Technical Report Documentation Page

1. Report No. 0-1833-3	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle IMPACTS OF CONTAINERSHIP SIZE, SERVICE ROUTES, AND DEMAND ON TEXAS GULF PORTS		5. Report Date March 2001, Rev. December 2001
		6. Performing Organization Code
7. Author(s): Robert Harrison and Miguel Figliozzi		8. Performing Organization Report No. Research Report 0-1833-3
9. Performing Organization Name and Address Center for Transportation Research The University of Texas at Austin 3208 Red River, Suite 200 Austin, Texas 78705-2650		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. Project No. 0-1833
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Implementation Office P.O. Box 5080 Austin, TX 78763-5080		13. Type of Report and Period Covered Research Report: September 1998–April 2001 December 2001
		14. Sponsoring Agency Code

15. Supplementary Notes

Research performed in cooperation with the U.S. Department of Transportation, Federal Highway Administration, and the Texas Department of Transportation

16. 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 for 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 through 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 mega-containerships. 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.

17. Key Words Texas Container Ports, Containership, mega-containership, container load center, containership operating costs, container forecasts in North Atlantic and Gulf	18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of pages 114	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

IMPACTS OF CONTAINERSHIP SIZE, SERVICE ROUTES, AND DEMAND ON TEXAS GULF PORTS

by
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and
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Research Report Number 0-1833-3

Research Project Number 0-1833
Research Project Title: *Infrastructure Impacts of Containerships (Including Mega-Containerships) on the Texas Transportation System*

Conducted for the

TEXAS DEPARTMENT OF TRANSPORTATION

in cooperation with the

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

by the

CENTER FOR TRANSPORTATION RESEARCH
Bureau of Engineering Research
THE UNIVERSITY OF TEXAS AT AUSTIN

March 2001
Rev. December 2001

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ACKNOWLEDGMENTS

The authors wish to acknowledge the involvement and direction of the Texas Department of Transportation (TxDOT) project monitoring committee, which includes project director Raul Cantu (MMO) and project monitoring committee members Jim Randall (TPP), Wayne Dennis (MMO), and Carol Nixon (HOU). Generously, John McCray (UTSA) provided the team with a special order trade commodity database and staff at the Port of Houston provided a sub-set of the Port Import Export Reporting System (PIERS) related to Gulf container flows. Staff at Maersk Sealand provided valuable guidance on containership deployment strategies. Particular thanks are due also to C. Michael Walton, Mr. Michael Bomba, and Qifei Wang, all of whom assisted in various aspects in the development of this report. Finally, thanks are due to Patricia Hord (assisted by Michael Gray) who helped draft the report and take it through various stages to final proofing.

Prepared in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.

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PROJECT BACKGROUND

Late in 1998, the Texas Department of Transportation (TxDOT) commissioned the Center for Transportation Research (CTR) at The University of Texas at Austin to examine the infrastructure impacts and operational requirements associated with large containerships, known as *mega-containerships*. The research project was designed with two primary goals. First, the project was to address the planning, institutional, and financial issues associated with increased containerized freight traffic. The second goal was to assess the demand placed on the multimodal transportation system in Texas, contingent on the operation of these 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 mega-containerships.

The first deliverable of the project, *Mega-Containerships and Mega-Containerports in the Gulf of Mexico: A Literature Review and Annotated Bibliography* (1833-1), provided a review of mega-containership literature in the context of global trade and the changing maritime sector. The second deliverable, *An Identification Process and Evaluation Framework for Texas Gulf Containerports* (1833-2), developed (1) a process for determining whether a candidate port could become a containership load center on the Texas Gulf Coast and (2) a port evaluation process that could be useful to all Texas ports providing containership services. A fourth report, *Technical Report on Mode Choice Modeling* (1833-4), provided a conceptual framework for a containerport landside mode split model, proposed a model formulation, and identified the data needed to calibrate and apply the model to facilitate transportation planning. This report, the project's third deliverable, considers the impact of ship size, liner service routes, and container demand on Texas Gulf seaports serving containerships.

