**1998**			
	Units	**% Share**	**Tons**	**% Share**	**Units**	**% Share**	**Tons**	**% Share**
BNSF	99,692	30.4	1,625,120	33.2	99,440	29.2	1,530,760	30.5
KCS	15,240	4.6	257,400	5.3	17,160	5.0	233,880	4.7
NS	0	0.0	0	0.0	1,240	0.4	25,040	0.5
UP	213,184	65.0	3,005,304	61.5	222,244	65.3	3,229,544	64.3
Terminating								
Railroad	**1996**				**1998**			
	Units	**% Share**	**Tons**	**% Share**	**Units**	**% Share**	**Tons**	**% Share**
BNSF	91,963	29.1	1,246,092	30.8	107,160	30.3	1,518,480	30.1
KCS	17,880	5.7	274,640	6.8	18,240	5.2	265,600	5.3
NS	0	0.0	0	0.0	960	0.3	11,040	0.2
UP	205,708	65.2	2,524,876	62.4	227,088	64.2	3,243,960	64.4

Besides containers that originate and terminate in Texas, there are a substantial number of containers that travel through the state. Table 5.11 shows the relationship between the containers originating or terminating in the state and the containers passing through the state. The through movements represent a greater portion of the container movement than the containers originating or terminating in Texas, with a 57.4% share in 1996 and a 66.3% share in 1998. The increased share in 1998 comes from significant growth in the through movements of almost 500,000 units versus only 56,000 units originating or terminating in Texas.

Table 5.11 Texas Container Movements

	1996				**1998**			
	Units	**%**	**Tons**	**%**	**Units**	**%**	**Tons**	**%**
Texas Orig. or Dest.	622,167	42.6	8,751,472	40.1	678,932	33.7	9,920,944	32.9
Through Movements	838,164	57.4	13,068,800	59.9	1,333,580	66.3	20,236,180	67.1
Total	1,460,331	100	21,820,272	100	2,012,512	100	30,157,124	100

The state combinations representing the majority of the container movements traveling through Texas include California-Illinois (390,576 units in 1996 and 700,400 units in 1998), California-Louisiana (160,768 units in 1996 and 152,520 units in 1998), and California-Tennessee (94,132 units in 1996 and 138,360 units in 1998). This demonstrates the major California ports connecting with major intermodal hubs located in Chicago, Illinois; Memphis, Tennessee; and New Orleans, Louisiana.

5.11 County Level Container Movement by Rail

The specific counties supporting container origination or termination are provided in Table 5.12. The table also includes the railroads transporting containers in each county.

Table 5.12 Counties Originating or Terminating Container Movements

Originating					
County	**Railroads**	**1996**		**1998**	
		Units	**Tons**	**Units**	**Tons**
Bexar	UP	2,280	22,960	6,280	65,240
Cameron	UP	280	3,000	164	2,504
Dallas	BNSF, KCS, UP	64,272	915,320	78,800	1,082,560
El Paso	BNSF, UP	21,980	264,840	23,640	272,920
Harris	BNSF, UP	126,988	2,364,044	112,360	2,040,320
Jefferson	UP	104	3,540	800	16,200
Lubbock	BNSF	2,960	63,720	1,400	25,240
Maverick	UP	21,120	83,400	20,120	203,440
Potter	BNSF	4,572	84,640	3,000	53,480
Robertson	UP	0	0	40	680
Tarrant	BNSF, UP	48,320	704,280	52,520	725,120
Webb	UP	35,240	378,080	40,960	531,520
Terminating					
County	**Railroads**	**1996**		**1998**	
		Units	**Tons**	**Units**	**Tons**
Bexar	UP	2,880	39,200	14,320	182,400
Dallas	BNSF, KCS, UP	71,280	1,010,280	92,560	1,348,240
El Paso	BNSF, UP	22,280	295,320	23,960	342,600
Gray	BNSF	0	0	40	160
Harris	BNSF, KCS, NS, UP	103,268	1,277,436	97,288	1,439,840
Jefferson	NS	0	0	520	4,960
Lubbock	BNSF	3,003	13,692	1,080	4,920
Maverick	UP	21,640	203,840	20,240	260,240
Potter	BNSF, UP	1,240	6,560	2,880	11,760
Tarrant	BNSF, UP	55,000	786,760	63,000	913,480
Ward	UP	0	0	40	520
Webb	UP	34,960	412,520	37,520	529,960

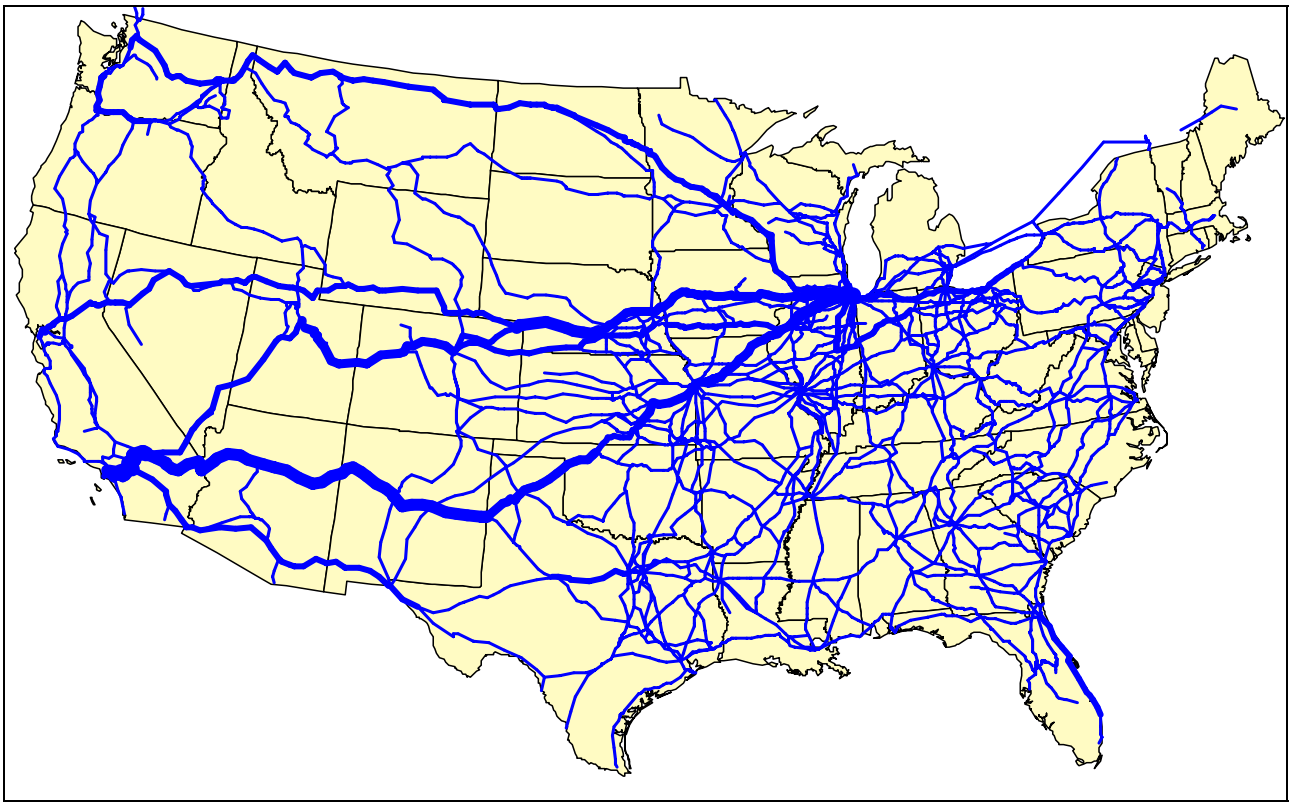
The counties with significant levels include those with intermodal facilities, port connections, and international border crossings. The following lists these counties along with the major cities and intermodal connection type:

- Bexar County – San Antonio (intermodal facilities)
- Dallas County – Dallas (intermodal facilities)
- El Paso County – El Paso (international border connection)
- Harris County – Houston (intermodal facilities and port connection)
- Maverick County – Eagle Pass (international border connection)
- Tarrant County – Fort Worth (intermodal facilities)
- Webb County – Laredo (international border connection).

Other counties in the table with major intermodal facilities include Lubbock and Potter; with port connections include Jefferson; and with international border connections include Cameron Counties.

5.12 Container Flows

To conclude, the FHWA has developed a national model for modal commodity flows. The flow of intermodal movements across the continental U.S. by rail is shown in Figure 5.4. The major movement of intermodal traffic exists between Los Angeles, California, and Chicago, Illinois, including the use of a major rail line through the Texas's Panhandle region. As previously indicated, the Los Angeles-Chicago combination resulted in over 700,000 container units passing through Texas in 1998.



Source: Maring, Gary. U.S. Department of Transportation, Federal Highway Administration. "Intermodal Freight History and Current Issues." Presented to the Transportation Research Board, Washington D.C, January 14, 2002.

Figure 5.4 U.S. Intermodal Flows for Tons Transported

The map also indicates intermodal movements to and from the Texas-Mexico border connections and major metropolitan areas, particularly Dallas-Fort Worth. Port-related flows appear limited to the Houston-Galveston area.

6. Container on Barge Operations

6.1 Introduction

The most successful Container on Barge (COB) operations have been in northern Europe and the Far East, specifically in the Netherlands, Germany, and China. In Rotterdam, trucks transport less than half of all the containers, because of the growing share of containers moved by barge and coastal shipping. Bomba (2002) reported that approximately 1.52 million TEUs were moved by barge in Antwerp in 2000. Although COB operations in the U.S. have not enjoyed the same level of success, there are a few success stories and one of these is the Osprey Lines based in Houston.

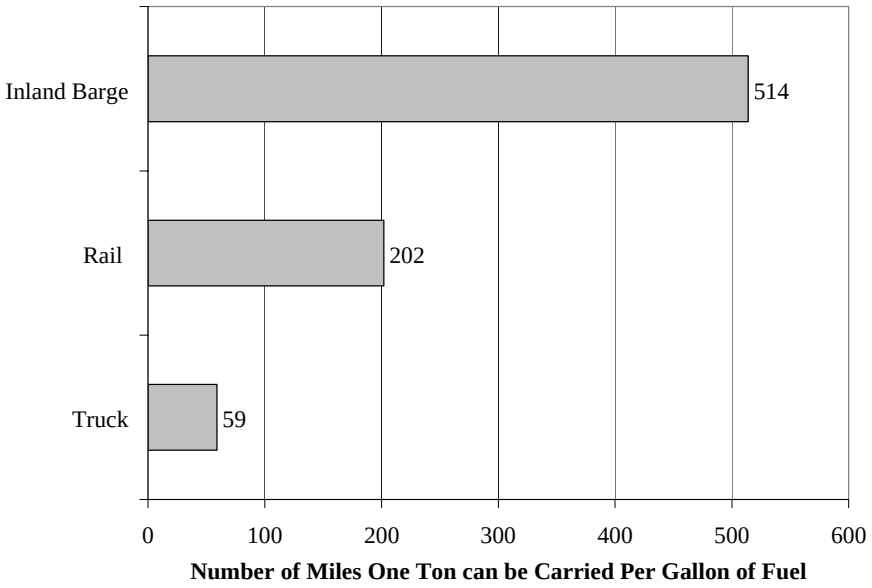
The Osprey Lines provides feeder services for Gulf Coast ports and operates from New Orleans to Corpus Christi. The company offers one scheduled service – a weekly Houston to New Orleans feeder service that moves between 20,000 and 25,000 containers a year. All other Osprey services are not scheduled and are based on cargo needs (Hensel Jr., 2001). Osprey built its reputation on moving food aid, principally from Lake Charles in Louisiana, to most countries in the world through a strategic alliance with Maersk Sealand based at the Port of Houston. In addition, it moves empty containers between port facilities, some with trip distances less than 15 miles (within the Houston Ship Channel) and others of longer length. (Port of Lake Charles in Louisiana, and Texas's Freeport) (Hensel Jr., 2001).

6.2 Benefits of Barge Operations

COB operations have a number of environmental and societal benefits over surface modes, such as rail and truck. This section provides a brief description of these benefits.

6.2.1 Energy Consumption

One of the environmental benefits of a barge operation is that barges consume less energy per ton/mile than railcars and trucks. Studies sponsored by the U.S. Departments of Energy and Transportation have shown that shallow-draft water transportation is the most fuel-efficient mode for moving bulk raw materials, and requires the least amount of energy when moving equivalent amounts of cargo (U.S. DOT, 1994). With only 1 gallon of fuel a barge can move one ton of cargo 514 miles. A train can move the same amount of cargo only 202 miles on 1 gallon of fuel, and a truck can move one ton on 1 gallon of fuel only 59 miles (U.S. DOT, 1994). From Figure 6.1, it is evident that barge is the most fuel-efficient compared to rail and truck.



Source: U.S. DOT: Maritime Administration, 1994

Figure 6.1 Relative Energy Efficiencies

6.2.2 Impacts on Water Quality

Some fear that barge traffic would have a negative impact on water quality. According to the Illinois State Water Survey, the Illinois River water quality was not being adversely affected by barge traffic. They came to this conclusion after "*ambitious sample collection regimens …, in combination with rigorous laboratory and quantitative analysis."* Researchers also found "*that natural phenomena influenced water quality to a far greater extent than commercial barge traffic*" (U.S. DOT, 1994). In 1996, the Texas Transportation Institute reported that barges spilled less than 1 gallon for every 60,000 gallons transported (Hardebeck et al., 1999). In addition, the Office of Hazardous Materials Safety reported 37 hazardous spills by air, 1,027 by highway, 124 by railway, and two by water transportation (Texas Department of Transportation, 2002)

Oil spills are contained, largely because the Oil Pollution Act of 1990 requires all new inland barges that will carry bulk oil cargo to be built with a double hull. It also prohibits the use of tank vessels with a capacity of less than 5,000 gross tons to transport liquid bulk as of January 1, 2015 (U.S. DOT, 1994). The second hull helps to reduce the impacts of potential spills. In addition, rigorous training programs for those operating barges and strict federal inspection standards have also reduced spills by barge operators.

6.2.3 Congestion

Increasing truck volumes are overwhelming key elements of the Texas and U.S. highway system, resulting in increasing congestion and travel times for goods moved by truck, safety and air quality concerns. Trucks moving containers contribute to the congestion experienced on these key elements. Unlike road and in key rail corridors,

congestion is not considered a problem for COB operations (U.S. DOT, 1994). Barges could actually be part of an intermodal solution to reduce congestion – a single barge could divert fifty-eight container-carrying trucks off the roadway (Bomba and Harrison, 2002).

When larger numbers of containers need to be shipped, the number of barges operating does not necessarily increase. Instead of congesting the waterway with additional barges, the horsepower of the existing fleet can be increased to handle the additional containers (U.S. DOT, 1994). In Texas, however, concerns have been raised about outdated facilities, navigational hazards, traffic delays, and the disposal of dredged materials pertaining to the Gulf Intracoastal Waterway (GIWW) (Texas Department of Transportation, 2002). These concerns impact waterway capacity and thus barge transportation on the Gulf Intracoastal Waterway.

6.2.4 Safety

Unlike trains and trucks, barges do not operate through downtown districts or residential areas. Therefore they have limited interaction with the public and are thus viewed as a safer mode (Cook, 2001). Both the U.S. DOT and the U.S. Coast Guard reported that water transportation is the safest mode of transportation. When compared to other surface transportation modes, water transportation had the fewest number of incidents, injuries, and fatalities. Barges share their right-of-way mostly with pleasure boats and have few crossing junctions. On the other hand, trucks operate in a mixed environment that include passenger vehicles, pedestrians, bicyclists, and rail has to move through a number of at-grade crossings – thus interacting with road traffic (USDOT, 1994).

Although widely regarded a safer mode than truck or rail, a barge incident, such as the Queen Isabella Causeway incident, can have serious consequences in terms of the number of fatalities and lives impacted. Adequate maintenance of barge infrastructure and channels are critical to the safe operation of barges. In this regard, the towing industry has identified the section of the GIWW beneath the dual Interstate Highway 45 bridges and the Galveston Island Railroad Bridge as the most hazardous to navigate on the entire GIWW. TxDOT is planning to replace the Interstate Highway bridges in 2005, and the Coast Guard is looking into replacing the railroad bridge by 2007. Upon completion of these structures the width of the openings for barge traffic will be 300 feet as opposed to the current 105 feet (Texas Department of Transportation, 2002).

6.2.5 Emissions Impacts

An EPA report showed that inland barges produce significantly fewer pollutants compared to trucks and trains. This is mainly attributable to the fact that barges are more fuel efficient per ton/mile and do not operate in congested environments. The report measured three pollutants: hydrocarbons, carbon monoxide, and nitrous oxide.

Table 6.1 Emissions Produced by Mode

Pollutants (in pounds) produced in moving one ton of cargo 1,000 miles			
Mode	**Hydrocarbon**	**Carbon Monoxide**	**Nitrous Oxide**
Tow boat	0.09	0.20	0.53
Train	0.46	0.64	1.83
Truck	0.63	1.90	10.17

Source: Environmental Protection Agency, available at http://www.mvr.usace.army.mil/navdata/tr-comp.htm. Accessed February, 2002.

From Table 6.1, it is evident that a truck produces 7 times more hydrocarbons, 9.5 times more carbon monoxide and 19 times more nitrous oxide when moving one ton of cargo 1,000 miles compared to a barge (EPA, 1994). The relatively low emissions of hydrocarbons are partly attributable to the fact that the U.S. Coast Guard is required under the Clean Air Act of 1990 to ensure that cargo vapor collection systems meet minimum safety standards. Cargo vapor collection systems are used to prevent volatile organic compound (VOC) emissions, which include a range of individual substances such as hydrocarbons. VOC emissions and nitrogen oxides are precursors to the formation of troposphere ozone, which contributes to smog (U.S. Coast Guard, 2002).

6.3 System Requirements for a Successful Container on Barge Operation

Osprey Lines, the only COB operation in Texas, was contacted to discuss the system requirements for a successful COB operation.

6.3.1 Barge Infrastructure

According to the Osprey Lines representative, a COB operation does not require additional infrastructure if a port already handles containers. Currently, Osprey Lines only calls at ports that already handle containers. A COB operation requires less than 10 ft of channel depth, and a flat space on stabilized ground, which is available at all the container ports they already visit (Personal Communication, March 2003). More details on container port infrastructure are provided in Chapter 3.

Specialized container cranes are used to move containers on and off barges. Ports interested in serving a COB operation would need to have this type of crane. Container cranes tend to be expensive and not all ports, especially smaller ports, are able to purchase them. One option is for smaller ports to buy used container cranes. The Ports of Lewiston and Pasco purchased older container cranes from the larger Port of Portland (Bomba and Harrison, 2002). Another option is using a wheeled crane with a modified jib to reach down into barges and lift the container. Such a crane cost less than $500,000 Ex-Works and can work on the Gulf Intercoastal Waterway where tidal variations are not an issue. According to the Osprey Lines representative, barges are “extremely low tech, meaning they have no moving parts.” (Personal Communication with Osprey Lines, March 2003). Consequently no, sophisticated vessel technology is required to ensure a successful COB operation.

6.4 Criteria for Successful Container on Barge Operations

Although not as prevalent as in Europe, a number of successful COB operations exist in the U.S. As an example, the COB operation on the Columbia-Snake River in the Pacific Northwest with feeder services along the West Coast has been very successful (Barnard, 2001 & Kaser, 2000). The COB operation on the Columbia-Snake River has been successful because it provides a low-cost service to local-source agricultural exports in one direction and containers on the backhauls (Johnson, 1984). In 2001, the Columbia-Snake River carried 47,835 TEUs (WorldCargo News Online, 2002).

In addition, the Port Inland Distribution Network (PIDN) is the Port Authority of New York and New Jersey's new initiative. The PIDN concept is similar to the Rotterdam initiative where the port is linked by barge or rail systems to key distribution centers inland from the port (PANYNJ Press Release, Nov 29, 2000). The PIDN would resemble a hub and spoke system with the Port of New York and New Jersey as the hubs (Urquhart, 2001). Containers landed at these hubs would be transported by barge to spokes (key distributions centers) along the coast.

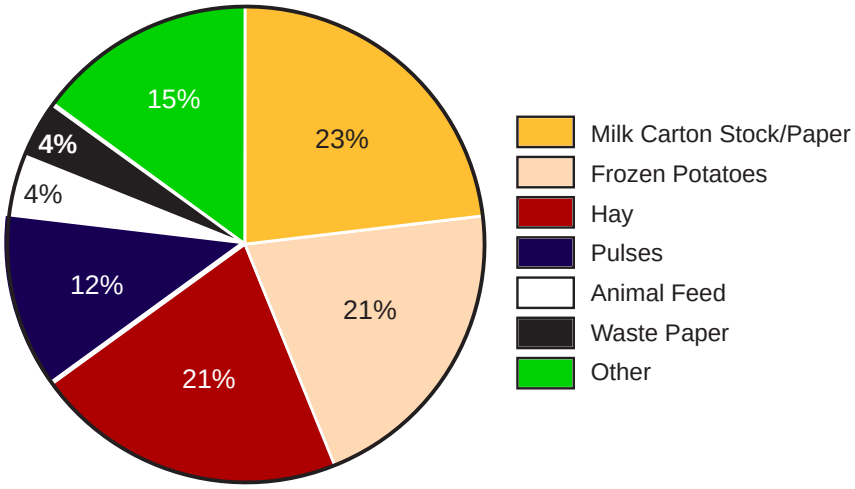
Several factors relating to both supply and demand characteristics combine to make a commercially successful COB operation. These include:

- the volume of containers should be sufficiently large to lower average costs per container,
- the product supply chain should be structured to allow barges to be complemented by trucks or rail,
- prices, including any drayage and lifting charges, should be competitive with other modes, and
- interacting with a regular steamship call frequency raises demand.

The following sections examine a range of issues that could facilitate the success of a COB operation.

6.4.1 Bulk Commodities

Because barges have relatively longer transit times, it is often suggested that barges are more suitable for the transport of low-value bulk commodities and empty containers. Following from this argument, the U.S. demise of barge operations is often attributed to increased competition from rail for grain transport (Muller, 1999). Data on containerized commodities moving by barge are fairly elusive. But statistics from the Port of Portland indicates a variety of containerized commodities moving by barge, including perishable products.



Source: Kaser, 2000

Figure 6.2 Containerized Commodities Moving by Barge through Portland's Terminal 6 (1999)

Figure 6.2 illustrates that 21% of the containers moving through Portland's Terminal 6 contain frozen potatoes (Kaser, 2000).

6.4.2 Longer distances

Barge transportation becomes more competitive with truck and rail as the transporting distance increases. Researchers at the University of Arkansas showed that barges were the most cost-efficient mode for carrying containers when the distance was more than 1,341 miles (Bomba and Harrison, 2002).

Contrary to the this study, one of Osprey Lines' most successful routes involves transporting containers along the Houston Ship Channel to Barbours Cut Terminal, thereby avoiding costly transfers on Houston highways. By the same token, the Matson shuttle, a weekly service between Los Angeles, the ports of Seattle, and Vancouver, British Columbia, could compete with truck. By highway, Los Angeles to Seattle is roughly 1,100 miles (McIntyre, 1996). The Matson shuttle service that started in 1994, however, was discontinued in 2000 after six years of operation (Mongelluzzo, 2000). It is thus important to note that break-even analyses depends on the input assumptions made, and it would seem probable that barges can be profitable over a wide range of distances given the right circumstances.

6.4.3 Frequent Scheduled Service

A COB operation does not have to be scheduled to be profitable. Osprey Lines' COB operates only one weekly scheduled service out of the Port of Houston (Personal Communications with Osprey Lines, March 2003). It may, however, be more profitable for a COB to match the schedules of container ships. A COB schedule could be timed to match those of the established liner container ships. For example, if a container ship arrives every Tuesday at a port – the barge operation could call at the port every Monday and Wednesday to transport containers both to and from other ports.

6.4.4 Information Systems

Information and communication technologies are becoming increasingly important to enable rapid price quotes, to track and monitor shipments, and to coordinate different modes across the transportation supply chain. COB operations will have to invest in such information systems to compete with rail and truck, or to be considered part of an intermodal solution by the shipping industry.

6.4.5 Intermodal Service

According to a survey conducted by the Louisiana State University, a successful COB operation must offer more than a port-to-port service. The researchers reported that a COB operation would need to offer a door-to-door service (Crew, 1988). For a barge operation to be successful it was argued that it needs to be part of an intermodal service, with intermodal being defined as involving more than one mode of transport during a single journey (Muller, 1999). For example, the container gets picked up by a truck at the origin, transported to the barge, loaded on the barge, transported by the barge, and then finally transported to the final destination by truck or a combination of truck and rail. Deregulation has resulted in some cooperative arrangements between barges and the surface modes: road and rail.

The U.S.-Mexico border can at times be congested for both trucks and rail. An intermodal service with barges as a component could perhaps be feasible for U.S.-Mexican trade. Although the physical distance between Mexican manufacturers and U.S. importers is relatively short the costs tend to be high due to congestion and delays at key border ports of entry. An intermodal service involving barges could potentially offer a lower cost service. The development of an intermodal COB service between Texas and northeast Mexico would not only direct some traffic away from the congested ports of entry, but a lower cost transport alternative might allow marginal industries to become competitive thereby facilitating trade growth. This idea has, however, been around for some time – at least a decade – with little progress toward implementation. One major obstacle is the need to extend the Gulf Intercoastal Waterway into Mexico, a move that is both financially expensive and environmentally sensitive.