PROJECT OBJECTIVE

During the 1990s, North American economies involved in world merchandise trade grew by more than 7 percent annually. By the end of the decade, as shown in Table 1.1, North America accounted for around 20 percent (over $11 trillion) of the total world merchandise trade. The ability to sustain both this high rate of growth and market share is a reflection of the benefits accruing to those economies (particularly the U.S. economy) through the impacts of new technologies, the liberalization of cross-border flows, a substantial improvement in transportation systems, and the development of supporting institutional arrangements such as the World Trade Organization (WTO). It is now widely recognized that the United States is part of a global market and must therefore develop the means to stay competitive in what is an extremely challenging and dynamic environment.

Table 1.1. Growth in the value of world merchandise trade by region, 1999

(Billion dollars and percentage)

Exports			**Imports**	
Value 1999	**Annual % change 1990-1999**		**Value 1999**	**Annual % change 1990-1999**
934	7	North America*****	1,280	8
297	8	Latin America	335	11
2,353	4	Western Europe	2,418	4
2,180	*4*	*European Union (15)*	*2,232*	*4*
214	6	C./E. Europe/Baltic States/CIS	214	5
102	*7*	*Central and Eastern Europe*	*131*	*10*
112	—	*Baltic States and the CIS*	*83*	—
112	1	Africa	133	4
170	3	Middle East	150	5
1,394	7	Asia	1,200	6
419	*4*	*Japan*	*311*	*3*
195	*14*	*China*	*166*	*13*
546	*8*	*Six East Asian Traders*	*485*	*6*
5,473	**5**	**World**	**5,729**	**6**

*****Excluding Mexico
Source:WTO, 2001.

Transportation operations played an important role in both forming and maintaining trade globalization in the 1990s. Over the decade, these operations effectively lowered transportation and communication costs and permitted, based on efficiency criteria, more choices for the location of manufacturing and assembly plants, load centers, and distribution sites throughout the various world markets. An excellent treatise on this subject is provided in a recent LBJ School of Public Affairs report examining the role of transportation in the Americas (LBJ, 2000). Intermodal activities have underpinned the successful movement of trade and central to the growth of intermodal trade routes is the use of containers. In 1999, over 200 million container moves took place across the world maritime ports (container throughput is measured in 20-foot equivalent units [TEUs], representing a box 20 feet long, 8 feet wide, and 8.5 feet high) and container use is forecasted to grow strongly in the coming decade.

Processes that provide industry and shippers with a greater understanding of the related costs associated with trade flows have also made important contributions to world trade growth. The application of such concepts as supply chain evaluation, real-time tracking, and e-commerce have resulted in a variety of multimodal network models that attempt to measure the logistics costs of various combinations of modes and routes from producer to consumer. Because such network costs play a critical role in locational theory and in the success of particular products on the world markets, they are, therefore, likely to remain an important decision-making tool of corporate planners. Where the supply chain has segments that are long, it may be possible to develop modal segments of the chain that allow economies of scale to be achieved. Examples of surface modal segments displaying economies of scale include the U.S. unit and shuttle trains that carry coal and grain, as well as the U.S. double-stack container rail service that, again, offers low per-mile shipping costs.

International trade flows largely depend on an efficient maritime element of the supply chain, and vessel design has reflected the impact of scale economies over the last decade. About 5 years ago, large vessels exceeding 4,400 TEUs began to be introduced on the world’s liner routes; the operational capacity of these vessels currently appears to be in the 5,500–8,000 TEU range. There have been even larger capacities proposed: In January 2001, the China Shipping Group announced plans to build three 9,800 TEU containerships to be deployed in the Trans-Pacific trade. Currently, there are around 121 large post-Panamax vessels (sometimes termed *mega-containerships*) in operation, averaging 5,300 TEU in capacity. With the current order book, excluding some of the recently planned orders, the fleet will rise by another 121 ships, averaging around 6,050 TEU in capacity. Vessel size, on average, in this group of ships (*Containerisation International*, 2001) is clearly on the rise.

The introduction of large post Panamax containerships into the world fleet will mean that a greater proportion of the total container slots offered to global shippers will be on ships of this type. Of immediate impact is the effect this introduction of new containerships has on the trade between Europe, the Far East, and the U.S. West Coast — the so-called pendulum route — where the volumes of containers justify the operation of large container vessels. A likely impact of the introduction of these large ships will be the displacement of some of the current vessels on the pendulum route to other routes, such as the North Atlantic. Undoubtedly, this trend toward larger vessels will have a “knock-on” effect on U.S. Atlantic ports and, possibly, the U.S. Gulf ports. For example, extremely large containerships require a simplified route structure so that the economies gained while sailing are not lost through their idling in port. Consequently, the route structure for these large ships is likely to concentrate on a few load centers in each of the continental areas served by these lines. (Maersk Shipping has already signed an agreement to build a load center capable of servicing a mega-containership in the New York/New Jersey area; if built, this load center is certain to change the way boxes are distributed in the North Atlantic market.) A central issue to be addressed in this study, then, is the likely impact that large containerships will have not only on the container flows into the Gulf, but also on the ports that service them.

REPORT OBJECTIVES AND ORGANIZATION

This report examines the technologies associated with vessel design and identifies the operating costs associated with different vessel sizes. It also addresses the impact larger vessels could have on Gulf ports and on the routes linking the markets they serve. Finally, the report addresses how these vessels will impact Texas ports and identifies possible implications for Texas state transportation planning.

Chapter 2 considers the world container fleet and the 2-year order book for new container vessels. The discussion will provide insight into the supply of container slots in the market and will allow some conclusions to be drawn in terms of the likely impact on the various markets. Chapter 3 examines containership characteristics, while Chapter 4 considers vessel technology and attempts to estimate the operating costs associated with vessels of different sizes. Chapter 5 identifies current container routes in the North Atlantic and U.S. Gulf and examines the likely impacts of larger ships on the route structure. Chapter 6 assesses the demand for container moves in the U.S. North Atlantic and U.S. Gulf; an estimate is made of the impact of newer vessels on the demand for container moves, particularly as they relate to the Texas Gulf. Chapter 7 considers the impact of the expected growth in container usage in the North Atlantic. It will consider some forecasting scenarios and use these to determine the implications that these have on Texas Gulf ports, including those currently servicing containerships and those that may well provide container services in the future. Finally, Chapter 8 summarizes the findings of the research and draws conclusions for Texas state transportation planning.

Chapter 2. World Containership Fleet

BACKGROUND

A previous report for this project characterized the size and nature of the world containership fleet (as registered in late 1998). It presented evidence that mega-containerships were being brought into service on key, high-density container routes (generally in the northern hemisphere) and were being introduced on a scale that would change both the composition of the world's fleet and the size of the container market. In the most likely deployment scenario, these large cellular[1] vessels would call at relatively few load centers throughout the world, which would then be serviced by smaller feeder containerships, linking the load center with regional ports. Mention was made of the dynamic nature of the maritime industry in the 1990s and of the role played by mergers and alliances in concentrating market power (Harrison et al., 2000).

INTRODUCTION

Liner routes and intercorporation cooperation in the maritime sector (ranging from vessel sharing to pure takeovers, global deregulation, and trade liberalization) are subjects examined in some detail in a recent book by a Canadian academic and maritime specialist (Brooks, 2000). Many of that Canadian author's conclusions are in fact similar to those drawn by the present project team on the maritime sector, although she goes beyond the scope of this investigation and concludes by examining national approaches to liner shipping regulation. A model of strategy formulation in liner companies is offered in Figure 2.1. This useful business model suggests why companies choose to compete alone, seek alliances, merge, develop takeovers, or why (perhaps) some companies fail to maintain commercial independence and are themselves taken over. The matter of competition versus alliance becomes more complex when seen within the global context, given that companies may seek alliances only on routes where they are weak and, as a result, may generate mixed strategies. In any event, this scholarly contribution to understanding how the current maritime industry works lends credence to many of the conclusions reached by the present researchers with regard to this sector.