6.4.6 Dense Population

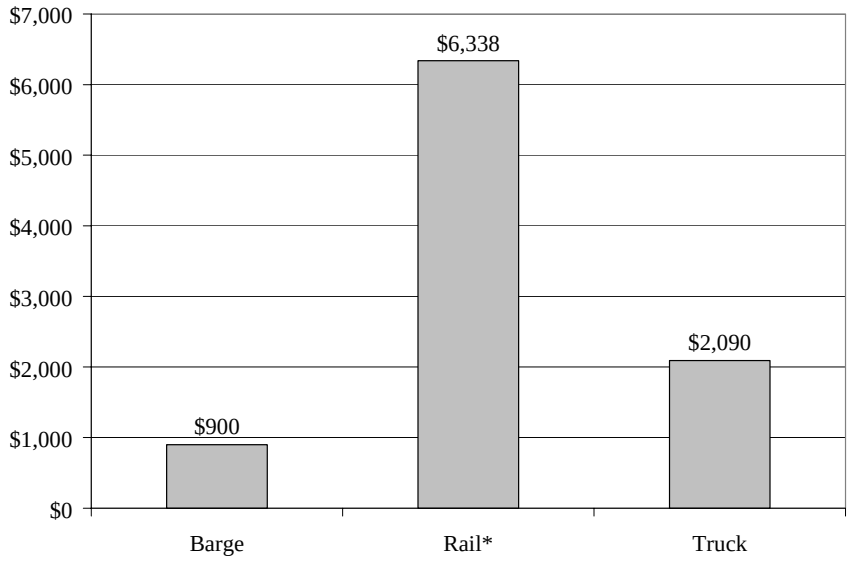
COB operations have been successful in Europe because of the high population density along inland waterways (Bomba and Harrison, 2002). Unfortunately for COB operators in Texas the population is concentrated in four cities, of which only one is close to the coast. The four cities are Dallas-Fort Worth, Houston, San Antonio, and Austin. Of these four only Houston is located along the Gulf Intercoastal Waterway (Bomba and Harrison, 2002).

The relative cost advantage of a barge operation is diminishing as the inland origins and destinations move away from the port, coast, or waterway because as the land feeder legs lengthens, the costs of the barge intermodal service increases.

6.4.7 Lower Operating Costs/ Rates

Barge operations have been successful in Europe, partly because they are more cost competitive compared to truck (Barnard, 2001). In Europe, the fuel costs, roadway user fees, labor costs, and other external costs that are transferred to road and rail are higher than those in the U.S. Higher costs increase the cost of trucking and rail which result in COB services becoming a viable alternative, even when accounting for time (inventory) and transfers (infrastructure). Higher costs in the form of user fees, taxes, and labor costs for truck and rail modes allow port and barge operators to charge fees that allow them to recoup investments in both infrastructure and equipment (Bomba and Harrison, 2002).

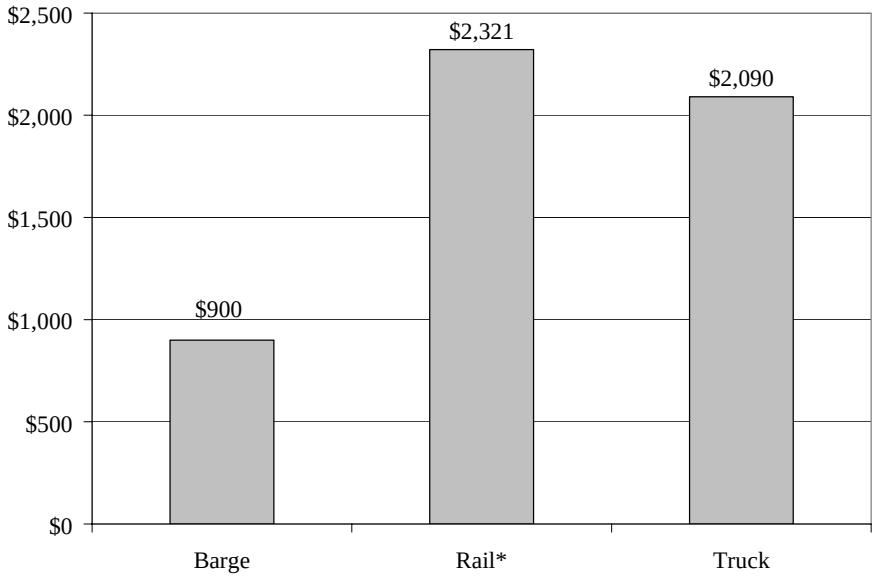
Successful COB operations in the U.S. and Europe have rate structures and service patterns that compete with other modal services (Crew, 1988). Shippers using the COB services offered on the Columbia-Snake River system (Portland) claimed that barges are less costly than either truck or rail (Kaser, 2000). Figure 6.3 illustrates that the barge rate charged to move 1 container from Pittsburgh to Houston is 7 times cheaper compared to rail and 2.3 times cheaper compared to truck.



*Rail rates based on 190,000-ton weight capacity.
Note: Rates are based on actual quotes. Rail rates are the average of at least two quotes. Truck rates are the average of three to four carrier quotes. Rates are updated quarterly.
Source: Port of Pittsburgh – SmartBarge (www.smartbarge.com); Personal Communication, Port of Pittsburgh (May 16, 2002)

Figure 6.3 Illustrative Container Rates by Mode from Pittsburgh to Houston (1 container)

Both barges and trucks have very high variable costs[5], because unlike rail, which owns the infrastructure, trucks and barges contribute to infrastructure in the form of a user fee (i.e., fuel taxes, vehicle licenses, wharfage, etc.). The principal advantage of public financing, as far as the railroads are concerned, is that fixed costs are converted to variable costs. User-charges are variable costs which will benefit the railroads as they will only pay for the use of publicly financed facilities when they use them. This puts the railroads on a more competitive footing with trucks, whose costs are almost 100% variable. As can be seen from Figure 6.4, the barge rate charged to move ten containers from Pittsburgh to Houston is approximately 2.5 times cheaper than rail and 2.3 times cheaper than truck.



*Rail rates based on 190,000-ton weight capacity.
Note: Rates are based on actual quotes. Rail rates are the average of at least two quotes. Truck rates are the average of three to four carrier quotes. Rates are updated quarterly.
Source: SmartBarge - Port of Pittsburgh (www.smartbarge.com); Personal Communication, Port of Pittsburgh (May 16, 2002)

Figure 6.4 Illustrative Container Rates by Mode Pittsburgh to Houston (10 containers)

6.4.8 Feeder Barge Service

The trend toward the use of mega-containerships (6,000 TEUs or more) on some trade routes, which stop at only one large port per continent, can potentially provide a niche market for barges by providing a feeder service to smaller ports (McIntyre, 1996).

[5] *"Variable (also called marginal) costs increase with consumption. Fixed costs do not. For example, fuel travel time and crash risk are variable vehicle costs because they increase directly with vehicle mileage, while depreciation, insurance, and residential parking are considered fixed, because vehicle owners pay the same, regardless of how much a vehicle is used"* (Victoria Transport Policy Institute, 2003).

A CTR research report, "Mega-Containerships and Mega-Containerports" found that the container volumes at Texas ports are not in the mega-containership range nor are they likely to be there in the near to medium term. Instead the report suggested a hub and spoke system, with a Caribbean or Central American port, for example Freeport in the Bahamas or Panama city, serving as the hub site, and Texas ports being connected by some of the spokes. This could provide a wide variety of COB opportunities (Harrison et al., 2000).

6.5 Impediments To Successful Container on Barge Operations

Although a few cases of profitable COB services exist in the U.S., the overall success rate of these operations have not been high. In 1985, a Texas COB service, which operated between Houston and Brownsville, failed. The reason given was that steamship agencies were not interested in moving containers by barge, but rather by truck or rail (Bomba and harrison, 2002). Almost 10 years later, in 1994, Burlington Northern suspended its 18-month-old rail barge service between the Port of Galveston, Texas, and the Port of Coatzacoalcos, Mexico. The suspension was attributed to high operating costs (BN Ends Mexico Barge Service, 1994). During the 18 months of operation, roughly 3,500 railcars were transported across the Gulf by barge (Taylor, 1996). The next section highlights some of the reasons why COB operations have failed in the U.S. and more specifically, in Texas.

6.5.1 Slower Transit Times

With the advent of global supply chains, distribution and transportation have become vital to shippers. Increasingly shippers want their goods and commodities to be transported faster or be delivered during a designated time window. Trucks are flexible and can easily accommodate production schedules of manufacturers that require their goods and components to be delivered during a designated time window. This allows for "just-in-time" manufacturing (Bomba and Harrison, 2002).

Barge transport takes a longer time than the other surface modes. It would take a barge traveling at 8 knots 3 or more days to travel from Jacksonville to New York. The same trip takes only 20 hours by truck and between 24-36 hours by rail (Baldwin, 1998). Longer transit times imply increased inventory costs associated with commodities transported by barge. In addition, the container has a certain opportunity cost: longer transit times results in lower effective utilization of the containers. It is generally accepted that COB services are not capable of meeting the needs of time-sensitive or just-in-time manufacturing (Bomba and Harrison, 2002). But in Europe, frequent barge shuttle services and increasing congestion on highways reduce transit-time penalties associated with barge operations (Barnard, 2001).

6.5.2 Rail Competition

Rail operators have been accused of reducing tariffs to price barges out of a market. In the U.S., barge operations have faced stiff competition from railroads when trying to move bulk goods, especially agricultural commodities. Railroads have used price-cutting strategies to challenge and ultimately defeat COB operations along the Mississippi River. Since COB operators tend to be small firms, it is most likely that they would not be able to

successfully compete in a price war with a Class I railroad for any extended period of time (Bomba and Harrison, 2002).

6.5.3 Shortage of Container Equipment

Special equipment is required to load containers on and off barges. The cost of such equipment to efficiently service barge operations is very high. Container cranes cost millions of dollars. In addition to these million-dollar cranes, ports also require berths, container stackers, and trailer chassis. The additional equipment would total several million dollars and it is not known if smaller ports could recoup such an investment (Bomba and Harrison, 2002). Barge operations will therefore be limited to ports that have the necessary container equipment.

Currently there are only three ports in Texas that have the container equipment required. The three ports are Houston, Galveston, and Freeport. The smaller Texas ports that sporadically handle containers tend to use ship-based or general-use cranes for moving containers. Smaller Texas gulf ports may not have the desire or the financial resources to invest in container infrastructure, especially since the American Association of Port Authorities found that in 1999 only a few (three out of seven) of the Texas ports were profitable (Bomba and Harrison, 2002).

6.5.4 Texas's Inland Waterways

The majority of Texas's inland waterway system consists of the Gulf Intracoastal Waterway (GIWW). Texas does not have a navigable inland waterway and it does not appear financially or environmentally feasible to dredge the Texas rivers to allow for barge operations. Rivers in Texas are usually narrow, shallow, and heavily vegetated. They have muddy bottoms and in some areas shallow rock outcropping. The channels are usually obstructed with trees and other debris. Moreover, many of Texas's rivers are dammed without any ship locks. This means that even if a barge could negotiate the river, it would be stopped by a reservoir (Bomba and Harrison, 2002).

6.5.5 The Jones Act

The Jones Act (Merchant Marine Act of 1920) prevents foreign-owned shipping companies and foreign-built vessels from operating between U.S. ports. In other words, a foreign vessel cannot provide a service (transport U.S. commodities) between two U.S. ports (Bomba and Harrison, 2002). The Jones Act prevents the world's major container shipping companies, which are all foreign owned, from operating a COB service between two ports in the U.S. According to Bomba and Harrison (2002), these large carriers have not only the expertise, but also the financial resources to provide a COB service that can compete effectively with railroads. Attempts to amend or repeal the Jones Act have failed because of strong opposition from domestic shipping companies, maritime labor unions, U.S. shipbuilders, and national defense advocates. It is foreseen that this opposition may have grown stronger after the terrorist attacks of September 11.

On the positive side, the Jones Act has facilitated the only regularly operating COB service in Texas. The Osprey Lines fills a niche market by moving empty containers between U.S. ports for a major foreign-owned shipping company (Bomba and Harrison, 2002).

6.5.6 Overall Container on Barge Cost

Bomba and Harrison (2002) argued that it is doubtful whether a Texas COB service could provide an attractive alternative to truck and rail in terms of costs, if COB rates reflected infrastructure costs and shippers accounted for time costs of containers in transit. Bomba and Harrison (2002) further argued that given the relatively low cost of truck and rail transport in the U.S. it will be very difficult or even impossible for a COB service to compete if infrastructure costs are reflected in COB rates. Access to costs and rate information is problematic, since such information is usually regarded proprietary. It is, however, known that the port charges, (including wharfage[6] and stevedoring costs), and the cost to transfer containers are substantial components in the cost structure of barge services. The cost to load and unload containers is heavily influenced by labor rates, port work rules, and productivity. This issue needs to be further explored.

6.6 Concluding Remarks

The chapter examined the benefits, system requirements, criteria for a successful COB operation, and the impediments to a successful COB operation. The benefits of a COB service include lower energy consumption, no adverse water quality impacts, reduced congestion, enhanced safety, and fewer emissions. A successful COB operation requires certain investments, of which container cranes are probably the most cost prohibitive. These requirements are briefly highlighted. The chapter also provides a synthesis of the criteria considered necessary to ensure a successful COB operation, including the need to move bulk commodities, long distances, frequent scheduled services, advance information systems, intermodal services, dense populations near coastal areas, lower operating costs/rates, and a feeder barge service. Finally, the chapter concludes by highlighting impediments to a successful COB operation such as slower transit times, rail competition, shortage of container equipment, no navigable inland waterway in Texas, limitations imposed on foreign owned barges by the Jones Act, and the overall cost of a COB operation.

[6] Wharfage rates: *"A charge assessed against the cargo or vessel on all cargo passing or conveyed over, onto, or under wharves or between vessels (to or from barge, lighter, or water) when berthed at wharf or when moored in slip adjacent to wharf. Wharfage is solely the charge for use of wharf and does not include charges for any other service*" (Port of Houston Authority Tariff No. 14: Rates, Rules and Regulations Governing the Fentress Bracewell Barbours Cut Container Terminal, 1998).

7. Containerized Freight Modal Diversion Scenarios

7.1 Introduction

In 1991 the Intermodal Surface Transportation Efficiency Act (ISTEA) introduced the need for freight transportation planning in statewide and metropolitan planning. Subsequently, the Transportation Efficiency Act for the 21st Century (TEA-21) built upon this requirement. Before ISTEA the primary focus of planning efforts was on issues in the passenger sector. Although a number of freight demand and freight mode choice models have emerged since ISTEA and TEA-21, these models still lag behind the better developed passenger models.

The most commonly cited challenge in the development of freight modeling is insufficient and inferior data. Unlike passenger demand, freight demand is more complex to model because of factors such as units of measure, value of time, loading and unloading, different equipment types, and the relatively small number of decision makers involved. For example, there could be three different units of measure for freight demand: number of shipments, weight or volume – as opposed to the single measure of passenger demand, the number of passengers. The value of time for freight can also vary dramatically by commodity. Some commodities have a low value of time, such as coal, and some have a high value of time, such as cut flowers. Although there is some difference in the value of time for passenger demand, it does not vary quite as dramatically as for freight demand. Freight also requires different types of facilities and equipment for loading and unloading cargo. Freight can be moved in containers, vans and boxcars, or special purpose vehicles. Finally, in contrast with passenger movements there are fewer decision makers (shippers, receivers, agents, and carriers) in the freight sector who as individual entities control a greater portion of the demand. It is thus necessary in freight demand modeling to have a better understanding of the factors that influence the individual decision makers than in the case of passenger demand modeling (Cambridge Systematics Inc., 1997).

The objective of this chapter is to review available freight mode choice models that can be used to estimate the amount of containerized freight that can be diverted from highway corridors under various scenarios. This chapter provides a brief overview of three recognized freight mode choice models and discusses the GIS platform (TransCAD) that will be used in the second phase of this study to evaluate containerized mode split under different scenarios.

7.2 Freight Mode Split Models

A review of the literature on freight models revealed that freight research tends to fall in one of two categories: commodity-based analyses focusing on the flow of goods, or truck traffic analyses focusing on the flow of vehicles. The former have been mostly applied at the regional and state level, while truck models have been applied at the urban scale. The latter models have sequential steps for trip generation, distribution, mode choice, and network assignment – analogues to the person travel models (Donnelly, undated). See Appendix C for a summary review of published freight model literature.

This report focuses on state level flows of containers, and this section provides an overview of three models:

- the American Association of Railroads Models: Intermodal Competition Model and the Cross Elasticity Model,
- the U.S. DOT's Intermodal Transportation and Inventory Cost Model, and
- the Fractional Mode Split Freight Distribution Model developed at the University of Texas at Austin.

7.2.1 American Association of Railroads Models

The American Association of Railroads (AAR) developed two discrete choice models to predict modal diversion: the Intermodal Competition Model (ICM) and the Cross Elasticity Model (CEM). Unlike traditional models that use the cost characteristics of individual companies, these models use the cost characteristics of individual shipments. The shipment characteristics are linked to the company's total logistics cost. The logistic costs are related to a probability that a shipment will move by a particular mode (Harrison and Euritt, 1992).

Cross Elasticity Model

The Cross Elasticity Model (CEM) is an AAR market-share economic model. It is a macroscopic model that was developed to estimate the impact of changes in federal legislation on the entire U.S. railway network. The model predicts the potential diversion of truck traffic to railroads and complements the Intermodal Competition Model (discussed below) which is limited to analyzing diversion of traffic from railroads to truck.

The CEM uses a logit equation to calculate the distribution of traffic between the two modes. The probability of a shipment moving by a specific mode is determined by the ratio of the rail to truck total logistics cost (Harrison and Euritt, 1992).

The initial probability of moving by a mode is calculated using the base case rail and truck total logistics costs. When rail costs and therefore rates decrease the rail-to-truck logistics cost ratio is changed in favor of rail. This is similar to rail costs remaining constant and the truck logistics costs being increased. In both cases, the probability of a shipment moving by rail increases. The percentage of truck traffic diverted to rail is calculated by subtracting the initial probability of shipping by truck from the "new" probability (Harrison and Euritt, 1992).

The CEM model examines truck diversion to rail at an aggregate level and is not designed to analyze state or carrier specific outcomes. The AAR has come to believe that state level policy analysis is needed. State-level railroad impacts associated with different policy scenarios are estimated by disaggregating the CEM output using state diesel fuel consumption data (Harrison and Euritt, 1992).

In 1994 the American Trucking Association (ATA), the Transportation Research Board (TRB), and the Federal Highway Administration (FHWA) agreed, while noting the model's limitations, that the CEM was the best model available for estimating traffic diversion from truck to rail at the national level (U.S. GAO, 1994).

Intermodal Competition Model

The ICM analysis of potential rail-to-truck diversion is limited by a lack of truck traffic data similar to the Rail Waybill Sample. Some attempts have been made to address this concern, by building a truck analog from data contained in the national motor transport database, and an analysis of the size and composition of the truckload freight industry. When used in diversion studies, this AAR model has, however, two disadvantages. First, it is static – that is, it calculates the diversion that would have occurred if a lower cost truck option had been available at the time of the rail shipment. Secondly, the model was basically designed to compute diversion in one direction – rail to highway.

7.2.2 Intermodal Transportation and Inventory Cost Model

The Intermodal Transportation and Inventory Cost Model (ITIC) was used to test the impacts of different scenarios in the U.S. DOT's Comprehensive Truck Size and Weight Study. Truck input data from several different sources were used because a single database capturing all the required variables was not available. The required variables include over-the-road shipments, transportation cost, line-haul miles, repositioning miles, and commodity attributes (U.S. DOT, 1999).

Data Sources Used

Several data sources were used in the development of the ITIC Model: 1993-1994 AAR's North American Transportation Survey (NATS), a report by Jack Faucett Associates (1991), 1993 Commodity Flow Survey (CFS) Report, and the 1994 Rail Waybill Sample.

The 1993-1994 NATS captures road shipment information including the origin and destination pairs, truck body type, and the commodity hauled (U.S. DOT, 2000). Three adjustments were made to the NATS data. First, the data was adjusted for trip length to correct possible bias associated with sampling primarily longer trips in the survey. Second, the data was adjusted to account for partial loads because NATS did not capture whether the trailer was loaded. Finally, the data was expanded to estimate total truck vehicle miles traveled (VMT). This data was combined with data on: (1) transportation cost; (2) line-haul miles; (3) repositioning miles; and (4) commodity information from the 1993 Commodity Flow Survey (U.S. DOT, 2000).

Truck transportation cost-per-mile was obtained from a 1991 report by Jack Faucett Associates entitled "The Effect of Size and Weight Limits on Truck Costs" (US DOT, 2000).

Line-haul miles were calculated for each truck configuration using the existing network data and the origin and destination cities from the NATS data. Repositioning miles were estimated and added to the line-haul mile estimates to represent the distance a truck would travel before obtaining a return shipment (US DOT, 2000).

Commodity information from the Bureau of Census' 1993 Commodity Flow Survey (CFS) Report was added, including annual truck utilization rates, and shipping density for commodities (U.S. DOT, 2000).

The Surface Transportation Board's (STB) 1994 Rail Waybill Sample was the primary source of railroad data. The ITIC Model uses seven variables from the Rail Waybill Sample: origin and destination pairs, commodities shipped, annual tons shipped,

number of railroads, equipment type, sample-to-population expansion factors, and the variable cost for the rail shipments (U.S. DOT, 2000).

The following Rail Waybill records were excluded: (1) shipments under 200 miles, because short rail moves are not competitive with truck; (2) coal shipments traveling more than 500 miles, since this heavy bulk freight is not directly competitive with truck; (3) autorack shipments, since autoracks are not explicitly analyzed in the illustrative scenarios; and (4) movements of locomotive and empty rail equipment (U.S. DOT, 2000).

ITIC Model Structure

The ITIC Model contains two modules: transportation costs and inventory costs. The transportation costs module is different for truck and rail while the inventory cost module is the same for both truck and rail (U.S. DOT, 1999).

Door-to-door transportation costs include truck transportation cost, carload transportation cost, intermodal transportation cost, and claims costs. Truck transportation parameters include gross vehicle weight, tare weight, trailer dimensions, cube capacity, cost-per-mile, pickup/delivery cost-per-mile, pickup/delivery cost per shipment, load and unload hours, hourly dock wages (U.S. DOT, 1999).

Inventory costs include the costs of holding and ordering inventory. Inventory holding costs include safety stock, cycle stock, and in-transit stock. Inventory-carrying cost factors and service levels include truck speed, transit time, wait time, rail service quality index, rail speed, lead-time reliability, and cost-per-order (U.S. DOT, 1999).

ITIC Limitations

Some of the limitations of the ITIC model are highlighted below (U.S. DOT, 2000).

- The assumption that any changes in truck size and weight limits would not change container sizes.
- A lack of specific TOFC/COFC commodity rail data. Instead of specific commodity information the Rail Waybill records typically indicate “freight all kinds” or “TOFC shipments.” Without available TOFC/COFC commodity density data it was assumed that all shipments are constrained by cubic capacity.
- Concerns in terms of the model under estimating rail diversion, because of a large number of mis-assigned shipments– model incorrectly assign rail shipments to trucks in the base case.
- The ITIC Model employs an all-or-nothing rule to determine if a shipment will be diverted. A shipment will be predicted to divert from rail if the cost of transporting it is 1¢ cheaper on an alternative truck configuration or mode. All similar shipments would also be assumed to divert and therefore overstate the potential for diversion.
- The model is only able to capture a shipper’s service considerations in general. For example, a service consideration, such as spoilage, is not considered in the ITIC Model (U.S. DOT, 2000).

7.2.3 Fractional Mode Split Freight Distribution Model

The Fractional Mode Split Freight Distribution Model was designed to predict the fraction of freight moved by truck and rail between a port, and the markets served by the port given port trade volumes, socio-demographic information about the markets the port serves, and transportation level-of-service offered by competing modes. The original intent of the model was to predict how the introduction of mega-containerships into maritime container freight trade would affect the landside traffic patterns in and around Texas ports (Sivakumar and Bhat, 2000). In this project, the model will be used to predict how containers move on Texas's road and rail networks. The structure of the Fractional Mode Split Freight Distribution Model was not changed, but conversion factors were calculated and will be applied to the model's output to estimate containerized tonnage and container flows by road and rail (see Appendix G). Two different conversion factors were developed: to convert total commodity tonnage to containerized tonnage and containerized tonnage to number of containers.

Fractional Mode Split Freight Distribution Model Structure

The model has a logit functional form (see Figure 7.1). In this model, ß is the parameter vector representing the effect of exogenous variables on rail mode share.

$$G(\beta, x_q) = \frac{1}{1 + e^{-\beta' x_q}}$$

Source: Sivakumar and Bhat, 2000

Figure 7.1 Fractional Mode Split Freight Distribution Model Structure

The dependent variable of the Fractional Mode Split Freight Distribution Model is the fraction of total county-to-county freight tonnage transported by rail. The latter is bounded from zero to one. County-to-county truck tonnage is thus calculated as the difference between one and the rail tonnage. For example, when the rail fraction is equal to zero, all freight moving between a specific county pair would move by truck.

Data Sources Used in Estimation

The model was estimated using five data sources: (1) Reebie TRANSEARCH Freight Database 1996; (2) TransCAD geographic maps and data sets; (3) U.S. Census Bureau County Business Patterns Database; (4) U.S. Census Bureau Population Projections; and (5) data made available by the U.S. Bureau of Economic Analysis (Sivakumar and Bhat, 2000). The Reebie TRANSEARCH Freight Database is widely used as a source of U.S. freight data. It is a multi-modal freight database that displays commodity tonnage by mode and between origins and destinations at the county, Business Economic Area (BEA), metropolitan area, and state or provincial levels. The modes included are for-hire truck load, for-hire less than truck load, private truck, rail carload, rail/truck intermodal, air, and water. Geographic maps and data sets – part of the TransCAD software – were used to

calculate centroidal distances and geographic areas. The centroidal distances were computed for county-to-county pairs, and county-to-external unit code (EUCs) pairs. The County Business Patterns Database is the primary source of socio-economic information for Texas counties. Variables used from this database include establishment counts by institution size, and mid-March employment statistics. The U.S. Census Bureau Population Projections apply future birth, deaths, international migration, and domestic migration assumptions to a base-year population. To correspond to the 1996 Reebie TRANSEARCH Freight Database, 1996 population projections were used for model estimation (Sivakumar and Bhat, 2000).

Fractional Mode Split Freight Distribution Model Parameters

Table 7.1 displays the estimation results of the Fractional Mode Split Freight Distribution Model for the best model specification by commodity type

Table 7.1 Estimation Results: Best Specification Model by Commodity Type

Variables	Agricultural & Related Products		Hazardous Materials		Construction Materials		Food & Related Products		Manufacturing Products	
	Parameter	t-stat	Parameter	t-stat	Parameter	t-stat	Parameter	t-stat	Parameter	t-stat
Constant	-3.4033	-6.70	-5.2345	-24.68	-4.5855	-27.58	-6.6887	-10.24	-6.1582	-22.80
Impednace distance	-	-	-	-	-0.2059	-3.69	0.2947	2.89	-0.1616	-2.16
Origin socioeconomics										
Origin population	-77.9598	-5.06	4.4291	2.16	-7.3743	-2.46	-4.5946	-1.70	5.7014	1.89
Origin Area	-	-	0.2851	1.98	0.5463	7.02	-0.7420	-1.23	0.5048	3.34
Origin personal income	2.3087	3.67	-0.1135	-1.38	0.1735	1.37	0.3432	2.40	-0.1520	-1.55
Origin payroll	-0.8890	-4.48	0.0471	1.10	-0.2714	-3.36	-0.1833	-2.92	-	-
Origin employee count	-106.1313	-2.48	-15.6901	-5.05	-	-	-	-	-	-
Origin # estab (1-500)	14.9046	4.14	1.1626	2.77	1.2108	2.93	-	-	-0.7482	-1.06
Origin # estab (500-1000)	25.7713	1.59	-	-	-	-	3.559	2.31	6.0321	2.52
Origin # estab (>1000)	21.4750	4.35	3.9868	4.32	2.2923	2.47	-	-	-3.2057	-3.42
Destination socieconomics										
Dest population	-	-	8.0581	4.49	-	-	-5.8814	-1.56	5.2057	2.50
Dest area	-0.4809	-1.13	0.2103	2.13	-	-	0.5251	3.98	0.4174	3.75
Dest personal income	0.1870	2.11	-0.1634	-1.79	-0.1411	-2.44	-	-	-0.1715	-1.69
Dest payroll	-	-	0.0946	1.98	-	-	-0.1536	-2.30	-0.0539	-1.04
Dest employee count	-	-	-9.3254	-3.21	-16.0850	-3.82	-17.8542	-1.74	-4.8414	-1.24
Dest # estab (1-500)	-	-	-	-	1.2074	4.57	1.8093	2.00	-	-
Dest # estab (500-1000)	-	-	-	-	8.3067	3.40	12.1688	2.20	4.2836	1.53
Dest # estab (>1000)	-1.9983	-3.11	2.0354	2.17	-	-	-	-	-	-
Other variables										
Shipment size (tons)	0.8261	10.30	0.0002	1.89	0.0031	6.10	-	-	-	-
Intracounty dummy	-	-	0.7453	1.32	-	-	-	-	-	-
Log-Likelihood	-105.4595		-1024.130		-1039.385		-284.3056		-605.1219	
Restricted Log-Likelihood	-577.317		-1763.628		-1811.437		-533.2275		-1089.553	
Chi-sqd	943.7151		1478.9970		1544.1030		497.8439		968.8631	

Source: Sivakumar et al., 2001

As indicated earlier, the dependent variable is the fraction of total tonnage moved by rail between each pair of counties within Texas. The goal of this analysis is to determine which exogenous variables – travel impendence, distance of haul, shipment size, and county socioeconomic characteristics – are relevant. The county socioeconomic variables

include population, geographic area of the county, annual personal income and payroll, employee count, and the number of establishments in the origin and destination counties (Sivakumar et al., 2001).

Two of the seven commodity groups (machinery and equipment and mixed freight shipments) were not reported because road transport clearly dominates the market with 99.9% of the county-to-county commodity flows having a rail share of zero (Sivakumar et al., 2001). For the five remaining commodity groups, all constant values were negative indicating an inherent preference for the truck mode. Distance did not appear to impact the rail mode share for two commodities: agricultural and related products and hazardous material. Distance does appear to have a positive effect on rail mode share in the case of food and related products, and a negative effect in the case of construction materials and manufactured products.

The socioeconomic variables indicate that rail is the preferred mode when origins and destinations have a larger number of establishments. It could thus be that counties with large number of establishments have better rail networks. Rail is also the preferred mode of larger size shipments for agricultural products, hazardous materials, and construction materials. Additional information on the development of the Fractional Mode Split FreightDistribution Model can be found online at:

http://www.utexas.edu/depts/ctr/pdf_reports/1833_4.pdf.

The Fractional Mode Split Freight Distribution Model was chosen to evaluate the containerized mode split under different scenarios for the following reasons. First, the model is Texas specific, which is a clear benefit. Second the model could be embedded in the TransCAD software. TransCAD has graphic capabilities that allow the user to display estimated container flows on the Texas infrastructure. Third, no proprietary cost data are required to perform the "what-if" analysis. Finally, it is a comprehensive yet relatively simple approach to modeling inter-regional commodity flow volumes[7] (Sivakumar and Bhat, 2000).

7.3 GIS Platform (TransCAD)

TransCAD is used to display containerized movements and as a platform to evaluate containerized mode split under different scenarios. The GIS platform (TransCAD) is capable of displaying actual container flows on the Texas road and rail network, displaying estimated road and rail container flows, and allows the analyst to perform "what-if" analysis. The Fractional Mode Split Freight Distribution Model, discussed previously, is embedded in the GIS platform.

[7] In 2001, one of the model's co-creators, Aruna Sivakumar, won the Milton Pikarsky Memorial Award for her Master's thesis "A Fractional Split Distribution Model for Statewide Commodity Flow Analysis." The Milton Pikarsky Memorial Award is presented annually to four graduate students in transportation: two awards for Ph.D. dissertations, and two for M.S. theses (http://cutc.tamu.edu/awards/).

7.3.1 Display Current Container Data

The GIS platform is capable of displaying actual container flow data on the Texas road and rail network. As indicated previously, the only container database that captures all the required variables (i.e., container origin, destination, commodity tonnage) is the Rail Waybill Sample.

A Rail Waybill Sample input table was compiled as follows: container records were selected from the Rail Waybill Sample; county records outside of Texas were aggregated to the state level; and commodity information was aggregated into seven major commodity groups. Table 7.2 provides an excerpt from the Rail Waybill Sample input table. Figure 7.2 shows the container flows displayed on the rail infrastructure. Available container data need to be structured in the form of the input table before it can be visually displayed on the network.

Table 7.2 Example of the Waybill Sample Input Table

Origin	Destination	Commodity Type	Road	Rail (Containerized Tonnage)
6	48201	1	0	240
20	48201	1	0	40
22	48113	1	0	1960
41	48113	1	0	40
48113	6	1	0	80
48201	6	1	0	160
48201	17	1	0	40
48201	39	1	0	120

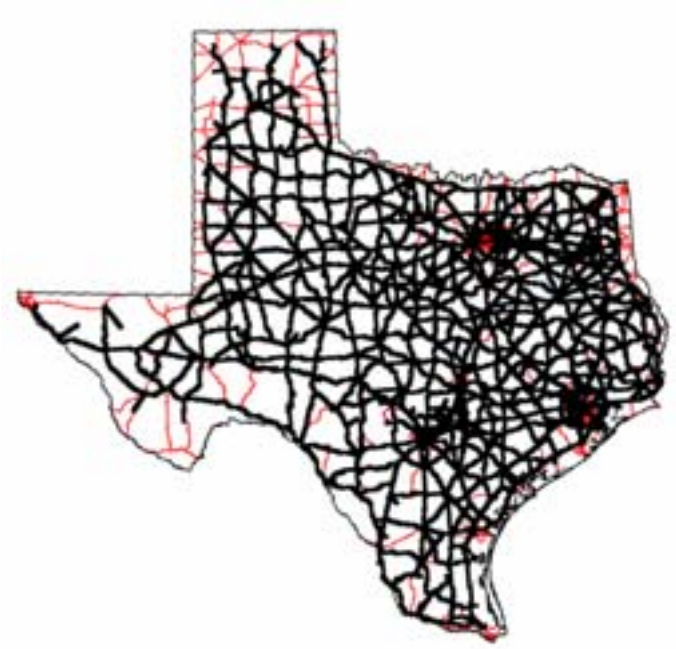
Source: Rail Waybill Sample

Figure 7.2 Rail Waybill Container Flows

Additional documentation on the preparation of input tables and displaying container flows is provided in the User Guide on the CD that contains the architecture of the model (a research product developed as part of this project and submitted separately to TxDOT).

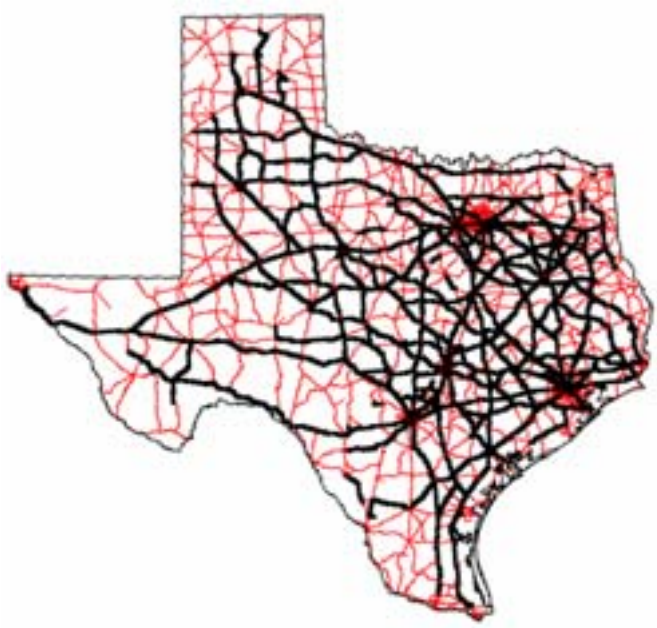
7.3.2 Simulated Truck and Rail Container Flows

The GIS platform can also be used to display estimated/simulated container data. Truck and rail container flow data were estimated using the 1996 Reebie data (see section 4.3 for a detailed description of the procedure followed). The annual estimated truck container flows are displayed in Figures 7.3, 7.4, and 7.5.



Source: Reebie TRANSEARCH Freight Database, 1996

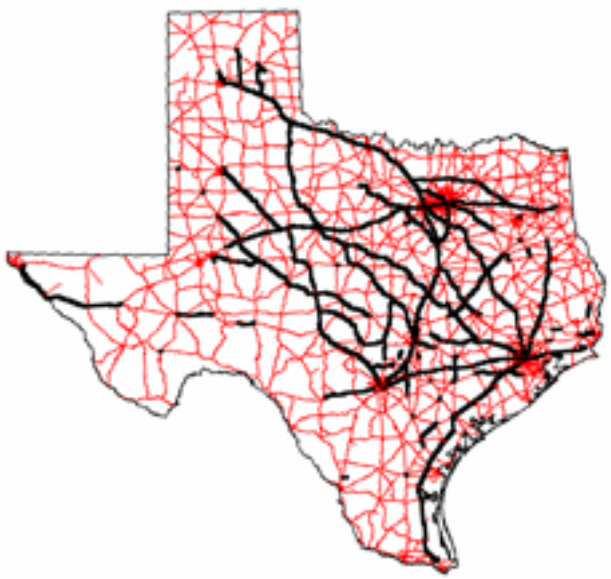
Figure 7.3 Annual Reebie Container Flows on the Road Network



Source: Reebie TRANSEARCH Freight Database, 1996

Figure 7.4 Annual Reebie Container Flows Greater than 1,000 containers on the Road Network

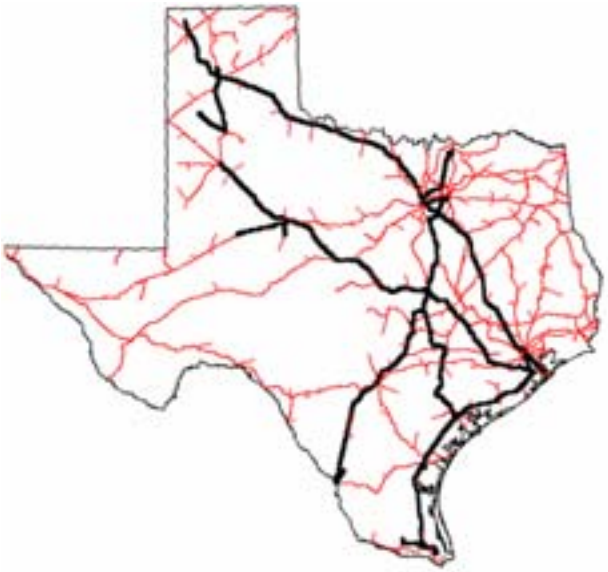
As can be seen from Figure 7.3, truck containers are moved on most of the road network considered. Roads that carry more than 1,000 containers per year are displayed in Figure 7.4.



Source: Reebie TRANSEARCH Freight Database, 1996

Figure 7.5 Annual Reebie Container Flows Greater than 3,000 containers on the Road Network

Figure 7.5 highlights the road network that carries more than 3,000 containers per year.



Source: Reebie TRANSEARCH Freight Database, 1996

Figure 7.6 Annual Reebie Container Flows on the Rail Network

Figure 7.6 displays the estimated rail container data based on the Reebie TRANSEARCH Freight Database and the calculated conversion factors discussed previously.

When Figure 7.2 is compared to Figure 7.6, it is evident that the simulated container rail flows needs future calibration, because no rail container flows are shown on two of the major East-West intra-state rail corridors converging at El Paso. Unfortunately, there is no truck database that is equivalent to the Rail Waybill Sample to calibrate truck flows. The simulated truck container data is definitely and underestimation of container truck flows. This is particularly evident from the estimated container truck flows on the Laredo to San Antonio corridor. Both the truck and rail containers flows will be calibrated during the next phase of this report before the scenario analysis will be undertaken.

7.3.3 "What If" Scenarios

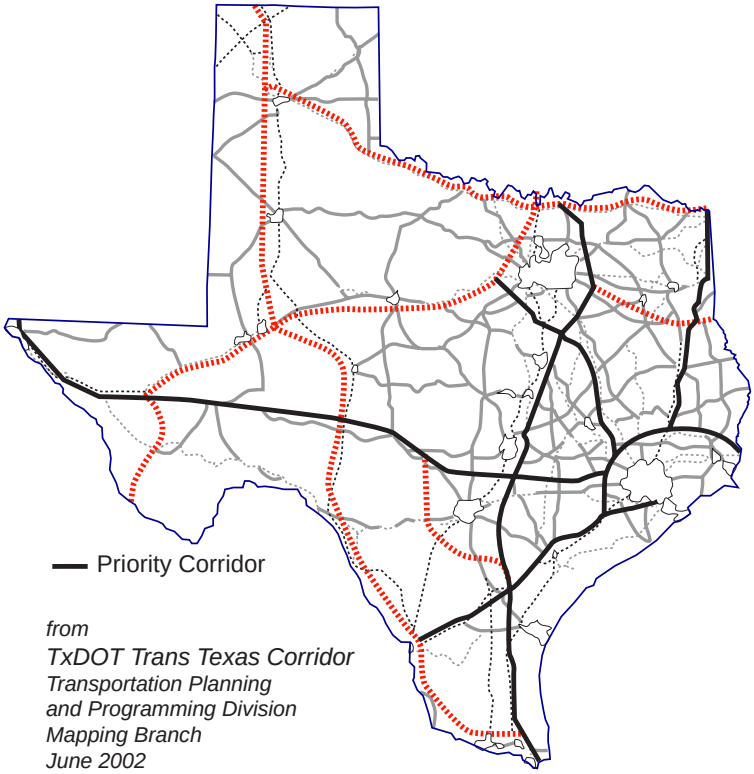
The GIS platform and its embedded Fractional Mode Split Freight Distribution Model also allows for "what-if" analysis to be conducted. Modal impacts associated with various policy options can be modeled including a port expansion project, road and rail infrastructure investments, or changes in the socio-economic characteristics of a region.

Possible scenarios to be considered in the next phase of this study include:

- The predicted container mode split associated with the building of the Bayport Container Terminal. This type of analysis can help TxDOT determine the impact of proposed investments on the state's road infrastructure and the implications in terms of funding. It can also inform strategies for improving freight mobility.
- Predict container mode split on a single segment of the Trans Texas Corridor. Four priority corridors have been identified (see Figure 7.7). They are (1) I-35, I-37, and I-69 from Denison to the Rio Grande Valley, (2) I-69 from Texarkana to Houston to Laredo, (3) I-45 from Dallas-Fort Worth to Houston, and (4) I-10 from El Paso to Orange. Fluor Enterprises Inc. of Sugarland, Texas, has submitted an unsolicited conceptual proposal to develop the corridor from Denison to the Rio Grande Valley, which parallels segments of I-35, I-37 and the proposed I-69 (Texas Department of Transportation Expressway, 2003). The container mode split on this segment can be analyzed and displayed using the GIS platform.

Box 7: Trans Texas Corridor

The Trans Texas Corridor Network is Governor Perry's vision for Texas. It would include roadways, a rail corridor, and a utility zone. The current plan calls for separate roadways for passenger vehicles and trucks. Passenger vehicles would have three separate 12-ft lanes in each direction. Trucks would have two 13-ft lanes in each direction. The rail component would include high-speed passenger rail, freight rail, and commuter rail with each having two tracks—one in each direction. The dedicated utility zone would be made up of water, electric, natural gas, petroleum, fiber optic, and telecommunications infrastructure. Current information is available at the Texas Department of Transportation Trans Texas Corridor Network Web site at http://www.dot.state.tx.us/ttc/ttc_home.htm



Source: Trans Texas Corridor Website

Figure 7.7 Trans Texas Corridor Priority Corridor

7.4 Concluding Remarks

Although freight demand models are starting to emerge as tools to inform transportation policies, the development of these models has lagged behind that of passenger demand models. The most commonly cited challenge in the development of freight models is insufficient data, given the lack of publicly available freight databases. This specifically pertains to truck data sources.

Despite this lack of data some mode split models exist and have been applied in modal diversion analysis. Three prominent mode split models were briefly discussed in this Chapter: the American Association of Railroads (AAR) Intermodal Competition Model and Cross Elasticity Model, the U.S. Department of Transportation's Intermodal Transportation and Inventory Cost Model, and the Fractional Mode Split Freight Distribution Model developed at the University of Texas.

The Fractional Mode Split Freight Distribution Model selected for scenario analysis in the current project predicts the fraction of total county-to-county freight volumes transported by rail. Truck mode share is inferred from the rail mode share. The Fractional Mode Split Freight Distribution Model is embedded in the TransCAD GIS platform.

The GIS platform is capable of displaying actual container flow data on the Texas road and rail network, displaying estimated container truck and rail data, and performing "what-if" analyses. Such analyses will be conducted during the next phase of the current project. Possible scenarios include the container mode split associated with the development of the Bayport Container Terminal and the construction of a segment of the Trans Texas Corridor.

8. Conclusions

Worldwide container demand has increased significantly over the past decade, due to growing international trade and the introduction of larger containerships on certain trade routes. Despite this widespread use of containers, it was found that relatively little is known about their surface movements. Some information exist on the container sector (manufacturers, deployment, the container shipping fleet, and routes), and the movement of containers through marine and border ports in a number of public and commercial data sources. Limited data, however, exists in terms of the movement of containers on rail (with the exception of the Rail Waybill Sample) and more critically on the movement of containers by truck.

The Texas Department of Transportation (TxDOT) thus contracted the Center for Transportation Research (CTR) at the University of Texas, Austin to examine containerized freight movements in Texas. The objective of this investigation was to gain a better understanding of how containers move across the state, what commodities are shipped in these containers, to what degree container shippers utilize the Texas-Mexico ports of entry, and to examine the potential for diverting containers from key highway corridors to rail. It was foreseen that an understanding of container flows in Texas would benefit TxDOT's transportation planners responsible for the future planning of transportation corridors and terminals.

The objective of this report was thus to summarize available information and data on the container sector and on container movements in and through Texas. A GIS platform (TransCAD) was used to map and display the available data. In the second phase of this study, the research team will examine the potential for diverting containerized traffic from Texas highway corridors to other modes, specifically rail.

In this current study, available data from secondary sources and information extracted through stakeholder interviews were summarized to gain an understanding of the container sector. Chapter 2 of this report provide a global perspective of the container sector, summarizing the available information on container manufacturers, container deployment, the size of the container fleet, container costs, liability, and container end life uses.

A detailed review of the available public and commercial freight databases confirmed the general lack of container flow data by surface mode. In Chapter 3, 4, 5, and 6 container movements through the Texas's maritime ports, by truck, rail and barge are summarized, respectively. From the maritime container data, it is evident that the Port of Houston dominates container handling in Texas. In 2001, the Port of Houston handled 87% of all the TEUs received and shipped at Texas's ports. A substantial share of these containers – 56% according to a port representative – remain in Harris county and are all transported by truck. Approximately 80% remained in Texas, while 20% have out-of-state origins or destinations. An origin/destination survey conducted by URS at Barbours Cut Terminal also provided evidence to support the information gathered during the stakeholder interviews that most of the Port of Houston containers have an origin or destination in the so-called Texas Triangle – Houston, Dallas, and Austin/San Antonio. A complementary copy of the Piers database (October to December 2000) was used to extract information on containerized import commodities. The data revealed that almost half of the containerized import tonnage (during this period) was manufactured products. Finally, a number of Texas's ports are looking into expanding existing container capacity (Port of Houston) or investing in container infrastructure (Texas City and Corpus Christi). Combining

the number of TEUs handled at the Port of Houston's Barbours Cut Terminal with the planned capacity at the proposed Bayport Terminal and Texas City International Terminal would place the container capacity of these three terminals in the range of that at the Port of New York/New Jersey. Given that approximately 80% of maritime containers originate or are destined for Texas destinations (and mostly transported by truck), the additional container capacity could significantly increase the concentration of containers moving on the state transportation system.

Trucks are a key component in the movement of containers, but information on container movements by truck is extremely limited. Chapter 4 discusses the benefits of container truck movements, and the data sources used to gain some insight into the movement of containers by truck to and from the maritime ports and through border ports of entry. Containerized truck flows to and from the Port of Houston was estimated based on the consultancy study by URS (mentioned earlier) and interviews with a port representative. Truck container flows crossing the Texas-Mexico border into the U.S. was estimated based on information made available by the BTS. The BTS data also revealed that 44% of the containerized tonnage moving into the U.S. across the US –Mexico border is manufactured products. Inter-city, intra-state and some of the Texas container through flows, however, needed to be estimated from the 1996 Reebie TRANSEARCH database – the only currently available database that captures truck commodity, tonnage, origin, and destination information. From the Reebie TRANSEARCH data it was estimated that more than half of the containers (55%) on the road network contained mixed freight.

Chapter 5 details the benefits and deficiencies of rail transport, provides an overview of the Texas rail system and intermodal infrastructure, and analyzes rail container flows captured in the Rail Waybill Sample. The chapter makes the argument that rail can potentially reduce highway congestion by diverting a large number of containers transported by truck to rail. At the same time, the chapter points out that the expected increase in rail intermodal container traffic over the next decade have raised concerns about the rail system's ability to handle the anticipated increased traffic levels. The fastest growing market for the railroads is intermodal transport. Data from the Rail Waybill Sample revealed that containers represent approximately two-thirds of all the intermodal movements originating and terminating in Texas. This share of intermodal movements grew in terms of both the number of units and the tons transported. In 1998, 340,000 containers originated in Texas and 353,448 terminated in Texas. California and Illinois are the major interchange states for both originating and terminating containers. The two major commodity groups transported in containers were mixed freight and manufactured products. In Texas, approximately 65% of the containers are moved by Union Pacific, 30% by Burlington Northern Santa Fe, and the remaining 5% by Kansas City Southern.