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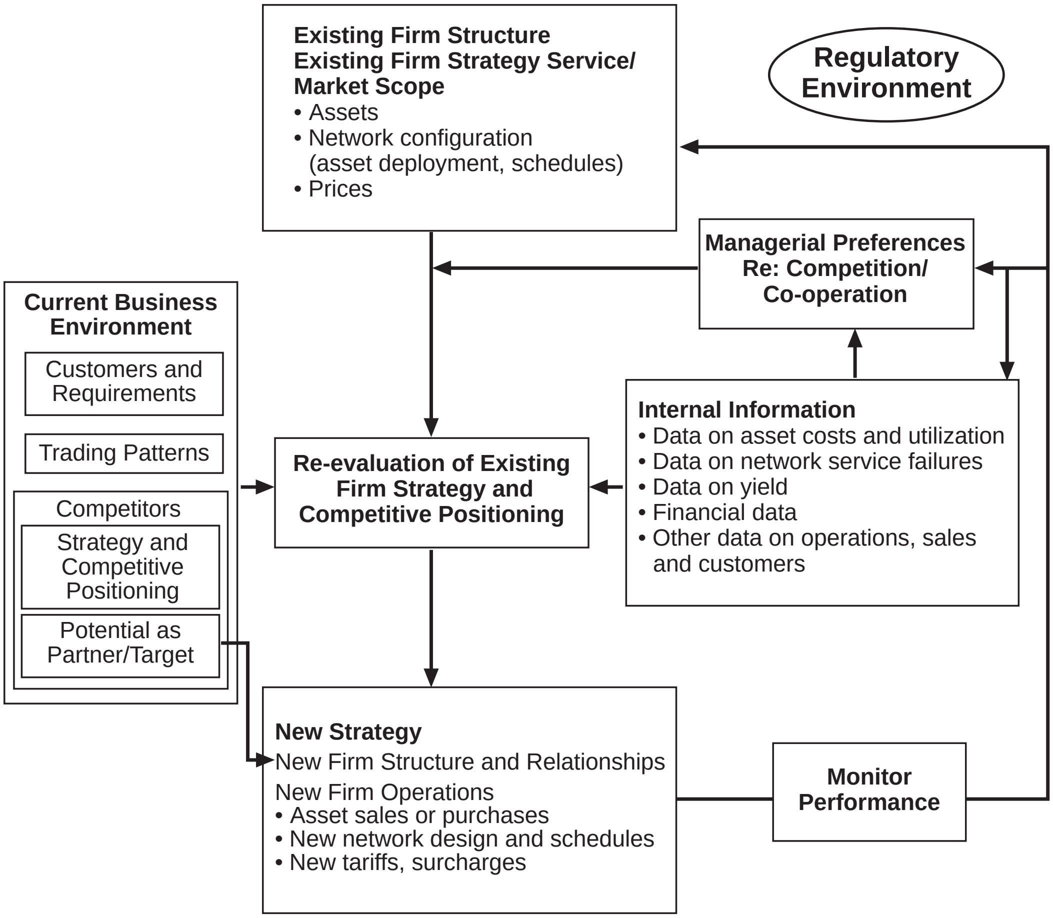
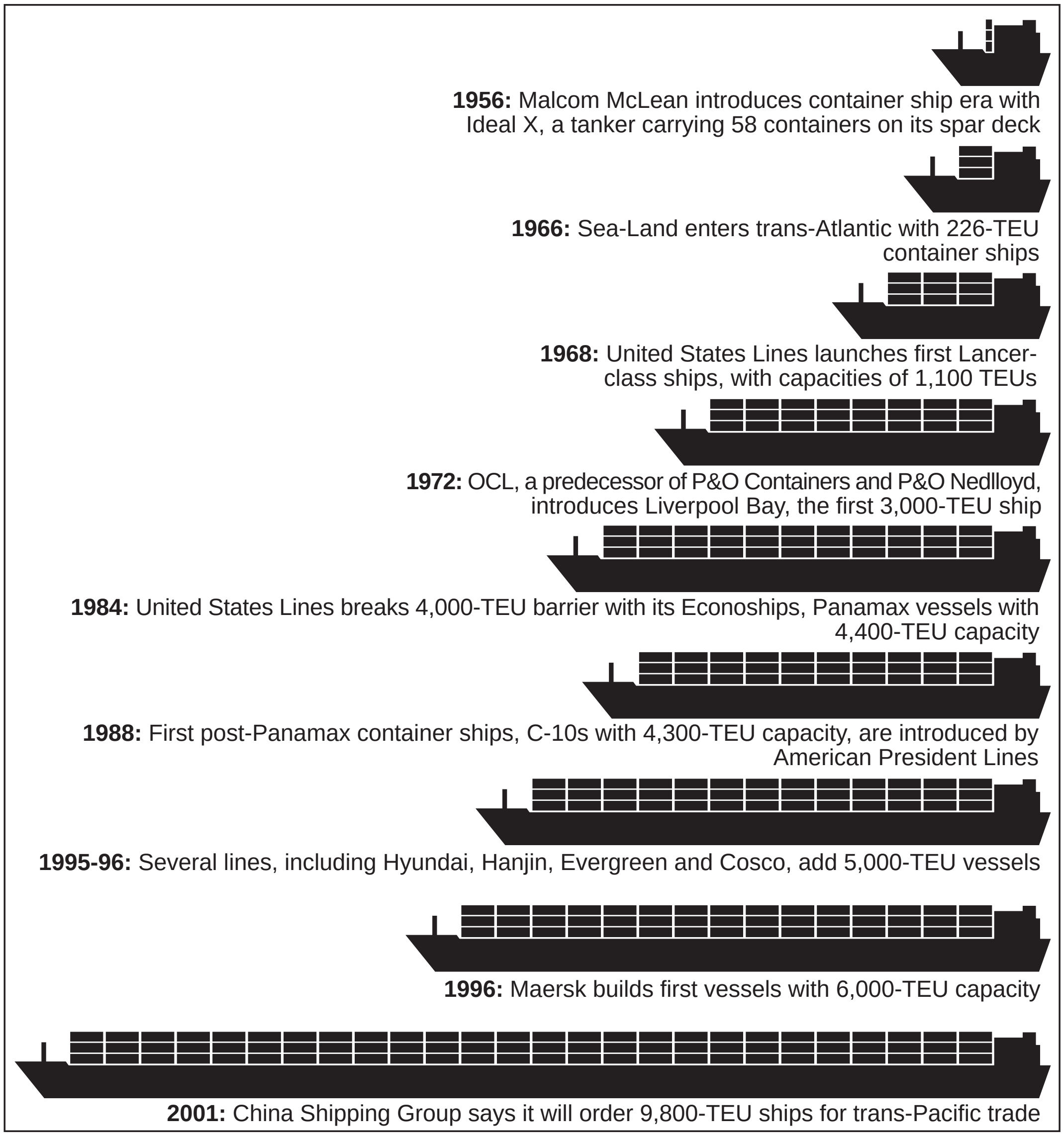
[1] A ship design that incorporates racks that allow containers to be slotted into place in a rapid and, therefore, efficient manner.