Although COB operations in the U.S. have not enjoyed the same level of success as their European and Far Eastern counterparts, there have been some success stories. One of these is Osprey Lines in Houston. The company provides feeder services for Gulf Coast ports and one weekly scheduled COB service between Houston and New Orleans. Chapter 6 highlights the benefits of COB operations, discusses the system requirements for a successful COB operation, and the criteria for and impediments to a successful COB operation. The benefits of a COB service include lower energy consumption, no adverse water quality impacts, reduced congestion, enhanced safety, and fewer emissions. If a port already handles containers it was found that no additional infrastructure is required for a COB operation. If, however, investments in container cranes are required to facilitate a COB operation, the cost can be prohibitive for smaller ports. The criteria discussed to ensure a successful COB service include the need for

bulk commodities, long distances, frequent scheduled services, advance information systems, intermodal services, dense populations near coastal areas, lower operating costs/rates, and a feeder barge service. Finally, the chapter concludes by highlighting the impediments to a COB service, including slower transit times, rail competition, shortage of container equipment, limitations imposed on foreign owned barges by the Jones Act, and the overall cost of a COB operation.

Finally, the objective of Chapter 7 was to review available freight mode choice models that can be used to estimate the amount of containerized freight that can be diverted from highway corridors during phase two of the current study. A detailed review of the literature revealed that freight models have lagged behind that of passenger models and that the most commonly cited challenge in the development of freight models have been insufficient and inferior data. The research team evaluated a number of freight mode choice models before selecting the Fractional Mode Split Freight Distribution Model developed at the University of Texas at Austin to evaluate container mode split under different scenarios. This model was selected mainly for the following reasons: the model is Texas specific, the model could be easily embedded in the TransCAD software used to display container flows on the Texas transport infrastructure, no proprietary cost data are required to perform "what-if" analysis, and finally, it is a comprehensive yet relatively simple approach to modeling inter-regional commodity flows. Finally, the chapter introduces the GIS platform used in the project to display available container flow data, the simulated truck and rail container flow data, and to conduct "what-if" analysis. Some concerns (specifically the under-estimation of truck and rail container flows) point to a clear need to calibrate the model and examine the Reebie TRANSEARCH data in the second phase of the project. Upon addressing these concerns, the GIS platform with its embedded mode split model will be used to evaluate containerized mode split under a number of different scenarios. Two possible scenarios include an evaluation of the containerized mode split given the development of the Bayport Container Terminal, and the construction of a priority segment of the Trans Texas Corridor. Appropriate scenarios will be developed in consultation with TxDOT during phase two of this study.

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Appendix A: Bibliography

Introduction

This bibliography provides abstracts of sources of information related to TxDOT research project 0-4410, entitled "Containerized Freight Movement in Texas." Included are peer-reviewed journal articles, trade journal articles, conference papers, professional reports, presentations, and relevant Internet sites that the search team considers to have made a contribution to the focus of this study. The sources are alphabetically categorized by key tasks in relation to the source's main emphasis. For each entry, a complete reference is provided. Abstracts were duplicated where available. The abstracts of sources that were thought to be particularly relevant to the project were supplemented with additional information contained in the source.

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Research at The University of Texas at Austin, Research Report 1833-3, December 2001.

Abstract: This is the third report for Texas Department of Transportation Project 0-1833, which is assessing containership activity in the Gulf of Mexico. The research project, undertaken by the Center of Transportation Research of The University of Texas at Austin, was designed with two primary goals. First, the project was to address the planning, institutional, and financial issues associated with increased containerized freight traffic moving thorough Texas ports. The second goal was to assess the demand on the multi-modal transportation system in Texas, contingent upon the operation of very large containerships in the Gulf of Mexico. This second goal was later modified to address the impacts of all types of containerships calling at Texas ports, including megacontainerships. This report considers the impact of ship size, liner service routes, and container demand for Texas Gulf seaports serving containerships. In particular, it describes containership fleets, vessel choices, containership technology and costs, containership routes to Gulf coast ports, and container demand. The report provides forecasts of future container demand in the North Atlantic and Gulf ports and summarizes the researchers' conclusions with respect to state transportation planning in Texas.

Harrison, R., M.A. Figliozzi, and C.M. Walton. "Mega-Containerships and Mega-Containerports in the Gulf of Mexico: A Literature Review and Annotated Bibliography." Austin, Texas: Center for Transportation Research at the University of Texas at Austin, Research Report 1883-1, May 1999, Revised: October 1999 / May 2000.

Supplemented Abstract: Container shipping plays a key role in international transshipments and is currently the system of choice for most global shippers handling non-bulk commodities. In the competitive maritime industry, steamship companies are looking for ways in which further economies can be achieved. One of the areas examined has been the maritime portion of the trip, wherein ship economies of scale can be obtained through the use of larger vessels.

During the 1990s, technical constraints associated with very large or mega-containership designs were overcome, and the operation of such vessels (in the range of 4,500 to 7,000 TEUs) offered the promise of lower container shipment costs over the densest trade routes. One of the objectives of this report was to determine the feasibility of infrastructure investments in Texas's ports to accommodate mega-containerships.

This report represents the findings of a literature review largely undertaken during the period from August 1998 to June 1999. The report includes chapters on international trade and maritime economics, the maritime industry, containerization, mega-containerships, and mega-containerport infrastructure. Some of the findings are as follows: (1) broad changes in the world maritime industry can be analyzed from existing information on ship design, port operations, and the network; (2) fewer mega-containerships are on order than had been predicted in the mid- to late-1990s, and their usage is restricted to a few higher density routes; (3) no mega-containerships are routed on the North Atlantic - U.S. East Coast and Gulf networks. Unfortunately for Texas, it was found that a fully loaded mega-

containership could be accommodated only by ports that have a minimum channel depth of 50 feet. Currently there is no port in Texas that meets this requirement.

Keller, B. "A South African Mall That Black Know-How Built." The New York Times, September 12, 1993, Section 1, Page 3, Column 1, Foreign Desk.

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Le Grand, C. "Jail Crush Spills to Sea Containers." The Australian, February 11, 1999.

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Lyndon B. Johnson School of Public Affairs. "U.S. Mexico Trade and Transportation Corridors, Logistics Practices and Multimodal Partnerships." Policy Research Project 113, University of Texas at Austin, 1995.

Abstract: This report provides a detailed investigation into the ways in which U.S. and Mexican firms are attempting to overcome the difficulties of cross-border transportation and distribution via partnerships, strategic alliances, and other kinds of business ventures designed to facilitate cross-border transfers of technology, capital, and expertise. The researchers explored how several firms involved in cross-border transportation and distribution are using these types of cooperative ventures to expand effectively and profitably into the markets opened in Mexico by the North American Free Trade Agreement (NAFTA).

"Malcolm McLean." The Times London, May 30, 2001.

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MARAD. "Intermodal Access to US Ports: Report on Survey Findings." U.S. Department of Transportation. Washington, D.C., August 2002.

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The Mobile Storage Group. "Products and Services." Online. Available at http://www.mobilestorage.com/products/offices.htm. Accessed July 9, 2002.

Abstract: Website – None Provided

Mongelluzzo, B. "Sweeping Intermodal Pact Fixes Liability Equipment Accord Saves Time, Money." Journal of Commerce, February 2, 1996.

Abstract: Trade Journal – None Provided

Muller, G. "Intermodal Freight Transportation." 4th Edition. Eno Transportation Foundation and Intermodal Association of North America. Washington, DC, 1999.

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Reynolds, F. "Incoterms for Americans." International Projects, Inc. Toledo, OH, 1999.

Abstract: None Provided

Sea Container LTD. "Securities and Exchange Commission Form 10-K." Fiscal Year Ended December 31, 2001.

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Uniform Intermodal Interchange and Facilities Access Agreement Homepage. Online. Available at http://www.uiia.org. Accessed June 25, 2002.

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Vickerman, J. VZM/TransSystems Report on Texas City Mega-Port Facility. Conference held on November 9, 1998, J. J. Pickle Research Campus, The University of Texas at Austin.

Abstract: None Provided

Willmington, R. "Lemming Syndrome Fuels Rates Slide." Containerisation International Yearbook 2002. Informa Group plc. London, UK, 2002.

Abstract: None Provided

GIS Platforms

Boile, M.P., S. Benson, and J. Rowinski. "Freight Flow Forecasting: An Application to New Jersey Highways." Journal of the Transportation Research Forum, Vol. 39, No. 2, Spring 2000, 159-170.

Abstract: The paper presents a methodology for forecasting freight flows over regional transportation networks. This methodology may be used by state departments of transportation (DOTs), metropolitan planning organizations (MPOs) and county transportation planners as a planning tool for identifying the most heavily traveled links of transportation networks and determining the direction of flow for major commodity groups.

The model may also be used to estimate the major routes for movement of hazardous materials and to ascertain the impact of freight flows on pavement maintenance. Application of the methodology to the state of New Jersey indicates that the most heavily freight-flow utilized routes are Interstate 80, New Jersey Turnpike, and Route 202.

Casevant, K.L., A. Arnis, W.R. Gillis, W. Nell, and E.L. Jessup. "Modeling Washington State Truck Freight Flows Using GIS-T: Data Collection and Design." Transportation Research Record 1497 (1995): 145-152.

Supplemented Abstract: As part of their planning process, state departments of transportation and metropolitan organizations are required to include detailed information on freight and goods movements. However, obtaining comprehensive information on freight truck movements is often difficult owing to the large number of carriers and numerous potential origins and destinations. The Washington State Department of Transportation initiated a statewide freight truck origin and destination study in April 1993 - completed in March 1994 - to meet this challenge.

Information was collected directly from drivers of freight trucks at 30 locations throughout the state of Washington. To account for seasonal variation in freight movements, the interviews were carried out four times over a one-year period. In other words, a survey was conducted in each of the four seasons. Washington State Patrol Officers flagged down trucks and conducted routine enforcement activities. After they were stopped, truck drivers were asked to participate in a two-minute interview. Approximately 7,000 truck drivers were interviewed during each season, providing a database of approximately 30,000 interviews for the year-long study.

An overview of the research procedures used to conduct the study is presented. Specific emphasis is given to arranging the data to complement the role of GIS-T, which is used as a tool for organizing, analyzing, and presenting information for use by transportation planners, program administrators, and policy makers.

A case study of southbound trucks on SR-395 from Canada to Spokane, WA, illustrates how GIS-T can be used to document and analyze the characteristics of freight truck movements.

Craig, B.W. "Identifying Strategic Freight Corridors in Texas Using GIS." Thesis, The University of Texas at Austin, 1997.

Supplemented Abstract: The goal of this paper was to identify the strategic freight corridors in the state of Texas. Freight corridors can be defined for various modes of transportation. For this project, however, only the truck mode was evaluated. A model was created to identify areas of economic significance within the state. For the purpose of data collection, the county was used as the analysis region.

The developed model identified the economically significant counties in the state using economic and noneconomic data to capture the demand to move goods within a county. The economic data used were the county income data for the five largest industries in the state, because these industries have a significant demand for transporting goods. The non-economic income data consisted of dummy variables that presented intermodal and border crossing facilities.

Each county was initially ranked considering county income data downloaded from the Regional Economic Information System (REIS). The Texas Gross State Product (GSP) was analyzed to determine the five most significant industries in the state that required a high demand for the movement of goods. These five industries were manufacturing, farming, mining, wholesale, and retail. Noneconomic factors that increase a county's demand for an efficient transportation system included in this analysis were intermodal and border crossing facilities. Operational characteristics of each facility were ignored, and only the presence of these facilities affected the county's score. A final score for each county was computed by assigning weighting factors based on each of the individual criteria scores. These were summed by criterion, and a cutoff value was calculated to determine whether a county was economically significant.

Forty-six counties were found to be economically significant. The Strategic Freight Corridor (SFC) network was defined by linking the economically significant counties with a network of primary roads that were not too circuitous.

A sensitivity test was performed to determine how the model's weighting scheme affected the selection of highways or the SFC network. This sensitivity test revealed that the weighting scheme had no effect on the selection of highways for the SFC network.

A Geographic Information System (GIS) was used to display the results of the model. GIS was also used to display patterns and trends in the geographic data. Basic GIS functions (e.g., querying, overlaying) were used to display economically significant counties and their links to the highway system in Texas.

Standifer, G. "Development of a GIS Model for Intermodal Freight." Thesis, University of Texas at Austin, 2000.

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Texas Maritime Container Flows

Armbruster, W. "Houston International Trade: Construction Projects Serve Water, Land and Air." Journal of Commerce, Vol. 2, No. 46, November 19-25, 2001.

Abstract: Trade Journal – None Provided

Bomba, M., and R. Harrison. "An Identification Process and Evaluation Framework for Texas Gulf Containerships." Austin, Texas: Center for Transportation Research at the University of Texas at Austin, Research Report 1883-2, December 2000.

Abstract: This is the second in a series of four reports prepared by the Center for Transportation Research at the University of Texas at Austin for the Texas Department of Transportation (TxDOT) to explore containership activity in the Gulf of Mexico. The original scope of work for this report was to produce a process for selecting a candidate

port to become a containership load center among Texas Gulf ports. As the project progressed, however, the scope was expanded to also provide a port evaluation process that would be useful to all Texas ports that might provide containership service. The report begins by identifying and discussing relevant topics of port development and operations in four general areas: infrastructure demands; environmental constraints; locational attraction and landside access; and port finance. After introducing the issues surrounding these topics, the report proposes a load center selection process and a containerport evaluation process. The procedure for constructing a load center selection process concentrates on the following: heuristic methods; selecting matrix parameters; parameter criteria; and the scoring and weighting of these parameters and criteria. The port evaluation process focuses on identifying baseline characteristics, determining objectives and alternatives, assessing these objectives and alternatives, and identifying a preferred alternative and its constraints. In its conclusion, the report recommends that these techniques be reviewed and tested on selected Texas ports and that the data collected for the project's decision tools be stored and updated in a database for TxDOT's future use.

Harrison, R., M.A. Figliozzi, and C.M. Walton. "Mega-Containerships and Mega-Containerports in the Gulf of Mexico: A Literature Review and Annotated Bibliography." Austin, Texas: Center for Transportation Research at the University of Texas at Austin, Research Report 1883-1, May 1999, Revised: October 1999 / May 2000.

Supplemented Abstract: Container shipping plays a key role in international transshipments and is currently the system of choice for most global shippers handling non-bulk commodities. In the competitive maritime industry, steamship companies are looking for ways in which further economies can be achieved. One of the areas examined has been the maritime portion of the trip, wherein ship economies of scale can be obtained through the use of larger vessels.

During the 1990s, technical constraints associated with very large or mega-containership designs were overcome, and the operation of such vessels (in the range of 4,500 to 7,000 TEUs) offered the promise of lower container shipment costs over the densest trade routes. One of the objectives of this report was to determine the feasibility of infrastructure investments in Texas's ports to accommodate mega-containerships.

This report represents the findings of a literature review largely undertaken during the period from August 1998 to June 1999. The report includes chapters on international trade and maritime economics, the maritime industry, containerization, mega-containerships, and mega-containerport infrastructure. Some of the findings are as follows: (1) broad changes in the world maritime industry can be analyzed from existing information on ship design, port operations, and the network; (2) fewer mega-containerships are on order than had been predicted in the mid- to late-1990s, and their usage is restricted to a few higher density routes; (3) no mega-containerships are routed on the North Atlantic - U.S. East Coast and Gulf networks. Unfortunately for Texas, it was found that a fully loaded mega-containership could be accommodated only by ports that have a minimum channel depth of 50 feet. Currently there is no port in Texas that meets this requirement.

Hensel, B. Jr., "Container Port Fever : Several Ports See Opportunities. Will the Market Support All of Them?" Journal of Commerce, April 2, 2001.

Abstract: Trade Journal – None Provided

Jacobson, L. "With All Hands on Board, Houston Project Underway." Planning, Vol. 65, No. 4, April 1999, 26.

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James, A.P., J.M. Howard, Jr., J.P. Basilotto, and H. Harbottle. "Megaports and Load Centers of the Furutre with the Port of Houston as the Baseline Port." Southwest Region University Transportation Center Report No. 467404-1, September 1997.

Abstract: Improvements in the containership technology will require modern port terminal facilities. The number of ships calling on U.S. ports is likely to decrease, but larger and more automated containerships will increase the amount of cargo handled per ship. The result will be greater cargo tonnages handled by seaports and the need for faster vessel turnaround. High capacity, expensive cargo handling equipment will be increasingly used and port terminal operations will become even more automated, particularly in container handling, where robotics equipment may well be introduced within the next decade. Present shipping trends seem to indicate that a small number of east, west, and gulf coast seaports will dominate the U.S. container business, thus gaining "megaport" status. The remaining U.S. ports in order to remain viable, will turn toward serving more specific market niches. These niches include handling the present containership fleet, feeding to and from the megaports, and non-traditional development activities such as bulk and breakbulk services. This study delineates and describes the external environment, facilities, and operational characteristics of a "megaport/load center port" capable of meeting market requirements by the year 2010. The port of Houston is evaluated within this research as an example of a prototypical, next generation seaport.

The Kingsley Group. "Market Feasibility Appraisal for a Container Terminal at Corpus Christi, Texas." March 14, 2001.

Abstract: Professional Report – Executive Summary Available

Luberoff, D., and J. Walker. "U.S. Ports and the Finding of Intermodal Facilities: An Overview of Key Issues." Transportation Quarterly, Vol. 54, No. 4, Fall 2000, 23-45.

Supplemented Abstract: Owing to economies of scale, the growing use of containers to move freight has led carriers to use fewer but larger ports. In their efforts to attract and retain carriers, U.S. ports have made or are planning substantial investments in new berths, docks, and improved connections with the nation's rail and highway systems. Harris

County voters in Texas have approved a $387 million bond issue as part of the funding required for a $1.2 billion container and cruise ship terminal in Houston.

However, the current port financing system-which generally relies on balance sheet financing and, in most cases, direct public subsidies – could create several serious problems as ports move to carry out their investment plans. To begin with, balance sheet financing makes it likely that public ports, not private shipping industries, will bear the risk of new investments. Moreover, subsidized balance sheet financing means that port officials will tend to underestimate the risks involved with new investments, which suggests that they will fail to choose the best investments and may even overinvest in new facilities. Such overinvestment could lead not only to less-than-optimal use of public resources, but also could force the general public (not carriers, railroads, or the ports) to subsidize both the debt-service and operating costs of uneconomic new facilities.

As an alternative, port officials and their political overseers might use true project-based financing, which is being used around the world in a variety of forms, to fund new infrastructure facilities. Such funding strategies are appealing not only because they shift risk from public to private entities, but also because they seem likely to lead to improved decision making about investments at intermodal facilities.

Muller, G. "Intermodal Freight Transportation." 4th Edition. Eno Transportation Foundation and Intermodal Association of North America. Washington, DC, 1999.

Abstract: None Provided

Port of Corpus Christi. "La Quinta Trade Gateway Preliminary Master Plan: Executive Summary." Online. Available at http://www.portofcorpuschristi.com/LaQuintaTradeGateway.html. Accessed February 17, 2003.

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Port of Galveston. "Port of Galveston Facilities." Online. Available at http://www.portofalveston.com/facilities. Accessed March 4, 2003.

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Port of Houston Authority. "PHA Galveston Container Terminal." Online. Available at http://www.portofhouston.com/facility/galv.htm. Accessed March 4, 2003.

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Schaeffer, M.T. "Container Terminal Expansion." Port Technology International, Edition 13, Section 2, Port Planning, 2001.

Abstract: The growth of the container business has expended rapidly. Port authorities need to allow for this in their planning and expansion so as to remain competitive and provide an ever growing service. The following report by the PHA will give an overview of the plans for the new Bayport Terminal Complex and a brief summary of each project area studied.

Tathagata, G. "Traffic Impact of Container Port Operations in the Southwest Region: A Case Study." Thesis, University of Texas at Austin, 1992.

Supplemented Abstract: The evolution of containers and the subsequent growth in intermodalism in recent years have resulted in a tremendous growth in both domestic movements and international trade through the seaports. This thesis includes case studies of two container ports: the Port of Houston's Barbours Cut Container Terminal and the Port of Orlean's New Orleans Marine Contractors, Inc. (N.O.M.C.). An automatic vehicle classification system was used to collect the necessary traffic data. Mathematical models were developed to accurately forecast travel demands and to assess the impact of container port operations on urban infrastructure and mobility. The results of the analysis provided trip generation rates for both an average weekday and the peak hour, and it also showed the variation in the traffic demand by vehicle type to and from the port. Such information is critical for planning and designing transportation facilities. Finally, a simulation model was presented to consider options to alleviate traffic congestion at the container terminal gates.

"Texas City International Terminal: March, 2001." Online. Available at http://www.abam.com/News/Texas_City.htm. Accessed February 14, 2003.

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"Top 50 Container Ports." *Journal of Commerce,* July, 2002.

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Rail Container Flows

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Federal Highway Administration (FHWA). "Addendum to the 1997 Federal Highway Cost Allocation Study Final Report." May 2000.

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Association of American Railroads. 2003 "Railroads: Building a Cleaner Environment, January." Online. Available at http://www.aar.org. Accessed February 20, 2003.

Abstract: Railroads are the environmentally friendly way to meet America's freight transportation needs. Whether it involves increasing fuel efficiency, reducing emissions, or relieving highway congestion, our nation's freight railroads are committed to continued environmental excellence to protect the health, safety, and quality of life of their employees, their customers, and the communities they serve.

Association of American Railroads. 2003 "Railroads and Highway Congestion, January." Online. Available at http://www.aar.org. Accessed February 20, 2003.

Abstract: The United States can make significant headway in reducing gridlock by taking advantage of the nation's more than 143,000-mile freight rail system. Railroads are the environmentally responsible means to meet our nation's freight transportation challenges while combating highway overcrowding and massive highway infrastructure costs.

Association of American Railroads. "Railroads and States 2000." Online. Available at www.aar.org/AboutTheIndustry/StateInformation.asp. Accessed February 21, 2003.

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Armbruster, W. "Houston International Trade: Construction Projects Serve Water, Land and Air." Journal of Commerce, Vol. 2, No. 46, November 19-25, 2001.

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Berwick, M. "Potential for Locating Intermodal Facilities on Short Line Railroads." North Dakota State University, Fargo, North Dakota, May 2000.

Abstract: One of the greatest challenges Upper Great Plains rural communities face in competing to attract value-added processing ventures is a lack of transportation options. Value-added ventures provide opportunities for rural America to diversify economies and manage risk. Rural agricultural communities' inbound procurement and outbound distribution options are limited to local trucking companies and rail. Few communities generate enough truck traffic through existing businesses to offer evidence of excess or available truck capacity. Where rail is available, Class I carriers are reluctant to make short, less-than unit train, hauls for grain and offer limited options for other products originating or terminating in rural areas.

An economic engineering model was developed to estimate start-up and operating costs of an intermodal facility located on a short line railroad. The model developed in this study has many useful features. Costs can be estimated for different equipment configurations and sizes of facilities. Sensitivity analysis provided insight into investment decisions where the proportions of annual operating costs increased at a much lower rate than proportionally larger investment costs. The model developed in this study provides information for shippers, short line railroads, economic developers, and Class I railroads.

Analysis of intermodal traffic originating in North Dakota through the Public Use Waybill shows decreasing volume from 1995 to 1997. Decreasing volume reveals that North Dakota shippers do not have the opportunity to participate in the intermodal growth enjoyed by most of the United States.

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Devries, J.B. "Chicago's Global Economic Connections and Challenges – Intermodal Transportation." Presentation, January 19, 2001.

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Federal Highway Administration, Office of Freight Management and Operations. "Freight Carriers From Modal Fragmentation to Coordinated Logistics." Online. Available at http://www.ops.fhwa.dot.gov. Accessed March 19, 2003.

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Frailey, F.W. "Fast Freight on the Golden State." Trains, Vol. 61, No. 11, November 2001.

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Fryer, D., and J. Adams, Union Pacific Railroad, Houston, TX. Interview, November 19, 2002.

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HNTB Corporation, et al. "I-35 Trade Corridor Study: Recommended Corridor Investment Strategies." September 30, 1999.

Abstract: None Provided

Houston-Galveston Area Council. "2025 Metropolitan Transportation Plan for the Houston-Galveston Transportation Management Area." Adopted February 25, 2000.

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Houston-Galveston Area Council. "Intermodal Facilities Inventory." August 1995.

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Houston-Galveston Area Council. "Intermodal Facility Inventory." January 2000.

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Houston-Galveston Area Council. "Strategic Freight Corridors Study: Intermodal Facility Access Needs and Recommendations." January 2000.

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Houston-Galveston Area Council. "Strategic Freight Corridors Study: Regionally Significant Facilities NHS Connectors Data Collection Report." January 2000.

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Maring, G. U.S. Department of Transportation, Federal Highway Administration. "Intermodal Freight History and Current Issues." Presented to the Transportation Research Board, Washington, DC, January 14, 2002.

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Marler, W., B. Shelton, and J. Adams, Union Pacific Railroad, Dallas, TX. Interview, December 4, 2002.

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Molitoris, J. "The Global Span of Rail Transportation." Federal Railroad Administration. U.S. Department of Transportation: International Information Programs, October 2000.

Introduction: Modern rail technology holds promise that railroads will deliver even more value in future years, as users of transportation worldwide demand ever more speed, reliability, capacity, and efficiency, according to Federal Railroad Administrator Jolene Molitoris. In this article, she examines new rail systems, best practices and linkages to international air travel and international intermodal freight.

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"Railroad Performance Measures." Online. Available at http://www.railroadpm.org. Accessed December 5, 2002.

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Roop, S., J. Warner, D. Rosa, and R. Dickinson. "The Railroad System of Texas: A Component of the State and National Transportation Infrastructure." Research Report 1703-3. Texas Transportation Institute, College Station, TX, November 1998.