Source: Brooks, 2000

Figure 2.1. A Model of Strategy Formulation in Liner Companies

A key focus of the first project report was the effect that mega-containerships will have on world trade, especially as it pertains to the North Atlantic sea lanes and to their links to the Texas Gulf ports. Figure 2.2 presents a schematic of how containerships have grown in size since being introduced in the late 1950s. The decade of the 1960s saw naval architects and ship builders concentrate on vessels of up to 1,100 TEU capacities; in response, ports geared up to service these vessels by constructing wharfs, cranes, and storage areas to process trade moved in containers. The limit of containership size in the early years was predicated on the width of the locks in the Panama Canal, with vessels such as could traverse these locks dubbed “Panamax.” These vessels had a maximum capacity of around 4,000 TEUs. In the early 1980s, as trade recovered from the global recession caused by the energy crisis of the1970s, attention turned again to using larger ships to gain economies of size in the transfer of container trade. In the mid-to-late 1980s, the first post-Panamax containerships were introduced; in the early 1990s, containership size crept up to around 5,500 TEUs. Then, in 1996, Maersk built the first vessel exceeding 6,000 TEUs, the introduction of which encouraged a spate of orders for vessels in the 6,000–7,500 TEU capacity range. Recently, in January 2001, China Shipping Group announced that it will order three 9,800 TEU vessels for its Transpacific liner service. The introduction of these extremely large vessels is expected to profoundly affect the composition of the world's fleet and the routes over which containers flow. This chapter will identify these effects in terms of composition of the world's fleet.



Ships not drawn to scale

Source: JoC Week; Jan. 15-21,2001

Figure 2.2. How Containerships Have Grown

This chapter will also examine the most recently reported information on the breakdown of the world container fleet, and will identify trends in ship size, both in terms of vessels actually operating on liner routes and those ordered at ship building yards throughout the world. The top twenty container service operators will be identified and remarks will be made about key carriers and their future intentions with respect to containership operations. Operators and vessels, representing the supply side of the container market, are discussed in a section on supply-side issues. Finally, this chapter will summarize the current status of the world container fleet and will suggest some of the likely effects on future container services to the Texas Gulf ports.

FLEET SIZE AND COMPETITION

Table 2.1 summarizes the world containership fleet in service and on order by ship type and size, as reported by *Containerisation International* in the 2000 yearbook. It shows that the world's containership fleet exceeded 6 million TEUs in 1999, equivalent to a 2.4 percent growth rate over the numbers reported for 1998. This growth rate is likely to be higher in the immediate future, based on the number of vessels currently on order and the number of older vessels that will be scrapped. Many of the vessels ordered by carriers, such as P&O Nedlloyd, Containerline, Hanjin Shipping, and the Evergreen Group, will replace older, less fuel-efficient tonnage. In today's competitive trading environment, ships having a service speed of around 20 knots are finding it increasingly difficult to operate efficiently, particularly on the east-west trade routes. Operators using vessels with a speed of around 25 knots can maintain the necessary liner schedules with fewer vessels on the route, which allows them a competitive advantage in the world market. Table 2.1 identifies the various types of vessels that carry containers. Yet as more trade moves toward the use of containers, the economies offered by fully cellular vessels have ensured this design's market domination. Currently cellular containerships account for over 70 percent of all container-carrying capacity deployed and almost 90 percent of the order book. Within this sector, there continues to be a clear focus on the deployment of large ships. Post-Panamax tonnage (defined as vessels over 5,000 TEU) now number sixty-eight and account for 9 percent of the total capacity, with another sixty-one units on order, which will double this number. Containership International reports that all of the major liner carriers, including Cosco Containerlines (7 x 5,250 TEU), P&O Nedlloyd (4 x 6,788 TEU and 4 x 5,460 TEU), Maersk

Sea (5 x 6,600 TEU and 5 x 6,200), and Evergreen (8 x 5,652 TEU), have orders for series ships in this size range.

Table 2.1. Summary of World Containership Fleet in Service and on Order

Summary of World Containership Fleet in Service and on Order by Ship Type and Size (November 1, 1999)

Ship type	<1,000	1,000-1,999	2,000-2,999	3,000-3,999	4,000>	Total
Fully cellular/ converted						
Present slots	509,907	1,124,684	917,188	740,886	944,383	4,237,048
Present ships	983	799	368	217	196	2,563
Slots on order	24,948	105,042	71,902	99,445	416,173	717,510
Ships on order	39	70	32	29	77	247
Ro-Ro/ container						
Present slots	54,092	43,939	20,660	15,550	0	134,241
Present ships	141	33	9	5	0	188
Slots on order	1,585	2,700	0	0	0	4,285
Ships on order	3	2	0	0	0	5
Ro-Ro						
Present slots	204,003	50,797	20,550	3,440	0	278,790
Present ships	705	39	9	1	0	754
Slots on order	4,880	0	0	3,400	0	8,280
Ships on order	10	0	0	1	0	11
Semi-container						
Present slots	845,659	164,808	0	0	0	1,010,467
Present ships	2,729	125	0	0	0	2,854
Slots on order	36,631	25,160	0	0	0	61,791
Ships on order	73	20	0	0	0	93
Other						
Present slots	145,158	196,789	18,614	0	0	360,561
Present ships	397	146	9	0	0	552
Slots on order	4,488	8,250	0	0	0	12,738
Ships on order	10	5	0	0	0	15
TOTALS						
Present slots	1,758,819	1,581,017	977,012	759,876	944,383	6,021,107
Present ships	4,955	1,142	395	223	196	6,911
Slots on order	72,532	141,152	71,902	102,845	416,173	804,604
Ships on order	135	97	32	30	77	371
Projected total	1,831,351	1,722,169	1,048,914	862,721	1,360,556	6,825,711
	5,090	**1,239**	**427**	**253**	**273**	**7,282**

Source: Containerization International, 2000.