Abstract: Railroads continue to play an important role in the Texas transportation system. This study addresses the potential for implementing a rail planning process in the Texas Department of Transportation (TxDOT). The study is documented in three reports, produced in coordinated and parallel efforts by the Center for Transportation Research and the Texas Transportation Institute (TTI). This report documents the work performed by TTI, whereby a rail planning framework is presented which formalizes the planning process and presents the key elements as a series of discrete and logical steps. These steps may be used to guide TxDOT in the formation of goals, identification of issues and affected parties, selection of appropriate analytical methodologies, location of data sources, and implementation of results. The report also presents an in-depth discussion of several key issues facing transportation agencies. These include rail line abandonment, intermodal service planning, and urban rail rationalization. A discussion of the Texas rail system covers the Class I railroads, shortline railroads, Amtrak, and the Mexican rail system.

Roop, S. S., J.E. Warner, F. Zambrano, R. Ismailova, and D. Kang. "The Impact of Mexican Rail Privatization on the Texas Transportation System." Research Report 2128-2. Texas Transportation Institute, College Station, TX, February 2001.

Abstract: The North American Free Trade Agreement (NAFTA) has increased truck traffic and infrastructure needs on the Texas highway network, which carried more than 70 percent of the total incoming U.S.-Mexico truck traffic due to trade in 1997. An opportunity to alleviate highway congestion on main highway corridors in Texas and the U.S. is through the encouragement of rail intermodal facilities that could divert freight from the highways. U.S. and Mexican railroad companies, created from the recent privatization of the Mexican Railroad System, are building intermodal facilities and rail yards and upgrading railroad infrastructure accessing Texas-Mexico rail border crossings, which could handle increasing amounts of transboundary freight via rail and/or intermodal, thus reducing the rates of deterioration of the highway systems in Texas and Mexico.

The purpose of this project is to provide Texas Department of Transportation (TxDOT) with information on current and future infrastructure and operational plans conducted by the U.S. and Mexican railroad private sectors and their impact on TxDOT's highway infrastructure needs.

Seaman, G. Burlington Northern Santa Fe Railway, Houston, TX. Interview, November 19, 2002.

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Surface Transportation Board. "Union Pacific's Report on Houston & Gulf Coast Infrastructure." Finance Docket No. 32760 (Sub-No. 21). Washington, DC, May 1, 1998.

Abstract: Presentation – None Provided

Texas Department of Transportation, I-35 Steering Committee. "I-35 Trade Corridor Study: Recommended Corridor Investment Strategies." September 30, 1999.

Annotation: The Federal Highway Administration (FHWA) and the Departments of Transportation in Texas, Oklahoma, Kansas, Missouri, Iowa and Minnesota combined their efforts to conduct a study of Interstate Highway 35 (I-35) from Laredo, Texas to Duluth, Minnesota. The purpose of the study was to assess the need for improved local, intrastate, interstate, and international service on I-35 and to clearly define a feasible improvement plan to address those needs. Its multimodal transportation hubs – where air, rail, river and truck cargo converge – make I-35 ideally positioned to be a major route for what is expected to be increasing levels of international trade activity.

Texas Department of Transportation. "The Texas Transportation Plan: Partnerships into the 21st Century." November 1994.

Abstract: State Transportation Plan – None Provided

Union Pacific Railroad. "Blue Streak." Online. Available at http:www.uprr.com. Accessed October 21, 2002.

Abstract: Website – None Provided

Union Pacific Railroad. "Intermodal." Online. Available at http://www.uprr.com. Accessed December 5, 2002.

Abstract: Website – None Provided

Union Pacific Railroad. "Mexico Intermodal." Online. Available at http://www.uprr.com. Accessed March 3, 2003.

Abstract: Website – None Provided

"Union Pacific Railroad, Trains Per Day." Trains, Vol. 61, No. 11, November 2001.

Abstract: Journal – None Provided

U.S. Department of Transportation. "The Comprehensive Truck Size and Weight Study Final Report." Vol. 2, Chap. 4, IV-35, 2000.

Abstract: None Provided

Wilson, R., Texas Department of Transportation Design Division. "Testimony before the House Committee on Transportation." March 25, 1998.

Abstract: None Provided

Container Movements by Truck

"Alliance Intermodal Facility Fact Sheet." Burlington Northern Santa Fe, provided as a response to an Email.

Abstract: Fact Sheet – None Provided

Casevant, K.L., W.R. Gillis, D. Blankenship, and C. Howard, Jr. "Survey Methodology for Collecting Freight Truck and Destination Data." Transportation Research Record 1477 (1995): 7-14.

Abstract: State departments of transportation and metropolitan planning organizations require a specific focus on freight and goods movements as one element of their planning process. A particular challenge is obtaining comprehensive information on freight truck movements. The Washington State Department of Transportation initiated a statewide freight truck origin and destination (O-D) study in April 1993 to meet this challenge. The Washington study is the first in the United States to collect statewide freight truck O-D data through direct personal interviews of truck drivers. Over 300 community service club members were hired and trained to conduct personal interviews at 28 separate locations throughout the state of Washington. A total of 30,000 truck drivers were interviewed, providing Washington with an extensive database on statewide freight and goods movements. The methodology and procedures utilized to collect statewide freight truck data in Washington are described. Specific issues include research design, interview team recruitment and training, field data collection procedures, as well as ongoing project management requirements. Lessons learned from the Washington study provide insights for other states or regional planning organizations contemplating a freight truck study.

"The Container in the Global Transport Chain." Routes=Roads, Vol. 299, July 1998, 67-74.

Abstract: Journal – None Provided

"The Container Transportation Chain," Intermodal Marine Container Transportation: Impediments and Opportunities, Special Report 236, Transportation Research Board, 1992.

Abstract: None Provided

"Draft Environmental Impact Statement for Port of Houston Authority's Proposed Bayport Channel Container/Cruise Terminal." U.S. Army Corps of Engineers, Galveston District, November 2001.

Abstract: None Provided

Environmental Protection Agency (EPA), Navigation Information System. "Transportation Mode Comparison – Energy Environment Efficiency." Online. Available at http://www.mvr.usace.army.mil/navdata/tr-comp.htm. Accessed February 15, 2002.

Abstract: None Provided

Figliozzi, M.A., R. Harrison, and J.P. McCray. "Using Weigh-in-Motion Data to Calibrate Trade-Derived Estimates of Mexican Trade Truck Volumes in Texas." Transportation Research Record 1719 (2000): 129-135.

Abstract: Weigh-in-motion (WIM) sites are being installed along many highway corridors that carry international trade trucks. Estimating the numbers of trucks carrying international commodities currently relies on manipulating and adjusting trade databases. The variety of vehicle classification data measured at WIM sites provides a rich source of data with which to enhance this adjustment process. Previous WIM border data have focused on port-of-entry truck traffic axle loads, which are heavily influenced by drayage operations. Examined is how WIM data collected at ports of entry and on truck corridors can be used in the determination of standardized truck volumes (termed equivalent trade truck or ETT) on international highway corridors. Data from the Texas-Mexico border are used to determine ETT North American Free Trade Agreement volumes.

"Growth Forecast for Pacific Northwest." Traffic World, Vol. 41, No. 1, April 26, 1999.

Abstract: Journal – None Provided

Harrison, R. "Using Brokers to Determine North American Free Trade Agreement Truck Origins and Destinations at Texas-Mexico Border." Transportation Research Record 1719 (2000): 136-139.

Supplemented Abstract: Much of the growing U.S.-Mexico trade carried by vehicular and rail traffic crosses into Texas over bridges spanning the Rio Grande. Substantial delays and other social costs are incurred at border port-of-entries, as more than 70 percent of U.S.-Mexico North American Free Trade Agreement (NAFTA) trade is by truck.

New bridge locations are being proposed, but each site must be carefully evaluated to ensure that it is economically feasible. As part of this evaluation process, origin and destination surveys are used to determine bridge location and demand. Many of the truck trailers are moved by drayage companies or by drivers who have not brought the load from its origin or who will not deliver it to the final destination. These surveys are thus flawed and present limited data.

The report suggests a methodology by which U.S. Customs brokers are interviewed and surveyed to obtain truck origin and destination data. Brokers play key roles in processing U.S.-Mexico trade, are intimately aware of the commodities moved, seasonality, routes, and origins and destinations, and are therefore the logical party to question on truck flows. This method was successfully employed at the Anzalduas International Bridge near McAllen, Texas. Because many ports of entry in Texas are similar to McAllen, the survey method can be applied to other ports of entry on the southern border.

Harrison, R., L. Boske, C.E. Lee, and J. McCray. "Transportation Issues and the U.S. – Mexico Free Trade Agreement." Austin, Texas: Center for Transportation Research at the University of Texas at Austin, Project No. 1319-6F, February 1997.

Abstract: Eight reports were produced during the four-year duration of Project 0-1319. These reports are summarized below into three areas comprising policy issues, weigh-in-motion studies, and trade transportation forecasting research.

Policy Research: The first study examined the transportation system in Mexico and the U.S., together with plans for improvements or expansion and the opportunities and constraints faced by each transportation mode. A particular focus of the first report was the identification, collection, and categorization of Mexican intermodal data. The second report explored the demand for transportation services generated by regulatory changes and the implementation of NAFTA. These changes are challenging both shippers and carriers to seek out nontraditional transportation systems to create linkages to overcome obstacles originating from the structural and regulatory disparities between the two nations. The third and final policy study examined how these policies were creating new logistics practices and multimodal, binational transportation partnerships.

Weigh-in-Motion Studies: Data obtained from two weigh-in-motion sites, one installed near the north end of the U.S. import lot at the City of Laredo (1993), and another at the Zaragosa Bridge in El Paso (1994), provide a unique source of information on the current characteristics of truck traffic at the Texas-Mexico border. Patterns of observed daily truck counts, truck types, and axle loads have been determined from 1993 through summer 1996. Equivalent single axle load (ESAL) factors have also been developed for each truck type. These data should help assess the current and future impacts of border-crossing traffic on the highway infrastructure in Texas and on other trade routes throughout the U.S. Finally, experience gained in installing and operating these systems will be of use in the implementation of future border weigh-in-motion systems.

Trade Transportation Forecasting: Freight demand forecasting is central to agencies responsible for the highway infrastructure in both countries and to users developing trade transportation partnerships in an effort to improve efficiency. Specifically, the objective of the two reports was to use publicly available data to develop a predictive model for transportation mode and Mexican destination decisions for shipments traveling from various U.S. regions to Mexico. Aggregate logit models were calibrated for three commodities: machinery, electronics, and automobiles. The first study reviewed past efforts in freight demand forecasting, and a three-stage model was developed and tested using a sample of trade data provided by U.S. customs.

Hodgson, M., H. Garrett, K. Thong, A. Villarreal, A. Ghareib, J. Lamkin, and D. Burke. "Commodity Movement on the Texas Highway System: Data Collection and Survey Results." College Station, TX, Texas Transportation Institute at the Texas A&M University, Project No. 1104-1, November 1991.

Abstract: This report presents the survey procedures used and data collected in the development of commodity flow statistics for movements over Texas Highways. Response rates, sampling procedures, questionnaire design and the types of data provided by the responding motor carrier firms and truck operators are presented and discussed.

"Intermodal Crossroads." Containerisation International, June 1, 1996.

Abstract: Journal – None Provided

Lambert, B. "National Freight Movements: Trends/Issues/Forecasts/Policy Implications." Presentation, Memphis Freight Planning Conference, Tennessee, October 2, 2001. Online. Available at http://ops.fhwa.dot.gov/freight/pp/freight_ops_7-26-01/tsld001.htm. Accessed March 19, 2003.

Abstract: Presentation – None Provided

Luker, W. Jr., S. Cuellar, J.L. Memmott, R.C. Danave, K.J. Steffel, and C. Stolp. "The Impact of a U.S.–Mexico Free Trade Agreement on the Texas Highway Network." College Station, TX: Texas Transportation Institute Project No. 1317-1F, December 1994.

Abstract: The study examines the effect that increased trade with Mexico, as a result of the passage of NAFTA, will have on the Texas highway network. A dominant portion of overland trade between the U.S. and Mexico travels through Texas. Exports to and imports from Mexico are expected to increase significantly over the next two decades. The study finds a strong positive relationship between dollar-valued trade flows and border truck crossings. Thus, increased trade will translate into a need for an improvement of highway infrastructure in Texas, particularly in the border areas. Through the adoption of NAFTA, and due to existing cost advantages, Mexican manufacturing will offer improved productivity at a lower cost, which will result in a significant increase in northbound trade, and hence truck traffic, which will pass through the Texas highway network.

McCray, J.P. "North American Free Trade Agreement Truck Highway Corridors: U.S.-Mexican Truck Rivers of Trade." Transportation Research Record 1613, (1998): 71-78.

Supplemented Abstract: The dramatic growth in trade between the United States and Mexico from $12.39 billion to $56.8 billion of U.S. exports and $17.56 billion to $73 billion of U.S. imports between 1977 and 1996 and the implementation of the North American Free Trade agreement (NAFTA) have focused attention on the impact that the truck-transported portion of this trade has on U.S. highways. State and federal highway administrators are concerned with the planning implications this additional anticipated traffic may have on the transportation infrastructure.

Public advocacy groups desire additional highway funds to promote one NAFTA highway corridor over another in an effort to stimulate economic development in particular areas. Most of these groups advocate a north-south route linking Canada and Mexico that traverses the United States and that follows the alignment of an existing federal highway number.

Research conducted by the U.S. government under the 1991 Intermodal Surface Transportation Efficiency Act has failed to define NAFTA highway corridors adequately, leaving policy makers with little concrete information with which to combat the rhetoric of the trade highway corridor advocacy groups. This report provides the research critical to both highway administrators and corridor advocacy groups – namely, the location of U.S.-

Mexican trade highway corridors and the trade truck density along these corridors. The report shows that there is no single, continuous U.S. highway, with a common number, that traverses the United States from Canada to Mexico where trucks transporting U.S.-Mexican trade dominates traffic flow.

McCray, J.P., and R. Harrison. "North American Free Trade Agreement: Trucks on U.S. Highway Corridors." Transportation Research Record 1653, (1999): 79-85.

Abstract: The increasing number of trucks that transport U.S.-Mexico and U.S.-Canada trade on U.S. highways has stimulated a strong interest among state departments of transportation and federal highway officials in the location and truck densities along these highway corridors. In many cases, public advocacy groups seeking corridor-related economic development have been formed to promote one or more highway trade corridors. Most of these groups advocate a north-south route through the United States between Canada and Mexico that follows the alignment of an existing federal highway number. Because of the interest in and promotion of highway trade corridors in the United States, the Transportation Equity Act for the 21st Century includes authorizations for a discretionary program for the development, study, and construction of highway trade corridors. This places a serious burden on state and federal highway administrators to define, plan, and upgrade these corridors adequately. Earlier work that defined U.S. highway trade corridors for U.S.-Mexico trade is extended by including U.S.-Canada trade and total North American Free Trade Agreement (NAFTA) trade. Results indicate that U.S.-Mexico trade transported by truck primarily affects the highway corridors in southern border states such as Texas, California, and Arizona. U.S.-Canada trade primarily affects highway trade corridors in the northern border states of Michigan, New York, Ohio, Illinois, and the states along I-80 from Salt Lake City to Chicago. Interestingly, there are no significant north-south NAFTA highway corridors with a single Interstate or U.S. Highway number.

Mendoza, A., M. De Alba, and E. Mayoral. "Analysis of Vehicles for International Motor Transport of Freight between Mexico and other NAFTA Countries." Transportation Research Record 1602, (1997): 39-44.

Abstract: Traditionally, the operative and normative practices of motor transport in the three countries that are party to the North American Free Trade Agreement (NAFTA), Mexico, the United States, and Canada, have been substantially different. In view of the imminent enforcement of the NAFTA motor transport accords, and with the aim of making transport more efficient, it is necessary to standardize such practices. Truck size and weight regulations in the three NAFTA countries are reviewed. A series of vehicles are ranked according to their transport productivity and their circulation possibilities through the part of the Mexican network that is most relevant to Mexico's international commerce with the United States and Canada. The analysis includes the most commonly used vehicles authorized by federal regulations and others that are authorized only regionally but whose more extensive utilization could mean important productivity increases for the freight motor industry. The vehicle types that are most convenient to use considering the

current condition of Mexican roads are identified. Other recommendations for making motor transport under NAFTA more efficient are addressed.

PANYNJ Press Release November 29, 2000. "Port Authority Taps Rotterdam Experience to Speed Cargo Flow in New York – New Jersey Ports – Cooperative Agreement Signed Between Two Ports."Online. Available at http://www.panynj.gov/pr/163-00.html. Accessed March 19, 2003.

Abstract: None Provided

Pennington, A. "Intermodal Business Parks Offer Transportation Plus." Online. Available at http://www.conway.com/geofacts/pdf/43151.pdf. Accessed March 3, 2003.

Abstract: Website – None Provided

"Port of Houston Authority: Port Access Projects." Port of Houston Authority, Houston, Texas, 2003.

Abstract: None Provided

Port of Pittsburgh. "SmartBarge." Online. Available at http://www.smartbarge.com. Accessed May 28, 2002.

Abstract: Website – None Provided

Pretorius, J., and I. Sallie. "Development of Capacity and Knowledge base in the Area of Costing of Freight Transport Operations." South Africa, Department of Transport, Report Number 12/94.

Abstract: The objective of this project was to compile a transport cost database for the different land transport modes (rail, road and sea) in the southern African region. An attempt was made to compile information on the dominant methods of transport or different commodity types on selected transport corridors, establish the choice of mode for the different commodity types and the costs involved. In addition to the financial costs of operations and tariffs, the study attempted to emphasize total distribution costs, thereby including loss and damage costs, time costs, storage costs and costs of feeder services in the case of railway and shipping. Economic costs of transport operations, such as accident, environmental and infrastructure costs, have also been referred to.

The available data were entered into a database. In the cases where data were unobtainable, the costs have been estimated or the difficulties in calculating the costs have been highlighted. Calculation and conceptualization problems, however, prohibited the study from reaching all the objectives. These problems are discussed in some detail throughout the study.

U.S. Coast Guard. "Overview of the U.S. Coast Guard Vapor Control System Program." Online. Available at http://www.uscg.mil.hq/gm/mso/mso3/vcsindex.html. Accessed May 28, 2002.

Abstract: None Provided

U.S. General Accounting Office (GAO), Longer Combination Trucks: Potential Infrastructure Impacts, Productivity Benefits, and Safety Concerns. GAO/RCED-94 106 Washington D.C., August 1994.

Abstract: None Provided

Urquhart, D. "NY Aims to Start Inland Port Distribution System." The Business Times Singapore, June 26, 2001.

Abstract: None Provided

Rail and Truck Container Movements

Muller, G. "Intermodal Freight Transportation." 4th Edition. Eno Transportation Foundation and Intermodal Association of North America. Washington, DC, 1999.

Abstract: None Provided

Murphy, P.R., and J.M. Daley. "Some Propositions Regarding Rail-Truck Intermodal: An Empirical Analysis." Journal Of Transportation Management, Vol. 10, No. 1, Spring 1998, 10-18.

Abstract: Journal – None Provided

Weissmann, A.J., and R. Harrison. "Analysis of U.S. – Mexico Traffic within Texas." Austin, Texas: Center for Transportation Research at the University of Texas at Austin, Project No. 2932-2, December 1995.

Abstract: In providing incentives for increased trade among the U.S., Canada, and Mexico, the North American Free Trade Agreement (NAFTA) could considerably liberalize freight carriage across these countries' respective borders. While Texas has a substantial economic interest in this increased trade, transportation planners indicate that the state, because of its strategic geographic location and its 2000-km-long border with Mexico, is destined to sustain a disproportionate share of such negative effects as traffic hazards, pavement consumption, and excessive capacity of its highways and border crossings. Accordingly, this report (1) updates and expands international traffic

information in the Transborder database; (2) analyzes Transborder traffic growth over the period 1993-94 (which takes into account the effects of NAFTA) and 1994-95 (which takes into account the Mexican peso devaluation); and (3) quantifies the amount of U.S.-Mexico trade that uses Texas's highway and rail infrastructure, but which has origins and destinations outside Texas.

Whitaker, C. "Move it Inland." Container Management, No. 188, January 2001, 18-19.

Abstract: Journal – None Provided

Container on Barges

Anderson, J. "Barge's Effect on Rail Disputed Rates." The Omaha World-Herald Company, August 26, 1998.

Abstract: Journal – None Provided

Ashar, A. "Maritime vs. Land Transport Between Mid-America and Mexico." Journal of the Transportation Research Forum, Vol. 36, No. 1, 1996, 1-18.

Supplemented Abstract: This article explores the potential for short-sea shipping on the trade route between Mid-America and Mexico, where it competes with both deep-sea shipping and land transportation. Five maritime systems were defined and assessed: (1) river barges navigating along the east coast of Mexico; (2) river barges transshipped to/from deep-sea bulkers; (3) small river barges lifted on/off mother vessels; (4) river barges floated on/off mother vessels (Fo/Fo); and (5) river/ocean vessels (R/O). River/ ocean vessels, although rather widespread in Europe, are somewhat novel in the U.S.

The analysis indicated that for bulk cargo the transshipment system has a clear advantage over all other maritime systems as well as over rail. In the case of general or non-containerized cargo, R/O was proven advantageous but only for cargoes generated close to the water. Accordingly, it is expected that several R/O services might be developed along the two routes between Mid-America and Mexico. It was also concluded that similar services can be developed to connect Mid-America to other Caribbean, Central, and South American points, giving rise to a total fleet of 15 to 20 R/O vessels.

Baldwin, T. "Malcom McLean New Service between Northeast and Jacksonville: Barges Could Lure Truck, Rail Cargo." Journal of Commerce, March 20, 1998.

Abstract: Trade Journal – None Provided

Barnard, B. "The Barge's Day Has Come: Container-on-Barge Shipment in Europe is Growing Faster than Intermodal Transportation by Rail or Truck." Journal of Commerce, May 28, 2001.

Abstract: Trade Journal – None Provided

"BN Ends Mexico Barge Service: US Co-Suspends Barge Service Without Mexico Co Protexa Between Galveston, TX & Coatzacoalcos, Mexico." Traffic World, October 17, 1994.

Abstract: Journal – None Provided

Bomba, M. and Harrison, R. "Feasibility of a Container-on-Barge Network Along the Texas Gulf Coast." Transportation Research Record 1782, Paper No. 02-4007, 2002.

Abstract: Freight volumes in Texas and throughout the world have been increasing as a result of growing national economies and international trade. The use of intermodal containers to transport this freight presents the opportunity for a more efficient transportation system. Using barges to carry containers could diminish roadway congestion, reduce fuel consumption and emissions, increase shipper options, and expand the reach of smaller ports. Although a number of benefits could be realized from container-on-barge (COB) service, the feasibility of a COB network along the Texas Gulf Coast remains less clear. At present, the likelihood of a COB network is slight because the hindrances are daunting: the lack of infrastructure and equipment; inadequate distribution of population along the Texas Gulf Coast; only a few navigable inland waterways, with none serving a major population center outside Houston; transport times that are incompatible with many manufacturers' needs; a history of failed attempts for COB companies; intense competition from railways; unclear costs for serving ports without container infrastructure; and a limited number of participants due to restrictions of the Jones Act. Opportunities may exist, however, for a COB operation to exploit the substantial amount of industrial activity along the Texas Gulf Coast and the inefficiencies in the existing supply chain. Growing U.S. trade with Mexico might also offer some possibilities for COB services, but the recent trend has been toward Texas receiving a diminishing share of the value and weight of containerized commodities being moved from Mexico.

Boyd, J. "Paper Giant Test Barges on Small Arkansas River." Journal of Commerce, January 8, 1992.

Abstract: Trade Journal – None Provided

Bray, L.G., C.A. Dager, R.L. Henry, and M.C. Koroa. "River Efficiency, Fuel Texas, and Model Shifts." TR News, No. 221, July-August 2002.

Abstract: Journal – None Provided

Brix, P. "Vessel Operations on the Columbia River." Transportation Research Circular, No. 350, May 1989, 59-60.

Abstract: Journal – None Provided

Bytnar L., A. Chiu, I. Frommann, L. Gruwell, L. Guttman, and W. Morgan. "Port Of Pittsburgh Practicum Project." TRB 2002 Annual Meeting CD-ROM, January 2002.

Abstract: In the past few years, traditional business strategies have been significantly challenged by the emergence of the Internet and eCommerce. Although old-economy companies currently dominate the transportation industry, an analysis of the opportunities ahead indicates that the industry is poised for change. Recent forecasts still predict explosive growth in business-to-consumer and business-to-business eCommerce. Without doubt, a shift from the traditional business model must include an Internet strategy and a viable aspect of eCommerce to secure competitive advantage.

Recognizing these macroeconomic trends, the Port of Pittsburgh Commission (PPC) engaged the Carnegie Mellon University practicum team to evaluate and recommend an eCommerce solution geared toward increasing barge awareness and opening a dialog between industry participants. Deploying a production strength solution required in-depth industry understanding, the combined intelligence of six CMU Masters of Science in eCommerce students, significant team commitment and daring leaps of creativity. SmartBarge offers the PPC the results of the practicum team efforts.

The approach taken in this practicum was to create a technical solution enabling shippers and providers to connect seamlessly and open a dialogue that was not currently functioning. In delivering this effective solution, a significant amount of the team's time was invested in industry meetings, onsite visits, and interviews with key shippers, terminal and barge operators. By growing both the sponsor's understanding of the range of issues involved and the support of key industry leaders, we have allowed the PPC to strategically position themselves for a subsequent step several months from now.

The registration of the domain name SmartBarge.com by the PPC was a plus for the practicum team. It was a domain name that could be easily remembered and used to build a theme for the new website. As a first step, the team built a Macromedia Flash introduction in order to catch and direct any new users that stumbled across or intentionally decided to explore the smartbarge.com site in advance of our May launch. The SmartBarge web site is a working model that will allow the PPC to build awareness of barge transport and to create a dialogue with shippers and waterway service providers. Although robust in functionality, it is only a first step to defining the requirements of a longer-term website that will handle end-to-end commercial transactions spanning the entire barging process.

Commins, P. "Barges, Railroads Face Grain Decline." Journal of Commerce, October 19, 1992.

Abstract: Trade Journal – None Provided

"Container On Barge 2001." Compact Disc, Port of Portland, April 2001.

Abstract: CD – None Provided

Cook, H. "A Solution to Congestion." Journal of Commerce, October 29, 2001.

Abstract: Trade Journal – None Provided

Crew, J., A. Hochstein, and K. Horn. "Prospects for Container-on-Barge Service on the Mississippi River." Transportation Research Record 1156, (1988): 56-65.

Abstract: Container-on-barge service represents an intermodal transport operation that takes advantage of high-capacity, low-cost inland waterways for the shipment of containers to coastal ports for transfer to ocean-going vessels. The feasibility of container-on-barge service between inland cities in the Midwest and Port of New Orleans via the Mississippi River system is examined. It is concluded that, because of the significantly longer transit time for containers shipped by barge, relative to rail service, container-on-barge service will be unable to compete for time-sensitive cargoes. To succeed, the container-on-barge service will need to attract neobulk and relatively low-value containerized shipments and reposition empty containers.

"Crowley Sells Barge Subsidiary." Journal of Commerce, September 18, 1987.

Annotation: The article reported that Crowley Maritime Corporation of San Francisco agreed to sell its Columbia Maritime Lines operations to Tidewater Barge Lines. It was reported that the buy-out stemmed from a lack of cargo on the Columbia River, stiff competition from railroads and a surplus of barges on the river system. Tidewater President, Ray Hickey, was quoted saying that "the ships are no longer coming to Columbia River ports (in the numbers they did). It is easier for them to go to the Puget Sound …" The number of containers moved by barge from upriver ports to Portland also dropped recently because the railroads have captured a bigger market share.

Dupin, C. "Containers on Barges on Ships." Journal of Commerce, Vol. 2, No. 23, June 11-17, 2001.

Abstract: Trade Journal – None Provided

Dupin, C. "End of the Line for Lash?" Journal of Commerce, Vol. 2, No. 23, June 11-17, 2001.

Abstract: Trade Journal – None Provided

Dupin, C. "Hub and Spoke: Port of New York Moves Ahead with Plans for Regional Network of Container Feeder Ports." Journal of Commerce, July 12, 2001.

Abstract: Trade Journal – None Provided

Edmonson, R.G. "House Bill Would Amend Jones Act." Journal of Commerce, May 30, 2001.

Abstract: Trade Journal – None Provided

Graaf, A. "Survey: The Netherlands: Barges Lead the Drive for Logistical Services." The Financial Times Limited, November 14, 2000.

Abstract: Journal – None Provided

Grier, D.V. "Measuring the Service Levels on Inland Waterways: Alternative Approaches for Budget Decision Making." TR News, No. 221, July-August 2002.

Abstract: Journal – None Provided

Hardebeck, S., B. Vogel Boze, J.P. Basilotto, J.M. McGuire, and P. Rhi-Perez. "Economic Impact of Barge Transportation on the Texas Portion of the Gulf Intracoastal Waterway (GIWW) and Extension of the GIWW into Mexico." College Station, Texas Transportation Institute at The Texas A&M University System Project No. 7-2993, April 1997. Revised March 1999.

Abstract: The purpose of this study is to update a 1989 study of the economic impact of the Gulf Intracoastal Waterway System in Texas. The study uses a variety of factors to determine the current impact of the GIWW on Texas including cargo value of domestic goods, Gulf Intracoastal Waterway maintenance dredging, and water transportation/services revenue.

Hensel, B., Jr. "Container-on-Barge Service Develops Gulf Coast Niche." Journal of Commerce, June 18, 2001.

Abstract: Trade Journal – None Provided

"Houston's Gulf Coast Supremacy is in the Clear." Containerisation International, Vol. 25, No. 7, July 1991, 51-57.

Abstract: Journal – None Provided

Johnson, B. Information Bank Abstracts. Journal of Commerce, August 1, 1984.

Abstract: Trade Journal – None Provided

"Jones Act: Don't Count on Changes." Journal of Commerce, January 18, 2000.

Abstract: Trade Journal – None Provided

"Jones Act Reform." Journal of Commerce, January 15, 2001.

Abstract: Trade Journal – None Provided

Kaser, T. "The Columbia Connection." Journal of Commerce, June 26, 2000

Abstract: Trade Journal – None Provided

McIntyre, J. "Over the Short Haul: Southern California Feeder Barge Service Proposed." WorkBoat Magazine, Vol. 53, No. 11/12, November/December 1996, 26-28.

Abstract: Journal – None Provided

"Mexican Waterways Plan Comes Under Fire at Conference." Traffic World, August 8, 1994.

Abstract: Journal – None Provided

Mongelluzzo, B. "Matson Replaces West Coast Water Service with Twice-Weekly Intermodal Rail." Journal of Commerce, November 14, 2000.

Abstract: Trade Journal – None Provided

Pfliegl, R. "Improving European Waterways Navigation: Danube Corridor Offers Key to Economic Development." TR News, No. 221, July-August 2001.

Abstract: Journal – None Provided

Pittam, C.C. "Combined Transport in Europe." Ekistics, Vol. 51, No. 305, March/April 1984, 102-109.

Abstract: Journal – None Provided

Prat, M. "Port Hopes for More." Journal of Commerce, May 22, 1987.

Abstract: Trade Journal – None Provided

"Quartel's Departure Signals Prospects for Compromise." Journal of Commerce, July 2, 1999.

Abstract: Trade Journal – None Provided

Sansbury, T. "Agreement Sought on Jones Act Issues." Journal of Commerce, January 31, 2000.

Abstract: Trade Journal – None Provided

Sansbury, T. "Navy Official Defends Jones Act." Journal of Commerce, September 1, 1998.

Abstract: Trade Journal – None Provided

Taylor, G. "Traffic to Mexico by Barge Still Limited." Journal of Commerce, March 14, 1996.

Abstract: Trade Journal – None Provided

Tirschwell, P. "Myth of the Megaport." Journal of Commerce, Vol. 2, No. 23, June 11-17, 2001.

Abstract: Trade Journal – None Provided

U.S. Department of Transportation: Maritime Administration. "Environmental Advantages of Inland Barge Transportation." Prepared by the Office of Market Promotion, August 1994.

Abstract: None Provided

WorldCargo New Online, "Columbia/Snake River System Faces Challenges." March 2002.

Abstract: Trade Journal – None Provided

Mini-Symposium/Workshop

Aultman-Hall, L., B. Johnson, and B. Aldridge. "Assessing Potential for Modal Substitution from Statewide Freight Commodity Flow Data." Transportation Research Record 1719, (2000): 10-16.

Supplemented Abstract: Kentucky has an extensive multimodal freight transportation network, despite its relatively small geographic area. The paper presented key findings of the statewide freight commodity flow analysis that relate to one of the multimodal transportation planning issues currently facing Kentucky: the relative role of various modes in freight transport and the potential for modal substitution.

Statewide issues affecting the type of data required for statewide freight planning studies were also discussed. As an example, modal substitution questions require freight commodity data by origin, destination, and mode. Publicly available data from the Bureau

of Transportation Statistics were considered unfeasible, and the study team was referred to Reebie Associates for detailed freight commodity flow information. The Reebie freight commodity flow data allowed for analysis by mode, commodity, and spatial zone within Kentucky where the potential for modal substitution was greatest.

In three areas of the state - central, far western, and northeastern - improvements to intermodal facilities for water and rail transportation might be considered. The analysis confirmed the extent to which Kentucky relies on multimodal transport. It was found that the majority of freight (by weight and volume) traveling to and from Kentucky moves by nonhighway modes. The concern was raised that certain rail and water connections between Kentucky and other areas of the United States may need further consideration and upgrading, because almost all freight to and from these areas moves by truck. Two other projects within the state that have capitalized on the Reebie data involved an analysis of traffic growth rate factors and the identification of new commercial vehicle monitoring stations.

Bookbinder, J.H., and N.S. Fox. "Intermodal Routing of Canada-Mexico Shipments under NAFTA." Transportation Research-E (Logistics and Transportation Revenue), Vol. 34, No. 4, 1998, 289-303.

Abstract: This paper obtains the optimal routing for intermodal containerized transport from Canada to Mexico. Such traffic is being stimulated by the North American Free Trade Agreement (NAFTA), but the cost and lead times of feasible routes are not well known. We summarize the links and routes to Mexico on which one or more carriers now operate, and then determine non-dominated tradeoffs between cost and service. Every southbound route from Canada requires a transshipment point in the southern or southwestern U.S. Feasible transshipment points are also locations for a manufacturing "twin plant", a distribution center, or a transportation hub. Here, as a first step in this bigger problem, a network is constructed between five Canadian origins and three important Mexican destinations. Each link employs available intermodal services whose transit time and transportation cost are obtained through industry sources. A shortest-path algorithm enables calculation of the route requiring least time and route of minimum cost. Nondominated time/cost tradeoffs are identified for each origin-destination pairs. After including inventory expenses (by parametrizing the unit value of lead time), total-cost curves then eliminate some routing alternatives. Guidelines are provided in the effects of mode, carrier, and O-D locations on selection of intermodal routes to Mexico. Finally, two new intermodal services are proposed and their benefits discussed.

U.S. Department of Transportation. "Comprehensive Truck Size and Weight (CTS&W) Study." Publication No. FHWA-PL-00-029. Vol. 3, Ch. 4, August 2000. Online. Available at http://www.fhwa.dot.gov/reports/tswstudy/. Accessed March 19, 2003.

Introduction: This chapter presents a discussion of the methodology used to evaluate changes in shipper decisions when faced with a change in trucking costs. Of particular interest to this study is a shift of freight from one truck configuration to another, and from

one gross vehicle weight (GVW) group to another. Also of concern is the shift in freight between rail and truck.

This information, expressed in truck vehicle-miles-of-travel (VMT) and rail car miles, is important in estimating not only shipper cost savings, but also impacts on pavements, safety, energy consumption, air quality, and noise levels.

Williams, B.M., and L.A. Hoel. "Freight Planning Requirements for Interstate Corridors." Transportation Quarterly, Vol. 52, No. 2, Spring 1998, 39-48.

Abstract: There is a consensus that transportation planning is at a crossroads. Forces of change include the completion of the Interstate System, advances in information technologies, and the emergence of a global economy. Transportation users seek high-quality service characterized by speed, flexibility, and responsiveness within a competitive environment that assures low cost. The public investment in infrastructure has diminished while control shifts to state and local governments.

A debate is underway as to how the planning processes should evolve. Among the new challenges to be faced is the need for improvements in the freight sector, where both private and public interests are strong. This article addresses a complex aspect of intermodal planning which deals with multistate concerns. Specifically, it addresses three requirements for corridor planning: data, analysis tools, and institutional structures. The article also discusses a redefined federal role and the need for cooperation among all governmental levels and for partnerships between the public and private sectors.

Modal Split Activities

Al-Deek, H.M. "Comparison of Two Approaches for Modeling Freight Movements at Seaports." Journal of Computing in Civil Engineering, Vol. 284, October 2001.

Abstract: Seaports host international cargo operations and are primary generators of freight traffic in the United States. Track/rail trip generation and modal split models provide public agencies with valuable information necessary to prioritize funds for roadway upgrade projects and port infrastructure modifications. This paper presents two approaches for developing freight trip generation models: regression analysis and back propagation neural networks (BPN). These models are used for predicting the levels of cargo truck traffic moving inbound and outbound at seaports. Based on the Port of Miami case, it was found that the BPN model is more accurate than the regression model. However, the BPN model requires a sizeable database. Using the BPN approach, the paper presents a new combined truck trip generation and truck-rail modal split model for the port of Jacksonville. It was found that the primary factors affecting truck-rail volume are the amount and direction of cargo vessel freight, commodity type, and the particular weekday of operation. In summary, the neural network model results were found to be significantly accurate for both Florida ports.

Ali, S., and Y.J. Stephanedes. "Policy-Sensitive Disaggregate Techniques for Estimating Freight Highway and Rail Use." Transportation Research Forum, 1984.

Abstract: A set of disaggregate, linear-probability demand models was developed to estimate the truck and rail shares in grain movement. The analysis was based on data from a survey of 768 country grain elevators in Minnesota, North Dakota and South Dakota and destined to the Twin Cities. Results indicate that freight rates and service availability time were the most significant determinants of modal decisions. All model coefficients were highly significant and of the expected sign. The models range from purely descriptive to policy-sensitive and can be applied by industry managers and public decision makers to evaluate the impacts of service policies on modal split.

Ben-Akiva, M., and S.R. Lerman. "Discrete Choice Analysis: Theory and Application to Travel Demand." The MIT Press, Cambridge, MA, 1985.

Abstract: Book – None Provided

Beuth, M., B. Jourquin, J. Geerts, and C. K. N. Ha. "Freight Transportation Demand Elasticities: A Geographic Multimodal Transportation Network Analysis." Transportation Research Part E, 2001.

Abstract: This paper presents direct and cross-elasticity estimates of the demands for three freight transportation modes: rail, road and inland waterway. They are computed for 10 different categories of goods with a detailed multimodal network model of Belgian freight transports. The mode, which minimises the generalized cost of transportation tasks defined by O-D matrices, assigns traffic flows to the different modes, transport means and routes. Successive simulations with different relative costs permit the computation of specific arc-elasticities. In contrast with the usual methodologies, the present methodology is not based on a statistical analysis of disaggregate data on actual modal choices and transport tariffs. This is a particularly useful feature since such data are mostly not available fore freight transports in Europe. Furthermore, it fully takes into account the detailed characteristics of the network, all available routes and combinations of odes, as well as the specific localization of activities within the network. Its estimates are compared with previously published estimates, and, in particular, with Abdelwahab's resulted published 91998) in this journal.

Bronzini, M.S. "Evolution of a Multimodal Freight Transportation Network Model." Proceedings, Transportation Research Forum, Vol. 21, 1980, 475-485.

Abstract: A national multimodal freight transportation network model has been used to study several possible federal government policy initiatives in the freight area. The model uses a large network database covering each of the principal modes of intercity freight transportation. Using decentralized decision logic, the model routes given commodity movements from origin regions to destination regions through the network so

as to minimize shipper transportation and inventory costs. The initial applications of the model were a study of the potential impacts of inland waterway user charges and an investigation of some alternatives for saving energy in intercity freight transportation. The model was next used for the National Energy Transportation Study, a joint Department of Energy-Department of Transportation effort designed to examine the capability of the national transportation system to support the fuel movements called for in the President's National Energy Plan. During this work, a network equilibrium algorithm was added to the model to achieve better estimates of flow patterns. The model is currently being exercised for the Electric Power Research Institute to examine the impacts of transportation network changes on energy supply costs. In this work the model's cost and capacity estimates were reassessed and a railroad-specific network routing algorithm was developed.

Cambridge Systematics, Inc. "A Guidebook for Forecasting Freight Transportation Demand." NCHRP Report 388, Transportation Research Board, National Academy Press, 1997.

Supplemented Abstract: This report provides extensive reference information on freight transportation planning processes, techniques, tools, data, and applications. The report is organized in a guidebook format to assist planning practitioners and policy analysts in effectively integrating freight planning and demand forecasting into the broader multimodal transportation planning process. Possible users of the guidebook include state DOTs, metropolitan planning organizations (MPOs), port and airport authorities, rail and trucking providers, shippers, various federal agencies, researchers, and academic institutions. Useful information concerning factors impacting freight demand are summarized in the Appendices, including economic indicators, international trade agreements, and just-in-time inventory practices; freight demand forecasting studies; freight data sources, including among others the commodity flow survey data; descriptions of survey procedures; statistical forecasting techniques; transport cost estimation; modal diversion and descriptions of related models; and case studies. This guidebook is intended not only to serve as a basic educational resource but also to support a range of planning initiatives and more detailed project-level analyses.

Chiang, Y.S., P.O. Roberts, and M. Ben-Akiva. "Short-Run Freight-Demand Model: Joint Choice Mode and Shipment Size." Transportation Research Record 828, 1981, 9-12.

Abstract: An important part of quantitative analysis of freight transportation is a capability for forecasting the demand for a certain type of service under a given set of conditions. Unfortunately, the state of the art in freight-demand modeling is still rather primitive. It is clear that the firm is the basic decision-making unit in the transportation of freight. However, the role of the firm in selecting freight transportation service has not been explored satisfactorily. Most of the existing freight-demand models are correlative rather than explanatory and insensitive to changes in transport level-of-service measures. Researchers in the past have been constrained either to piecing together useful aggregate data to estimate an aggregate demand model or to using shipper surveys to estimate a very limited shipper-choice model. An attempt to develop a freight-demand model that involves

the choice of mode as well as shipment size without imposing the assumption of constant transportation rate is given. A multinomial logit model of mode and shipment size is developed at the level of the individual firm. The utility function is derived from logistics inventory theory that considers explicitly the trade-offs the firm can make in response to a short-run change in transportation level of service. The major assumption is that the substitution between transportation and other factors of production, such as labor and capital, is relatively inelastic when compared with the substitutions that can take place within the transportation sector itself.

Crainic, T.G., M. Florian, and J. Leal. "A Model for the Strategic Planning of National Freight Transportation by Rail." Transportation Science, Vol. 24, No. 1, February 1900.

Abstract: Recently, we developed a multimode multiproduct network optimization model, that is the network assignment method implemented in an interactive-graphic system for the strategic analysis and planning of national freight transportation systems, called STAN. For STAN, we developed a modeling framework of the rail freight transportation system, its components, operations and goals, that is adapted for both the strategic objectives of the planning system and there presentation of the other transportation modes that compose a national multimode transportation systems. The objective of this paper is to present and analyze the rail component of this strategic model of a national freight transportation system. We show how the rail model is integrated into STAN, as well as how this modeling framework may be used to represent a number of realistic scenarios.

Danielis, R. and L. Rotaris. "Analyzing Freight Transport Demand Using Stated Preference Data: A Survey and A Research Project for the Friuli-Venezia Giulia Region." Trasporti Europei, n 13, 1999, 30-38.

Abstract: The paper surveys the application of the stated preference technique to analyze freight transport demand. The objective is to identify the contribution of the analysis of hypothetical data to the understanding of freight transport markets as opposed to the results obtained using observed, revealed preference data.

Donnelly, R. "The Development of a Hyrid Microsulation Model of Freight Flows." PBConsult, Inc., Albuquerque, New Mexico, Undated.

Abstract: None Provided

Eatough, C.J., S.C. Brich, and M.J. Demetsky. "A Statewide Intermodal Freight Transportation Planning Methodology." Journal of the Transportation Research Forum, Vol. 39, No. 1, Winter 2000, 145-155.

Abstract: This article describes a framework for planning from a state's perspective for the infrastructure to support efficient intermodal freight transportation. A prototype set of models and procedures is established using existing transportation planning techniques

and principles. The methodology is flexible, so that it can adapt to changing planning concerns and resources and can be applied to a broad range of issues. Throughout the process, the role of a Freight Advisory Council is shown to reflect the input and perspective of the private sector. The methodology is applicable with limited freight flow data and can lead to standard practices in statewide freight transportation planning.

Fang, Y.Y., R. Harrison, and H.S. Mahmassani. "Forecasting Freight Traffic Between the U.S. and Mexico." Austin, Texas: Center for Transportation Research at the University of Texas at Austin, Project No. 1319-2, August 1996.

Abstract: The North American Free Trade Agreement (NAFTA), a 1992 agreement negotiated by the U.S., Canada, and Mexico, has prompted new interest in freight demand forecasting. With respect to those goods moving between the U.S. and Mexico, most are transported by highway through Texas, California, New Mexico, and Arizona. Freight demand forecasting can assist transportation professionals in planning for the infrastructure maintenance required to avoid serious disruptions to trade flows across the border.

The objective of this research is to use publicly available data to develop predictive models for transport mode and Mexican destination decisions for shipments from various U.S. regions. Aggregate logit models have been calibrated for three commodities: machinery, electronics, and automobiles. A profile of Mexico and its industries is presented along with a review of past efforts in freight demand forecasting. The data set of aggregate shipments used in the model estimation is comprised of origin, destination, commodity type, mode of transport across the border, and value. Destination attributes, such as population, employment, number of firms in the industry, and number of shippers and warehouses, are also included. Based on the results of this research, origin and commodity-specific models may be used as a basis for future studies developing forecasting tools that include additional modes and commodities at a more disaggregate level.

Friesz, T.L., J.A. Gottfried, and E.K. Morlok. "A Sequential Shipper-Carrier Network Model for Prediction Freight Flows." Transportation Science, Vol. 20, No. 2, May 1986.

Abstract: A sequential shipper-carrier predictive freight network model is presented. This model is applied to three detailed network data bases. The predicted arc loadings are compared to published railway arc density codes and goodness-of-fit measures are reported for the origin-destination flows of 15 commodities. A discussion of some sources of error in the model and recommendations for further research to lessen that error are given.

Gray, R. "Behavioral Approaches to Freight Transport Modal Choice." Transport Reviews, Vol. 2 No. 2, 1982, 161-184.

Abstract: Three main types of institutions are interested in the determinants of freight transport modal choice –the government, the carrier, and the shipper. Researchers have emphasized the importance of understanding the decision-making procedures of actors involved in freight modal choice (e.g., Meyburg 1979, Roberts 1971). This requires the

development of behavioral models and the paper is a review of the state of the art in such modeling.

Most models can be included under two main prevailing orthodoxies. First, these are models which assume that modal choice is based on some form of short-term cost optimization by the shipper. The approach may be called "economic positivism" since it assumes that modal choice is determined by economic or cost variables. Second, there are modal which assume that modal choice is based on relationships between physical aspects of the transport system (e.g., speed, frequency) and physical aspects of the product (e.g. perishability, value-weight ratio). This approach may be called "technological positivism" since it assumes that modal choice is determined by technological variables. In addition, there is a third broad approach to the study of freight modal choice which bases its assumptions on the perceptions of members of shippers organizations, particularly transport managers. This approach may be called the "perceptual approach".

The review examines empirical studies undertaken in Australia, Canada, the Untied Kingdom, and the U.S.A. Particular areas for discussion are the assumptions of the disciplines from which the models are drawn and the relevant units of analysis (e.g., the firm, the individual person, the consignment).

Guelat, J., M. Florian, and T.G. Crainic. "A Multimode Multiproduct Network Assignment Model for Strategic Planning of Freight Flows." Transportation Science, Vol. 24, No. 1, 1990, 25-39.

Abstract: We present in this paper a normative model for simulating freight flows of multiple products in a multimodal network. The multimodal aspects of the transportation system considered are accounted for in the network representation chosen. The multiproduct aspects of the model are exploited in the solution procedure, which is a Gauss-Seidel-Linear Approximation Algorithm. An important component of the solution algorithm is the computation of shortest paths with intermodal transfer costs. Computational results obtained with this algorithm on a network that corresponds to the Brazil transportation network are presented. Several applications of this model are reported as well.

Harker, P.T., and T.L. Friesz. "Prediction of Intercity Freight Flows I: Theory." Transportation Research, Vol. 20B, No. 2, 1986, 139-153.

Abstract: This paper presents the conceptual framework for a predictive network equilibrium model of a freight transportation system in which the generation, distribution, modal split and assignment of freight movements are performed simultaneously. A neoclassical profit maximization model is stated for the supply-side of the transportation market, the demand-side is represented by a spatial price equilibrium model, and the economic mechanism which integrates the supply and demand submodels is described. The theoretical limitations imposed on the model by the requirement that it be capable of solving large-scale problems are also addressed.

Harrison, R. and M. A. Euritt. "Truck to Rail Diversion Over the Conrail Network Using Pennsylvania I-80 Corridor Data." Texas Research Development Foundation, October 1, 1992.

Abstract: None Provided

Harrison, R., M.T. McNerney, M. Eurit, and W.R. Hudson. "Truck Versus Rail Freight System Cost Comparison: Conrail and I-80 Pennsylvania Corridors." Texas Research and Development Foundation, September 1991.

Abstract: This report describes truck traffic on the I-80 corridor and highlights the system costs associated with the I-80 facility including: construction, maintenance, right-of-way, and rehabilitation and reconstruction. Presents a summary of the highway-user taxes and fees paid to the government for truck use of the I-80 corridor. Summarizes the costs associated with I-80 truck operations, which must be recovered through freight shipping charges and also quantifies the social costs of truck accidents and air pollution. Separate appendices for Chapters One through Four detail the procedures used to determine and calculate traffic facility costs, user taxes and fees, and operating costs. Chapter Five details life cycle rail costs for a comparable section of Conrail's Pennsylvania rail corridor. The final chapter presents a modal comparison of through-costs for truck and rail.

Hensher, D., and K.J. Button. "Handbook of Transport Modeling." Pergamon. New York, 2000.

Abstract: None Provided

Herendeen, J.H., Jr. "Theoretical Development and Preliminary Testing of a Mathematical Model for Predicting Freight Modal Split." Thesis, The Pennsylvania State University, 1969.