Compared with 1998 figures, large vessels (above 3,000 TEU) account for about 40 percent of the total cellular fleet. Interestingly, there were also increases in feeder class tonnage of under 1,000 TEU (up by almost 3 percent) and 1,000 to 1,999 TEU (up by over 3 percent) compared with the previous year. The fact that the medium-sized sector has declined suggests that the fleet is now beginning to polarize into two major types: large vessels that will serve load centers and smaller vessels that will act as regional feeders in the different markets.

As regards the North Atlantic, megaship deployment is closely linked to the ability of U.S. ports to handle ships of this size. The obvious candidate is New York/New Jersey and, indeed, ground has now been broken to build a site there capable of servicing these large vessels (it is expected to be operational by 2005). This development will slow down the deployment of these large ships in the North Atlantic, suggesting, as a consequence, that the substantial changes to the route structure, particularly as they relate to new hub and spoke configurations, will be delayed in this region of the world. As the large vessels are entered into service on the east-west trade routes of the northern hemisphere, they are likely to displace vessels to other routes, including those in the North Atlantic. Currently the largest vessel serving the Texas Gulf port is an econoship design that was built in the early 1980s and designed to be extremely fuel efficient. In order to achieve such energy efficiency, the ship was designed to have an operational speed of around 20 knots — a speed that is likely to become inadequate for current world liner schedule operations. The first effect of mega-containership deployment in the north is therefore likely to be the replacement of the econoships serving Gulf ports with ship designs of similar size, but capable of operating at 25 knots. It is highly likely that most econoships will be scrapped as the world fleet changes. Over the longer term, as the larger vessels begin to serve the North Atlantic, there will be changes in the route structure and the possible development of feeder services, which will affect Texas ports. This development will be discussed in more detail in a later section of this report. Because the growth of large container vessels is, in part, a reflection of the changes in the maritime industry, these changes will now be discussed.

CONTAINERSHIP OPERATORS

Research report 1833-1 described the changes the maritime industry experienced during the 1990s, as well as the effect that these changes were having on the sizes of containership being deployed, the routes over which they operate, and the effects these had on regional ports. At this time, the maritime industry was undergoing one of its most important restructuring phases since the advent of shipping conferences in the late 1880s. It was clear that fewer companies, incorporated into strategic alliances, would become major players in the world container trade. More than 40 years after hub terminals were first proposed, a small number of world ports are poised to become the regional conduits for mega-containerships and transshipments to smaller vessels.

Table 2.2 identifies the top 20 container service operators analyzed on the basis of vessel size in TEU. It shows a projected TEU comprising slots in service and slots on ordered vessels. These carriers have over 55 percent of the TEU in service and around 65 percent of the TEU on order (orders continue to grow, as shown by Cosco's mega-containership order identified in Table 2.2). These companies are able to undertake a number of activities that were not available before the 1990s. They are able to form large strategic alliances with each other and extend these into the area of global financing. Mention has already been made about scrapping and new orders. Another critical aspect of current maritime business is chartering versus purchasing. Containerization International reports that the trend by global service providers will be to charter in more tonnage, including line haul vessels hired on a longer term (between 5 and 10 years). This trend will allow companies to invest more of their capital in value-added logistics and supply-chain management initiatives; in addition, it is predicted that the current charter level of around 40 percent will increase to about 60 percent in the early years of this millennium. Such trends will allow companies to negotiate substantial business arrangements with key ports and will strengthen the effect of supply chain analysis and logistical models.

The dynamic nature of the industry means that service operators continue to grow as new orders are placed and as businesses continue to merge. Several companies are "on the move" to become one of the top ten carriers in the world — no doubt eager to enjoy the advantages that such a position brings in terms of port service and competitive benefits. Zim Israel Navigation is one company that has pushed its way into the top ten. Another liner climbing in the ranking is China Shipping Container Lines, which is currently aggressively following a chartering program to increase its container capacity (Containerisation International, 2000 Yearbook).