Abstract: A brief description of the regional transportation planning process serves to delineate the task performed by a freight modal split model. Existing techniques for performing the freight modal split function are reviewed. A new model for predicting freight modal split is presented along with a discussion of the rationale for the form of the model. The documentation of the preliminary testing of the model serves as a procedural guide for use of the freight modal split model and a description of the preliminary testing procedure. Results of the preliminary test indicate that the freight modal split model will perform adequately as part of a regional planning tool. Additional research is indicated, however, to coordinate other parts of the analytical process of regional transportation planning with the freight modal split model. Complete testing and implementation of the model should be undertaken as part of a total transportation planning effort.

Holguin-Veras, J., and E. Thorson. "Trip Length Distributions in Commodity-Based and Trip-Based Freight Demand Modeling: Investigation of Relationships." Transportation Research Record 1707, (2000): 37-48.

Abstract: Commodity-based and vehicle-trip-based freight demand modeling is discussed. The characteristics of the trip length distributions (TLDs) are examined, defined in terms of tons, as required in commodity-based modeling, and in vehicle trips, as required in trip-based modeling. With data used from a major transportation study in Guatemala, the TLDs are estimated for both tons and vehicle-trips. The analysis revealed that (a) the shape of the TLDs depends upon the type of movements being considered; (b) TLDs defined in terms of tonnage differ significantly from those defined in terms of vehicle trips; (c) TLDs for different types of vehicles, transporting similar commodities, reflect the range of use of each type of vehicle; (d) through tons TLDs and vehicle TLDs are different, the relationship between them seems to follow a systematic pattern that, if successfully identified, would enable transportation planners to estimate one type of TLD given the other; and (e) major freight generators affect the shape of the TLDs, so complementary models may be needed to provide meaningful depictions of freight movements.

Howie, P., and P. Nelson. "Freight Mode Choice- A Discrete Choice Mode." In Proceedings of the Third Conference of the Hong Kong Society for Transportation Studies, December 1998.

Abstract: The predicting of mode choice for freight services and calculating freight service elasticities is becoming increasingly important to the transport industry. This is due to the fact that freight service providers are under increasing pressure to provide reliable, damage free, timely, and low cost freight services. This paper investigates the relationship between the mode selected to transport freight and a number of service characteristics including price, transit time, reliability, flexibility of service and care of goods. The paper discusses two methods used to investigate mode choice selection: revealed preference and stated preference techniques. Relatively high elasticity values were derived from both methods for price, the stated preference method also derived an elasticity value for care of goods. Both methods however, were unable to derive values for reliability and transit time. Further research is proposed to improve the stated preference methodology and hence study freight mode choice in more depth.

Marchant, M.A. "Analysis of the Effects of Rising Transportation Costs on California's Fresh Fruit and Vegetable Markets." Journal of the Transportation Research Forum, Vol. 32, No. 1, 1991, 17-32.

Abstract: None Provided

Middendorf, D.P., M. Jelavich, and R.H. Ellis. "Development and Application of Statewide, Multimodal Freight Forecasting Procedures for Florida." Transportation Research Record 889, (1982): 7-14.

Abstract: The development and application of a goods movement forecasting methodology resulting from the Statewide Multi-Modal Planning Process Project sponsored by the Florida Department of Transportation are described. The methodology involves two steps. First, the generation and distribution of freight are projected through a Fratar model that applies growth factors to current flows of commodities. In the second

step, the projected freight flows are distributed among competing modes through modal-split models. The Fratar model was successfully applied to produce reasonable projections of freight traffic to, from, and within Florida in 1985 and 2000. Efforts to develop modal-split models by using the logit formulation were not successful. The Fratar model was based on existing secondary sources of data. Because these sources exist in the same or an analogous form in other states, a similar modeling approach could be developed and applied elsewhere.

Murthy, A.S.N., B. Ashtakala. "Modal Split Analysis Using Logit Models." Journal of Transportation Engineering, Vol. 113, No. 5, 1987.

Abstract: This study attempts to identify the mode and the factors that contribute to the selection of a particular mode for commodity movements provincially based on average shipment size, control, loads, hire, and type of commodity. The main objective of this study is to propose a more comprehensive and statistically credible method to analyze the vast data required in transportation planning. It involves the application of standard statistical techniques such as the log-linear and logit models. The data are collapsed to form multidimensional contingency tables in order to develop these models. The data from both shippers and consignees are taken from a survey conducted by Alberta Transportation, Canada. From the analysis it is found that truck and rail are the only two major carriers of freight across the province. Truck mode dominated over rail in transporting all commodities. The less-than-full-load market belongs exclusively to truck mode, The rail shares a very small percentage (<15%) of the full-load market, and is used to transport specific bulk commodities under higher average shipment size.

Nam, K. "A Study on the Estimation and Aggregation of Disaggregate Models of Mode Choice for Freight Transport." Transportation Research-E (Logistics and Transportation Revenue), Vol. 33, No. 3, 1997, 223-231.

Abstract: The literature on modal choice analysis of freight transport has revealed that the freight transport market is highly diverse. Aggregation over heterogeneous commodity types can cause a bias in the estimation of models. Therefore, disaggregation over commodity groups has been the norm and different models developed. In some cases, however, aggregate models might be preferable because they are less costly and may be adequate for prediction. The present paper attempts to improve our understanding of this area by investigating the desirability of aggregation over commodity groups.

Nozick, L.K., M.A. Turnquist, and G.F. List. "Trade Pattern Estimation Between the United States and Mexico." Transportation Research Circular, Issue 459, 1996, 74-86.

Abstract: The North America Free Trade Agreement (NAFTA) established the largest free trade zone in the world, with a population of more than 360 million people. To evaluate potential investments in intermodal terminals near the U.S.-Mexican border – terminals that will handle the escalation in trade that is likely to result from NAFTA – transportation planners must understand current trade patterns. Unfortunately, most data

required to achieve this understanding are considered confidential between the shipper and the government customs agency. However, both the governments of Mexico and the United States do release summaries of these shipment data. This paper presents a method for estimating commodity-based origin-destination matrices based on these summaries.

Ortuzar, J., and L.G. Willumsen. "Modeling Transport." John Wiley & Sons Ltd. New York, 1990.

Abstract: None Provided

Pendyala, R.M., V.N. Shankar, and R.G. McCullough. "Freight Travel Demand Modeling: Synthesis of Approaches and Development of a Framework." Transportation Research Record 1725, 2000, 9-16.

Supplemented Abstract: All levels of decision making are increasingly realizing that freight transportation and economic development are inextricably linked. As a result, many urban entities and states are embarking upon comprehensive freight transportation planning efforts aimed at ensuring safe, efficient, and smooth movement of freight along multimodal and intermodal networks. Over the past few decades there has been considerable published research on (1) freight transportation factors, (2) freight travel demand modeling methods, (3) freight transportation planning issues, and (4) freight data needs, deficiencies, and collection methods. This paper provides a synthesis of the body of knowledge in these four areas with a view to developing a comprehensive statewide freight transportation planning framework. The proposed framework consists of two interrelated components: first, an analytical modeling framework that closely parallels the traditional four-step transportation modeling structure and, second, a post-freight assignment process. These components facilitate demand estimation and decision making in the freight transportation sector.

Picard, G. "Exploration of a Box Cox Logit Model of Intercity Freight Mode Choice." Transportation Research E, Vol. 34. No. 1, 1998.

Abstract: During the past years, the linear logit model has been used extensively in modal choice analysis. More recently, the introduction of Box-Cox transformations on the explanatory variables in passenger studies have generally shown the superiority of the Box-Cox logit over the linear logit. Nevertheless, we have found only one such application in freight transportation. This study is devoted to filling this gap by testing different configurations of the Box-Cox logit over the linear logit. Our results confirm the usefulness of the nonlinear Box-Cox specifications found in passenger studies. We have used an original data bank developed for Canada. The bank contains, for 64 commodity groups, the 1979 domestic flows among 67 geographical zones, by three transportation modes: truck (private and for hire), rail and ship. To the author's knowledge, this is the first Canadian study on mode choice that takes into account private trucking; since Canadian private trucking is at least as important as for hire, this could contributed to the results obtained.

Sivakumar, A. "A Fractional Split Distribution Model for Statewide Commodity Flow Analysis." Thesis, University of Texas at Austin, 2001.

Abstract: This thesis proposes and applies a relatively simple, but comprehensive, approach to modeling inter-regional commodity flow volumes. The approach estimates the fraction of the commodities consumed at each destination zone that originates from alternative production zones. The resulting fractional split model for commodity flow distribution is more general in structure than the typical gravity model used today for statewide freight planning. The fractional split model is estimated using a quasi-likehood approach, which provides consistent and asymptotically robust inference for the model's parameters. The empirical analysis in the thesis applies the fractional split model to analyze commodity flows between Texas counties and between Texas counties and external stations. The results provide important insights into the determinants of inter-regional commodity flow in Texas.

Sivakumar, A., and C.R. Bhat. "Freight Modal Split Modeling: Conceptual Framework, Model Structure, and Data Sources." Austin, Texas. Center for Transportation Research at The University of Texas at Austin, Project Number 1833-4, August 2000.

Abstract: This report, as a follow-up to the previous report, presents the results of the model estimation task. The final commodity-specific modal split models are presented, followed by a discussion of their implications. These models are embedded within a larger Geographic Information System (GIS) based modeling system, the development of which is also presented here. This model system is intended to forecast the effects of port expansions, market changes, and network changes on the statewide transportation network.

Sivakumar, A., A. Srinivasan, and C.R. Bhat. "Freight Model Split: Estimation Results and Model Implementation." Austin, Texas. Center for Transportation Research at The University of Texas at Austin, Project Number 1833-5, July 2001.

Abstract: This report, as a follow-up to the previous report, presents the results of the model estimation task. The final commodity-specific modal split models are presented, followed by a discussion of their implications. These models are embedded within a larger Geographic Information System (GIS) based modeling system, the development of which is also presented here. This model system is intended to forecast the effects of port expansions, market changes, and network changes on the statewide transportation network.

Smadi, A., and T.H. Maze. "Statewide Truck Transportation Planning: Methodology and Case Study." Transportation Research Record 1522, (1996): 55-63.

Abstract: An alternate approach for truck transportation planning at the state level is presented using a case study application in the State of Iowa. The method was based on some freight modeling concepts and available freight data sets. However, the model takes advantage of two concepts: unconstrained highway capacities and the decomposition of

commodities resulting in manageable data and modeling requirements. Identification of significant economic sectors, selection of appropriate measures, estimation of truck freight volumes for each sector individually, and estimation of routing of truck traffic on major highway routes are major elements of the planning method. The case study used two industrial sectors – food and kindred products, and machinery products – which accounted for the largest portion of state employment in nonservice sectors and for the largest truck traffic generated in the state. A simplistic transportation network was used to demonstrate the modeling procedure. The analysis uses county-level employment and population to estimate zonal freight tonnage. The truck share of generated freight was estimated as the total freight generated less the freight tonnage shipped by rail. A gravity model was used to distribute the truck tonnage among origin-destination pairs, using travel time as the impedance on highway links. Estimated truck flows were converted to vehicle trips on least time highway routes using typical vehicle equivalent weight.

Sorratini, J.A., and R.L. Smith, Jr. "Development of a Statewide Truck Trip Forecasting Model Based on Commodity Flows and Input-Output Coefficients." Transportation Research Record 1707, (2000): 49-55.

Abstract: This research attempts to improve the modeling of statewide truck travel demand models by using commodity flow data from the U.S. Census Bureau, a private freight database (TRANSEARCH), and input-output (I-O) coefficients. The standard urban transportation planning modeling process was applied at the state level to estimate heavy truck trips. Economic-based I-O software was used to derive the I-O direct matrix and the I-O direct coefficients at the state level for developing the trip attraction rates for 28 manufacturing sectors. The Commodity Flow Survey from the U.S. Census Bureau together with a private database developed for Wisconsin were used to develop the trip production rates. Transportation planning software (TRANPLAN) was used to distribute and assign truck trips generated at the zonal level. The selected link function in TRANPLAN was used to adjust the initial productions and attractions in order to generate link volumes that match the actual ground counts for 40 selected links. The model only required two iterations of the selected link analysis in order to produce an acceptable match with the ground counts, compared with three iterations for two prior similar models. The rapid convergence provides clear evidence that the disaggregate trip generation models give better initial estimates of trip productions and attractions than was possible with the prior studies. A "back forecast" of 15 years to the year 1977 was found to be reasonable both in terms of the present root mean square error by volume group and the performance measures for five screen lines.

Strong, C.K., R. Harrison, and H.S. Mahmassani. "A Methodology for Determining the Freight Border Transportation Impact of the North American Free Trade Agreement." Austin, Texas: Center for Transportation Research at the University of Texas at Austin, Project No.1319-4, December 1996.

Supplemented Abstract: The demand for infrastructure investment in the Texas-Mexico border region – a demand heightened by the growth in trade resulting from the North American Free Trade Agreement (NAFTA) – has created the need for a

comprehensive freight forecasting model. Accordingly, this report presents a useful methodology to forecast the effects of NAFTA on the demand for freight transportation at the Texas-Mexico border. In developing long-term estimates of future freight-related traffic crossing the border, the methodology employs three steps: (1) an economic analysis of the region, (2) calibration of modal choice models, and (3) an assessment of inventory practices. The methodology is designed to improve upon previous efforts by considering how NAFTA would alter the economic environment in which firms operate, as well as the decisions these forms make regarding modal choice and shipment size. By optimizing the efficient allocation of staff and resources, this methodology could be used to upgrade the operations and infrastructure of the Texas-Mexico border region. This report, however, makes no assessment of the availability of the level of disaggregated data required to implement the methodology.

Texas Department of Transportation Expressway. "Proposal submitted for Trans Texas Corridor." February 28, 2003. Online. Available at http://www.dot.state.tx.us/txdotnews/004%2D2003.htm. Accessed March 3, 2003.

Abstract: Website – None Provided

U.S. Department of Transportation. "TMIP: The Travel Model Improvement Program." Online. Available at http://tmip.fhwa.dot.gov. Accessed March 19, 2003.

Abstract: Website – None Provided

U.S. Department of Transportation (U.S. DOT), Comprehensive Truck Size and Weight Study, The Intermodal Transportation Inventory Cost Model Documentation, April 1999.

Abstract: None Provided

Wilson, F.R., B.G. Bisson, and K.B. Kobia. "Factors That Determine Mode Choice in the Transportation of General Freight." Transportation Research Record 1061.

Abstract: This study examines the factors that influence the mode choice decisions of shippers of general freight commodities in the Atlantic provinces of Canada. The study employed a mail-response questionnaire directed to randomly selected manufacturers to determine the basis of each firm's decision to ship by its regular mode. Respondents were required to identify the product shipped most frequently by the firm and the most regular origin-destination link. They were then required to provide pertinent details, such as transit time, shipping costs, and frequency of shipments, relating to the shipment of that product on the identified origin-destination link. Linear logit models were used to determine the variables that influence the selection of various modes for goods shipment and the relationship between the utility of each mode and the explanatory variables. The models obtained were as intuitively expected. It is concluded that logit analysis using survey data represents a valid and potentially more useful methodology than the use of waybill data. It

is recommended that further research using the suggested model forms and data obtained from personal interviews of shippers would improve the quality of the results and provide a greater understanding of the shipper mode choice decision process.

Winston, C. "The Demand for Freight Transportation: Models and Applications." Transportation Research, Vol. 17A, No. 6, 1983, 419-427.

Abstract: This paper provides an overview of models of the demand for freight transportation and applications of these models. Aggregate and disaggregate freight demand models are presented and critically evaluated with regard to conceptual coherence and estimability. These models are then discussed in the context of various freight transportation issues including the extent and nature of intermodal competition, the importance of service quality, the desirability and effects of changes in the regulatory environment, and forecasting flows that are carried by existing or new freight transportation modes. The paper concludes with suggestions for further work to be done in the area of freight demand.

Young, W., A.J. Richardson, K.W. Odgen, and A.L. Rattray. "Road and Rail Freight Mode Choice: Application of an Elimination-by-Aspects Mode." Transportation Research Record 838.

Abstract: The Australian Railway Research and Development Organization is conducting a study, and one of its objectives is to determine factors that affect freight modal use. Part of this has included the development and calibration of freight modal-choice models. The results obtained from the application of an elimination-by-aspects (EBA) model to this task are outlined. The theoretical background to the EBA model and the results o the model when applied to three samples of shippers involved in regional freight transport re described. For each sample, models are calibrated and , on the basis of attribute significance and correlations, these models are refined and recalibrated. Measures or elasticity are then calculated for each attribute in the refined model. The results of the model calibration are then discussed and are found to be plausible given the nature of the shippers in each sample. It is concluded that it is possible to use an EBA model for the analysis of freight modal choice. Areas of future research are identified, and implications of the research for railways are discussed.

Appendix B:
Potential Container Freight Data Sources

Potential Container Freight Data Sources

Data Source	Organization	Data Available	Year Available	Comments
TRANSEARCH Freight Market Data	Reebie Associates	Includes tonnage and equipment volumes by commodity, transportation mode, and lane It contains the following: • Truck shipments of manufactured goods and select nonmanufactured goods • Rail shipments, including carload and intermodal • Waterborne and air shipments • US/Mexico and US/Canada shipments for select transport modes • Other data elements on a custom basis Geographic definitions are produced at the county, zip code, metropolitan area, and state or province level. Goods are described in terms of commodity or Standard Industrial Code (SIC) with volumes in loads, tonnage, or value.	2000	Very expensive
CO$TLINE Rail Cost Analysis Model	Reebie Associates	Based on Reebie's comprehensive rail cost and mileage database. Accepts origin, destination, payload weight, car type, commodity, and routing inputs.	Updated quarterly	All Co$tline models calculate the shipment costs of U.S. and Canadian freight carriers only.
CO$TLINE Truck Cost Analysis Model	Reebie Associates	Based on Reebie's comprehensive truck cost and mileage database. Consider shipment parameters including weight, distance, and trailer type.	Updated quarterly	
CO$TLINE Intermodal Cost Analysis Model	Reebie Associates	Consider shipment parameters, including weight, distance, routing, service code, and trailer/container type	Updated quarterly	
CO$TLINE Barge Cost Analysis Model	Reebie Associates	Based on network, service, and cost model developed in conjunction with the Corps of Engineers. Consider shipment characteristics such as	Updated quarterly	

Data Source	Organization	Data Available	Year Available	Comments
		weight, distance, lock delays, and barge type.		
Commodity Flow Survey Data	U.S Department of Transportation: Bureau of Transportation Statistics, U.S Census Bureau, Department of Commerce, Oak Ridge National Laboratory	Designed to provide data on the flow of goods and materials by mode of transport. A sample of 100,000 establishments engaged in mining, manufacturing, wholesale, auxiliary establishments (warehouses), and some activities in retail and service was selected (1997), representing over 5 million shipments. For each of these shipments, the following data were recorded: • Zip code of origin and destination. Data available are national, stratified by state and metropolitan area • 5-digit Standard Classification of Transported Goods (SCTG) code • Weight • Value • Modes of transport • Check box information on whether the shipment was containerized, a hazardous material, or an export.	1993 1997	Texas coverage and sample size Contacted Felix Amatago (BTS). At the state level containerized data were found to be statistically unreliable. BTS decided to exclude questions on domestic container shipments in the 2002 survey.
Transborder Surface Freight Data	U.S. Department of Transportation: Bureau of Transportation Statistics, U.S Census Bureau	Provides North American merchandise trade data by commodity type and surface mode of transportation (rail, truck, pipeline, mail, and other), with state detail for U.S. exports to and imports from Canada and Mexico. Table Number 09: Imports from Mexico with commodity and selected geographical detail: • Method of transportation (i.e., mail, truck, rail, pipeline, other) • Distinguishes whether the merchandise is containerized • Commodity code (Harmonized Tariff Schedule) • U.S. state of destination • Commodity value • Aggregate freight charges	Monthly: April 1993 to Nov 2001	Contacted Lize Randall (BTS). Respondent required to check a box to indicate whether cargo is containerized or not. Container data should be used only to indicate broad orders of magnitude.

Data Source	Organization	Data Available	Year Available	Comments
		• Shipping weight Table 10: Imports from Canada with commodity and selected geographical detail: • Method of transportation (i.e., mail, truck, rail, pipeline, other) • Distinguishes whether the merchandise is containerized • U.S. state of destination • Commodity code (Harmonized Tariff Schedule) • Canadian province of origin • Commodity value • Aggregate freight charges • Shipping weight Table Number 11: Imports from Mexico with geographical detail: • Method of transportation (i.e., mail, truck, rail, pipeline, other) • Distinguishes whether the merchandise is containerized • U.S. state of destination • U.S. district and port of entry • Commodity value • Aggregate freight charges • Shipping weight Table 12: Imports from Canada with geographical detail: • Method of transportation (i.e., mail, truck, rail, pipeline, other) • Distinguishes whether the merchandise is containerized • U.S. state of destination • U.S. district and port of entry • Canadian province of origin • Commodity value • Aggregate freight charges		

Data Source	Organization	Data Available	Year Available	Comments
		• Shipping weight		
Port Import Export Reporting Service (PIERS)	The Journal of Commerce	Includes: • Product description • Piers product code • Harmonized tariff code and description • U.S. and overseas port names • Container size, quantity, TEU count, and cubic feet • Cargo quantity and unit of measure • Cargo weight • Estimated cargo value • U.S. and overseas origins and destinations • Name and address of U.S. importer • Name and address of U.S. exporter • Name and address of foreign shipper • Customs clearing district	Complete reports are available approximately four to five weeks after the close of the month.	
Container Crossing U.S.-Mexico Border	U.S. Department of Transportation: Bureau of Transportation Statistics	• Incoming truck crossings, U.S.-Mexican Border • Incoming truck container (loaded) crossings, U.S.-Mexican Border • Incoming truck container (unloaded) crossings, U.S.-Mexican Border • Incoming train crossings, US-Mexican Border • Incoming rail container (full) crossings, US-Mexican Border • Incoming rail containers (empty) crossings, U.S.-Mexican Border	Yearly from 1994 to 2001, and monthly from January 2003 to September 2003.	Available upon request from the Bureau of Transportation Statistics.
Vehicle Inventory and Use Survey (VIUS)	U.S. Department of Commerce, Bureau of the Census	Questions included: the following: • Approximate percentage of 1997 vehicle mileage pulling a trailer that hauled railroad, maritime, or domestic containers. • Which of the following best describes your	First collected in 1963 (previously called Truck Inventory and	No origin/destination information; no tonnage, volume; or value data Cost: $18.00 (excluding shipping and handling)

Data Source	Organization	Data Available	Year Available	Comments
		business (or the part of your business in which the vehicle was used)? (e.g., agricultural or farming activities, forestry or lumbering activities, construction work, contractor activities or special trades, manufacturing, refining, or processing activities, wholesale trade, retail trade, etc.) • From the following list of products, materials, and equipment, indicate which item or items this vehicle carried.	Use Survey) and in five year intervals since. Latest VIUS data are for 1997.	
Deskmap	Deskmap	Digital map databases are available for the following: • Entire rail network in the U.S. representing major and short-line railroad companies (includes link specific details, such as rail operators, track rights and passenger services; excludes rail classified as abandoned) • Class I rail lines in the U.S. (includes link specific details, such as rail operators and state in which the rail line operates) • Entire rail network in Canada representing major and short line railroad companies (includes link specific details, such as rail operators, track rights, and passenger services; excludes rail classified as abandoned) • Entire rail network in Mexico representing major and short-line railroad companies (includes link specific details, such as rail operators, track rights, and passenger services; excludes rail classified as abandoned) • Stations to or from which rail carriers ship freight for the U.S., Canada and Mexico (includes station ID, station name, station	Continually updated.	Individually priced.

Data Source	Organization	Data Available	Year Available	Comments
		state, station county, rating zip code, etc.)		
2001 National Transportation Atlas Database	Bureau of Transportation Statistics	GIS data layers (available in ESRI shapefile format) depict transportation facilities, networks, and services of national significance: • Intermodal terminals: point database of major highway-rail intermodal freight facilities in the U.S. Includes data for facilities in the U.S. and data for TOFC and COFC, the modes involved, the type of cargo, and direction of transfer. • Water port facilities: extracted from national Waterway Network database. • National highway planning network version 3.0, representing 400,000 miles of federal aid roads. Includes sign route number, alternate sign route, length of the link, permissible flow of traffic, toll features, degree of access control, functional class, etc. • National rail network, representing railway mainlines, railroad yards, and major sidings. Includes railroad owner, track rights, abandoned lines, passenger services, density, railroad classification code, type of signaling system, year of abandonment, etc. • National waterway network, representing navigable inland and intracoastal waterways. Includes control depth, geographic class, functional class, waterway type, compass direction, etc.	Intermodal (1998) Water ports (1994 - 2000) Road network (1992 - 2001) Rail network (2000) Waterway network (1994 - 2000)	Intermodal – No origin/ destination information; no tonnage, volume, or value data. Water ports – No container, origin/destination information; no tonnage, volume, or value data Highway network – No container or origin/destination information; no tonnage, volume, or value data Rail network – No container or origin/destination information; no tonnage, volume, or value data Waterway network – No container, or origin/destination information; no tonnage, volume, or value data
North American Transportation Database (NORTAD 1998)	Bureau of Transportation Statistics	GIS data layers that depict U.S., Canadian, and Mexican transportation facilities, networks, and services of national significance. U.S. data layers were also included in the 2001 National Transportation Atlas Database (see above). Available Canadian and Mexican data include	Canadian road data (1996) Canadian rail data (1995) Canadian port data (1995)	No container, origin/ destination information; no tonnage, volume, or value data

Data Source	Organization	Data Available	Year Available	Comments
		the following: • Network database of Canadian highways and primary roads. Includes place name from, place name to, number of lanes, speed limit, national highway system • Network database of Canadian railway mainlines. Includes railroad owner, length of link, etc. • Point database of Canadian port facilities • Network database of Mexican highways and primary roads. Includes highway name, highway mode, highway route number, highway classification, number of lanes, type of topography, rural/ urban categorization, operator, etc. • Network database of Mexican railway mainlines. Includes railroad name, rail mode, railroad line, track type, etc. • Point database of major Mexican highway-rail intermodal freight terminals. • Point database of major commercial seaports in Mexico. • Point database of highway border crossing facilities between the U.S. and Canada or the U.S. and Mexico. • Point database of rail border crossing facilities between the U.S. and Canada or the U.S. and Mexico.	Mexican road data (1996) Mexican rail data (1996) Mexican intermodal data (1995) Mexican port data (1995) Highway border crossing data (1996) Rail border crossing data (1996)	
Rail Waybill Sample	Interstate Commerce Commission	Database contains rail shipment data, including the following: • Intermodal service code (TOFC/ COFC) • Origin and destination points • Type of commodity • Number of cars • Tons • Revenue • Length of haul	1983 - 2000	

Data Source	Organization	Data Available	Year Available	Comments
		• Participating railroads • Interchange locations		
Waterborne Data Bank: Cargo Statistical Data Bank	U.S. Department of Transportation Maritime Administration	• Percentage of containerized value and weight in the import and export waterborne databanks	1995-2001 monthly	
Maritime Data	U.S. Army Corps of Engineers	Domestic container movement information		Contacted Arlene Dietz. Surveys have recently been initiated to collect domestic container movement data. Container data will be available only in 2003.
	Intermodal Association of North America	Quarterly intermodal report, which contains data on the following: • Trailer and container movements by corridor, as reported by the Class I railroads • Intermodal load volumes, highway load volumes, intermodal revenues, and highway revenues, as reported by 14 intermodal marketing companies.		No detailed information on movements within a state, value of shipments, commodity, or weight of shipments.
	Containerization International	Data on containerized movements through the Texas ports of Houston, Freeport, Galveston and Gulfport: • Full landed TEUs • Empty landed TEUs • Landed tonnage • Full shipped TEUs • Empty shipped TEUs • Shipped tonnage • Total TEUs • Total tonnage	1996 to 2000	No container or origin/ destination information
Texas Statewide Analysis Model	Texas Department of Transportation	Freight output to be calculated in terms of number of truckloads and number of trucks with imbedded conversion factors.	To be completed Nov/ Dec 2002	To be determined whether a conversion factor will exist to determine container loads or the particular commodities transported in containers.

Appendix C: Freight Models

Freight Models

Source	Author	Model Structure	Year[8]	Modes	Region	Variables	Data Used	Assumptions /Limitations
Analysis of the Effects of Rising Transportation Costs On California's Fresh Fruit and Vegetables Markets	M.A. Marchant	Linear programming model	1991	Truck only	U.S.	Fresh fruit and vegetable prices, price of diesel fuel, fuel efficiency data, and mileage data	U.S. Department of Agriculture (USDA) Agricultural Marketing Service's Fresh Fruit and Vegetable Prices 1988, Army Regulation Report #55-60, American Trucking Associations, Inc.	
A Multimode Multiproduct Network Assignment Model for Strategic Planning of Freight Flows	J. Guelat, M. Florian, and T.B. Crainic	Normative model	1990	10 modes including rail, road, ports, and coastal and interior navigation modes	Brazil	Six products (cement and steel products, iron ore, fertilizer and coal, soya oil, soya grain, and all other)	O/D data from GEIPOT (planning organization of the Brazilian Ministry of Transportation)	Goods are shipped at minimum total generalized costs.
A Fractional Spilt Distribution Model for Statewide Commodity Flow Analysis	A. Sivakumar	Fractional mode split model		Truck and rail	Texas	Production zone size variables, impedance variables, nonsize production zone variables, employment by sector, area, population, number of establishments, annual	1996 Reebie data, county business patterns database, the U.S. Census Bureau population projections, the REIS database, and the TransCAD-related data.	

[8] Year published.

Source	Author	Model Structure	Year[8]	Modes	Region	Variables	Data Used	Assumptions /Limitations
						payroll, and rail and road distances		
A Study on the Estimation and Aggregation of Disaggregate Models of Mode Choice for Freight Transport	K. Nam	Logit model		Truck and rail	Korea	Accessibility, rate, transit time, daily service frequency, and size of shipment	Nationwide survey of route trucking companies that included commodity type, shipper type, consignment weight, freight charge, and origin and destination pair	
Forecasting Freight Traffic Between the U.S. and Mexico	Y.Y. Fang	Aggregate logit model		Truck and rail		Origin, destination, commodity type, mode of transport across the border, and value		
Prediction of Intercity Freight Flows I: Theory	P.T. Harker and T.L. Friesz		1986					
Evolution of a Multimodal Freight Transportation Network Model	M.S. Bronzini	National multimodal freight transportation network model	1980					Does not consider the effects of congestion

Source	Author	Model Structure	Year[8]	Modes	Region	Variables	Data Used	Assumptions /Limitations
Development of a Statewide Truck Trip Forecasting Model Based on Commodity Flows and Input-Output Coefficients	J.A. Sorratini and R.L. Smith, Jr.	Statewide truck travel demand model	2000	Truck only	Wisconsin		1993 Commodity Flow Survey, TRANSEARCH database	Tested by back forecasting over a 15-year time period. It is assumed in this paper that if the model is able to forecast heavy truck trips in a prior year then it should be able to forecast those trips for a future year as well.
Freight Flow Forecasting-An Application to New Jersey Highways	M.P. Boile, S. Benson, and J. Rowinski		2000	Truck and rail	New Jersey		TIGER/Line, 1995; U.S. Streets, 1995; and National Transportation Atlas Database, 1997	Assignment is based on the shortest path out of New Jersey headed toward the commodity destination, owing to the assumption that once trucks leave New Jersey they would travel on an interstate highway
A Sequential Shipper-Carrier Network Model for Prediction of Freight Flows	T.L. Friesz, J.A. Gottfried, and E.K. Morlok	Sequential shipper-carrier predictive freight network equilibrium model	1986	Rail, water, and water/rail	1) Railway-waterway network, 2)railway for entire U.S., and 3) a railway-waterway network for the entire			Does not consider backhauling

Source	Author	Model Structure	Year[8]	Modes	Region	Variables	Data Used	Assumptions /Limitations
					U.S.			
A Model for the Strategic Planning of National Freight Transportation by Rail	T. Crainic, M. Florian, and J. Leal	Network assignment model	1990	Rail	Brazil	Cost, five products (agricultural solid bulk, gypsum, salt, cement, and petroleum byproducts including alcohol)	Direct surveys	
Factors That Determine Mode Choice in Transportation	F.R. Wilson, B.G. Bisson, and K.B. Kobia	Discrete individual shipper choice/Linear logit models	1986	Hired truck, private truck, and rail	Atlantic provinces of Canada	Frequency, transit time, cooperation, pickup	Survey of shippers	
Statewide Truck Transportation Planning: Methodology and Case Study	A. Smadi and T.H. Maze	Truck demand model: generation, distribution, and assignment	1996	Truck	Iowa	Travel time	Iowa Truck Weight Survey, Waybill Samples, and AUTOMAP	
Determinants of Modal Choice in Freight Transport	V.P. Jeffs and P.J. Hills	Discrete individual shipper choice, methodology	1990			Customer requirements, product characteristics, company structure/organization, government interventions, available transport facilities, and perception of the		

Source	Author	Model Structure	Year[8]	Modes	Region	Variables	Data Used	Assumptions /Limitations
						decision maker in the firm		
Intermodal Competition Model (ICM)	American Association of Railroads	Discrete choice model: Truck to rail traffic diversion model		Rail and truck				Limited analysis of potential truck to rail diversion due to a lack of truck traffic data similar to the rail waybill sample
Cross Elasticity Model (CEM)	American Association of Railroads	Discrete choice model					National motor transport database, ICM, and analysis of the size and composition of the truck-load freight industry	Market-share economic model
Intermodal Transportation and Inventory Cost Model						Over-the-road shipments, transportation cost, line-haul miles, reposition miles, commodity attributes, O/D pairs, commodity shipped, annual tons shipped, number of railroads, equipment type, and variable cost	1993-1994 Association of American Railroads North American Transportation Survey (NATS) and STB's 1994 Waybill Sample	Assumed that any changes in truck size and weight limits would not change container sizes. The model also employs an all-or-nothing rule to determine if a shipment will be diverted.

Source	Author	Model Structure	Year[8]	Modes	Region	Variables	Data Used	Assumptions /Limitations
A Statewide Intermodal Freight Transportation Planning Methodology	C.J. Eatough, S.C. Brich, and M.J. Demetsky	Freight flow assignment	2000				TRANPLAN	
Freight Mode Choice: A Discrete Choice Model	P. Howie and P. Nelson	Logit discrete choice model	1998	Road and rail	Australia	Price, transit time, reliability, service availability, and damage	Interstate container traffic data including tonnage, market share, prices, distance, and travel time by road and rail	
Modal Split Analysis Using Logit Models	A.S.N. Murthy and B. Ashtakala	Log-linear and logit modes	1987	Truck and rail	Canada	Origin-destination, type of commodity, type of firm, type of goods, annual tonnage, average shipment size, mode of transport, loads (full or less than full), control (yes or no), hire (private or for hire), market share, and demographic data such as population, retail sales volumes, etc.	Surveys of shippers and consignees	
Policy-Sensitive Disaggregate Techniques for Estimating Freight Highway and Rail Use	S. Ali and Y.J. Stephanedes	Disaggregate linear-probability demand models	1987	Truck and rail	Minnesota, North Dakota, and South Dakota	Type of grain, destination, shipment size, perceived unloading time, mode chosen, shipping data, delivery date, unloading date, selling price, freight rate, and	Mail survey of individual count grain elevators in the three-state region	

Source	Author	Model Structure	Year[8]	Modes	Region	Variables	Data Used	Assumptions /Limitations
						amount of loss and damage		
Short-Run Freight-Demand Model: Joint Choice of Mode and Shipment Size	Y.S. Chiang, P.O. Roberts, Jr., and M. Ben-Akiva	Mulitnomial logit model of mode and shipment size at the individual firm level	1980	Rail, common carrier truck, private truck and air	National	LOS variables include freight rate and special charges, mean transit time, waiting time, transit-time reliability, loss and damage, and the time required to complete the investigation of loss and damage claims. Logistics costs include transportation charges, capital carrying cost in storage, capital carrying cost in transit, order cost, loss of value during transit or stage, and mode and shipment size constants.	1972 Census of Transportation Commodity Transportation Survey (CTS) and a number of sources and documentation at MIT	

Source	Author	Model Structure	Year[8]	Modes	Region	Variables	Data Used	Assumptions /Limitations
Freight Transportation Demand Elasticities: A geographic Multimodal Transportation Network Analysis	M. Beuthe, B. Jourquin, J Geerts, C.K.N. Ha	Direct and cross-elasticity	2000	Road, rail, and inland wterway	Belgium	10 categories of goods, vehicle operations costs, handling costs, and commodities inventory costs		Assumes that shippers minimize their generalized cost of transport
Exploration of a Box-Cox Logit Model of Intercity Freight Mode Choice	G. Picard and M. Gaudy	Nonlinear Box-Cox logit model	1997	Truck (private and for hire), rail, and ship	Canada		Canadian Institute of Guided Ground Transport and Statistics, Canada Input/Output Division databases, and the Canadian Mineral Yearbook	
Road and Rail Freight Mode Choice: Application of an Elimination-by-Aspects Model	W. Young, A.J. Richardson, K.W. Ogden, and A.L. Rattray	Elimination-by-aspects model	1981	Road and rail	Australia	Transit time, reliability, capacity, frequency, freight rates, damage, loss, convenience, and communication	Data collected at two major corridors and from interviews with executives of freight forwarding firms and firms that shipped their own goods	

Appendix D: Survey Cover Letter and Questionnaires

Center for Transportation Research
The University of Texas at Austin
3208 Red River, #200 • Austin • Texas • 78705
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Total Pages including cover sheet:
Recipient:
Recipient's Fax Number:
Copy Faxed To:
Subject:

From: Kellie Spurgeon
Sender's Fax Number: (512) 232-3070
Sender's Phone Number: (512) 232-3110
Date:

Dear:

The Center for Transportation Research at the University of Texas, Austin has been contracted by the Texas Department of Transportation to analyze containerized freight movements in Texas. The Texas economy imports and exports substantial volumes of freight by container – through east coast, west coast and Gulf ports – as well as providing highway and rail corridors for containerized traffic moving through Texas to origins and destinations outside the state. Little is, however, currently known about how containers move within and through Texas.

The objective of our investigation is to gain a better understanding of containerized flows and to evaluate the potential impacts of containers that pass through Texas on the state's transportation system. We are currently seeking the assistance of transportation stakeholders involved in containerized freight movements in an effort to characterize and gain a better understanding of how containers move in and across the state (i.e. rail, truck, barge), what commodities are in these containers, the significant origins and destinations of containerized movements, and container volumes (in terms of number of containers, weight and value, if available) on key corridors. An understanding of container flows in Texas will be of great benefit to transportation planners at the Texas Department of Transportation, who are responsible for the future planning of transportation corridors and terminals.

I will contact you next week to determine if you are willing to participate in this study. Participation requires a 15-minute telephone interview with me. Please be assured that your responses would be regarded as strictly confidential and under no circumstances would individual respondents be identified.

If you have any questions regarding this study, please do not hesitate to contact the Deputy Director of the Center for Transportation Research, Robert Harrison, at (512) 232-3113 or my research supervisor, Jolanda Prozzi, at (512) 232-3079.

Thank you in advance for your cooperation.

Sincerely,

Kellie Spurgeon

Trucking Company Questionnaire

1. Does a significant share of your business involve the movement of containers?

2. In terms of container movements, what is the principal geographic area in which you operate? (Between origins and destinations (a) in the county, (b) in the Texas Triangle, (c) in the rest of Texas (d) in Texas and Mexico, (e) in Texas and other U.S. states)

3. Does a substantial share of your container movements have an origin or destination at a rail intermodal yard?

4. Does a substantial share of your container movements have an origin or destination at a port?

5. As far as possible, what roadways do you use? (Interstates, major highways, local and county roads)

6. Does your company own or lease any containers? In your opinion, what are the benefits/ detriments of owning/ leasing?

    a. If leasing, on average what is the leasing term? (per trip, specified time period)
    b. If leasing for a specified time, who is responsible for repositioning the containers?
    c. If leasing for a specified time/ owning, do you find repositioning empty containers problematic/ costly?
    d. If owning, what is the average "life" of a container?
    e. If owning, what does your company do with the containers at the end of their "life"?

7. Are you part of a container pool? In your opinion, what are the benefits/ detriments?

    a. If part of a container pool, who is responsible for repositioning the containers?

8. What size containers do you most often transport/ own/ lease?

9. Do you insure the container?

10. Is there a system in place that tracks container movements from origin to destination? If yes, who tracks the container movements?

11. When is responsibility for the container transferred from one mode of transport to the next?

12. What is the charge to transfer a container between modes? Is the charge included in the quoted truck tariff?

13. In your opinion, does the movement of containers represent a security concern?

    a. If yes, do you feel that technology can mitigate security concerns?

14. Have you recently been asked to participate in a container study? If yes, who approached you?

Freight Forwarder Questionnaire

1. Does a significant share of your business involve arranging the movement of containers?

2. What is the principal origins and destinations of these container movements? (Between origins and destinations (a) in the county, (b) in the Texas Triangle, (c) in the rest of Texas (d) in Texas and Mexico, (e) in Texas and other U.S states)

3. Does a substantial share of the container movements have an origin or destination at a port?

4. Does a substantial share of the container movements have an origin or destination in Mexico?

5. Does your company own or lease any containers? In your opinion, what are the benefits/ detriments of owning/ leasing?

   a. If leasing, on average what is the leasing term? (per trip, specified time period)
   b. If leasing for a specified time, who is responsible for repositioning the containers?
   c. If leasing for a specified time/ owning, do you find repositioning empty containers problematic/ costly?
   d. If owning, what is the average "life" of a container?
   e. If owning, what does your company do with the containers at the end of their "life"?

6. Do you have access to a container pool? In your opinion, what are the benefits/ detriments?

   a. If part of a container pool, who is responsible for repositioning the containers?

7. Is there a system in place that tracks container movements from origin to destination? If yes, who tracks the container movements?

8. When is responsibility for the container transferred from one mode of transport to the next?

9. What are the different cost components involved in moving a container between an origin and destination in the United States?

10. How does these cost components differ when importing/ exporting containers?

11. What is the charge to transfer a container between modes?

12. Who is financially responsible for insuring the container?

13. Who is financially responsible for insuring the contents of the container?

14. In your opinion, does the movement of containers represent a security concern?

    a. If yes, do you feel that technology can mitigate security concerns?

15. The Port of Pittsburgh reports on their website (www.smartbarge.com) that the rail charge for moving one 20ft container from Houston to Pittsburgh amounts to $6,000. However, if two containers are moved between these points, the charge per container is almost half. Does this seem reasonable?

16. Have you recently been asked to participate in a container study? If yes, who approached you?

Ocean Carrier Questionnaire

1. Does a significant share of your business involve arranging the movement of containers?

2. What is the principal origins and destinations of these container movements? (Between origins and destinations (a) in the county, (b) in the Texas Triangle, (c) in the rest of Texas (d) in Texas and Mexico, (e) in Texas and other U.S states)

3. Does your company own or lease any containers? In your opinion, what are the benefits/ detriments of owning/ leasing?

    a. If leasing, on average what is the leasing term? (per trip, specified time period)
    b. If leasing for a specified time, who is responsible for repositioning the containers?
    c. If leasing for a specified time/ owning, do you find repositioning empty containers problematic/ costly?
    d. If owning, what is the average "life" of a container?
    e. If owning, what does your company do with the containers at the end of their "life"?

4. Do you have access to a container pool? In your opinion, what are the benefits/detriments?

    a. If part of a container pool, who is responsible for repositioning the containers?

5. Is there a system in place that tracks container movements from origin to destination? If yes, who tracks the container movements?

6. When is responsibility for the container transferred from one mode of transport to the next?

7. What are the different port cost components involved in moving a container?

8. What is the charge to transfer a container between modes?

9. Who is financially responsible for insuring the container?

10. Who is financially responsible for insuring the contents of the container?

11. In your opinion, does the movement of containers represent a security concern?

    a. If yes, do you feel that technology can mitigate security concerns?

12. Have you recently been asked to participate in a container study? If yes, who approached you?

Container Lessor Questionnaire

1. Does a significant share of your business involve arranging the movement of containers?

2. What is the principal origins and destinations of these container movements? (Between origins and destinations (a) in the county, (b) in the Texas Triangle, (c) in the rest of Texas (d) in Texas and Mexico, (e) in Texas and other U.S states)

3. Does a substantial share of the container movements have an origin or destination at a port?

4. Does a substantial share of the container movements have an origin or destination in Mexico?

5. Does your company own containers? In your opinion, what are the benefits/ detriments of owning?

6. On average what is the leasing term?

7. When leasing for a specified time, who is responsible for repositioning the containers?

8. When leasing for a trip, do you find repositioning empty containers problematic/ costly?

9. What is the average “life” of a container?

10. What does your company do with the containers at the end of their “life”?

11. Is there a system in place that tracks container movements from origin to destination? If yes, who tracks the container movements?

12. When is responsibility for the container transferred from one mode of transport to the next?

13. What are the different cost components involved in moving a container between an origin and destination in the United States?

14. How does these cost components differ when importing/ exporting containers?

15. What is the charge to transfer a container between modes?

16. Who is financially responsible for insuring the container?

17. Who is financially responsible for insuring the contents of the container?

18. In your opinion, does the movement of containers represent a security concern?

    a. If yes, do you feel that technology can mitigate security concerns?

19. Have you recently been asked to participate in a container study? If yes, who approached you?

Railroad Company Questionnaire

1. Does a significant share of your business involve the movement of containers?

2. In terms of container movements, what is the principal geographic area in which you operate? (Between origins and destinations (a) in the county, (b) in the Texas Triangle, (c) in the rest of Texas (d) in Texas and Mexico, (e) in Texas and other U.S. states)

3. Does a substantial share of your container movements have an origin or destination at a port?

4. Does the railway own or lease any containers? In your opinion, what are the benefits/ detriments of owning/ leasing?

    a. If leasing, on average what is the leasing term? (per trip, specified time period)
    b. If leasing for a specified time, who is responsible for repositioning the containers?
    c. If leasing for a specified time/ owning, do you find repositioning empty containers problematic/ costly?
    d. If owning, what is the average "life" of a container?
    e. If owning, what does your company do with the containers at the end of their "life"?

5. Do you have access to a container pool? In your opinion, what are the benefits/ detriments?

    a. If part of a container pool, who is responsible for repositioning the containers?

6. What size containers do you most often transport/ own/ lease?

7. Is there a system in place that tracks container movements from origin to destination? If yes, who tracks the container movements?

8. When is responsibility for the container transferred from one mode of transport to the next?

9. What is the charge to transfer a container between modes? Is the charge included in the quoted rail tariff?

10. Do you insure the container?

11. In your opinion, does the movement of containers represent a security concern?

a. If yes, do you feel that technology can mitigate security concerns?

12. The Port of Pittsburgh reports on their website (www.smartbarge.com) that the rail charge for moving one 20ft container from Houston to Pittsburgh amounts to $6,000. However, if two containers are moved between these points, the charge per container is almost half. Does this seem reasonable?

13. Have you recently been asked to participate in a container study? If yes, who approached you?

Appendix E: Survey Respondents

Leasing	**Trucking Companies**
CAI	Bridge Terminal Transport
Florens	Canal Cartage Company
Gateway	Clark Freight Lines
GESEACO	Container Port Services
One Way Lease	Container Transportation
Seateq	JB Hunt
United Container Systems	Palletized Trucking
	Servitrans
Freight Forwarding	Transports Specialist
ABX Logistics	Unlimited Trucking Inc.
Alliance International Forwarders	Wilson Transportation Company
Aries Freight System	WWW Rowland
Gis Container	
InCorpro	**Railroads**
K-International	Union Pacific
NJ International	Burlington Northern Santa Fe
Panalpina	
Pro-Service	**Ocean Carriers**
	ACL
	Maersk
	P&O Nedlloyd

Appendix F: Aggregated Commodities

Aggregated Commodity Code	Aggregated Commodity Description	Harmonized Tariff Schedule	Standard Transportation Commodity Code
1	Agricultural & Related Products	1,2,3,6,13,41,42	01, 08, 09, 31
2	Hazardous Materials	27,28,29,30,31,34,35,36,38,93	13, 19, 28, 29, 40
3	Construction Materials	25,26,32,44,68,70	10, 11, 14, 24, 32
4	Food & Related Products	4,5,7,8,9,10,11,12,14,15,16,17,18,19,20,21,22,23,24	20, 21
5	Manufacturing Products	33,37,39,41,43,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,69,71,72,73,74,75,76,78,79,80,81,82,83,86,87,88,89,90,91,92,94,95,96	22, 23, 25, 26, 27, 30, 33,34, 37, 38, 39
6	Machinery & Equipment	84,85	35, 36
7	Mixed Freight Shipments	97,98	41, 42, 43, 44,45, 46, 47

Appendix G: Conversion Factors

Converts total commodity tonnages to commodity container tonnages

COMMODITY	TRUCK	RAIL
Agricultural Products	0.040	0.200
Construction Materials	0.020	0.002
Food	0.030	0.010
Hazardous Materials	0.020	0.070
Machinery & Equipment	0.010	0.020
Manufacturing Products	0.040	0.040
Mixed Freight Shipment	0.030	0.020

Converts commodity container tonnages to container flows

COMMODITY	TRUCK	RAIL
Agricultural Products	15.8	21.4
Construction Materials	15.8	16.8
Food	15.8	19.8
Hazardous Materials	15.8	19.4
Machinery & Equipment	15.8	11.8
Manufacturing Products	15.8	15.7
Mixed Freight Shipment	15.8	15.1

Appendix H: Barbours Cut Terminal Truck Survey Input Table

ORIGIN	DEST	COMM_TYP	ROAD	RAIL
2	48201	1	2564	0
22	48201	1	6411	0
40	48201	1	2137	0
48037	48201	1	1710	0
48039	48201	1	4701	0
48113	48201	1	10684	0
48167	48201	1	4274	0
48167	48201	1	3846	0
48201	48245	1	1852	0
48201	48113	1	16668	0
48201	48141	1	8025	0
48201	48039	1	1852	0
48201	48215	1	2469	0
48201	48479	1	14198	0
48201	48361	1	7408	0
48201	48167	1	6791	0
48201	48423	1	3087	0
48201	40	1	4939	0
48201	22	1	3087	0
48201	2	1	3704	0
48245	48201	1	5983	0
48355	48201	1	1710	0
48355	48201	1	2564	0
48361	48201	1	5983	0
48479	48201	1	1710	0

Note: Data is in terms of boxes without commodity information