Table 2.2. Top 20 Container Service Operators Analyzed on the Basis of Vessel Size

Top 20 Container Service Operators (as of September 1, 1998), Analyzed on the Basis of Vessel Size (TEU)				
		TEU		
Rank	**Carrier**	**In Service**	**On Order**	**Projected**
1 (1)	Maersk-Sealand*	544,558	128,340	672,898
2 (2)	Evergreen/Uniglory Marine Corp	311,951	65,450	377,401
3 (3)	P&O Nedlloyd[1]	268,625	83,952	352,577
4 (8)	Mediterranean Shipping Co	225,636	8,200	233,836
5 (6)	Hanjin Shipping Co[2]	217,804	40,600	258,404
6 (8)	APL	199,881	15,160	215,041
7 (7)	Cosco Container Lines	189,016	57,550	246,566
8 (9)	NYK Line/TSK	156,821	0	156,821
9 (10)	Mitsui OSK Lines	146,026	16,500	162,526
10 (12)	Zim Israel Navigation	144,751	0	144,751
11 (13)	CP Ships[3]	133,006	0	133,006
12 (14)	CMA-CGM[4]	127,147	8,800	135,947
13 (11)	Hyundai Merchant Marine[5]	109,105	0	109,105
14 (18)	Yangming Marine Transport Corp	101,445	27,500	128,945
15 (16)	OOCL	94,967	33,000	127,967
16 (17	K Line*	90,228	0	90,228
17 (15)	Hapag-Lloyd	88,283	33,600	121,883
18 (19)	United Arab Shipping Co	68,880	0	68,880
19 (-)	China Shipping Container Lines[6]	65,535	0	65,535
20 (-)	Compania Sud Americana de Vapores	61,535	0	61,535
TOTAL		**3,345,200**	**518,652**	**3,863,852**
		55.6%	**64.5%**	**56.6%**

Notes: 1 = Includes Blue Star Line and KNSM; 2 = Includes 70% of DSR-Senator Lines' capacity; 3 = Includes the services of Canada Maritime, Cast, Contship Containerlines, Ivaran Lines and Lykes Lines. The ANZDL deal was still subject to due diligence; 4 = order for 8 x 6,500 TEU had not been confirmed; 5 = order for 5 x 6,400 TEU ships had not been confirmed; 6 = Contract with Costamare Shipping had not been signed

Source: Containerisation International, 2000 Yearbook

At first, mega-containership deployment was an issue of great concern to many port operators and a number sought advice to establish if their port merited load-center status. As an example, emphasis on a 50 foot draught was seen as a major issue during this period of technical review. Subsequently, and to some degree ironically, this deployment may in fact be the salvation of many ports who will be in a position to feed the designated load centers without having to undertake massive capital investments in channels, berths, cranes, and storage areas.

Companies that are operating and/or ordering mega-containerships are doing so because they see trade on their liner routes increasing and seek the competitive advantage of economies of scale that are present in larger vessels. As previously mentioned, this in turn affects the supply of slots on the various world liner routes.

SUPPLY SIDE

Decisions made on routes, schedules, vessel sharing agreements, and other operational issues are not made without regard to the demand for container shipments. However, for the purposes of this study, demand is treated as a separate section (Chapter 5). This chapter will look at the effect of fleet composition and its placement on the world's liner routes in order to draw conclusions about the likely effects on the North Atlantic market. The maritime industry must develop four key elements to make up its liner schedule: size, speed, numbers, and service frequency. Box 2.1 provides evidence of this on a Yang Ming line schedule. The news release, though short in length, covers mega-containership deployment, smaller ship displacement, slot capacity, speed, vessel numbers on the liner route, and service frequency. It clearly demonstrates the interdependency of these factors and the dynamic nature of vessel deployment. For a given market (like the Texas regional market around Houston), all interact with the accepted proviso that for key markets and regional containerports, a weekly liner service is absolutely vital for competitive success. Anything less causes box diversion either to other liner schedules (treating container service rather like a commodity) or even to other ports. The larger the ship, the lower the operating cost per box when loaded; additionally, faster ships mean that fewer ships are needed (or that a better service call frequency is possible). A short-run supply function is shown in Figure 2.3, which offers a simplified business strategy to show how the four decisions facing a containership operator may be determined.

Box 2.1. Yang Ming, "'K' Line Revamps Trans-Pacific Services"
(*JoC Online,* February 6, 2001)

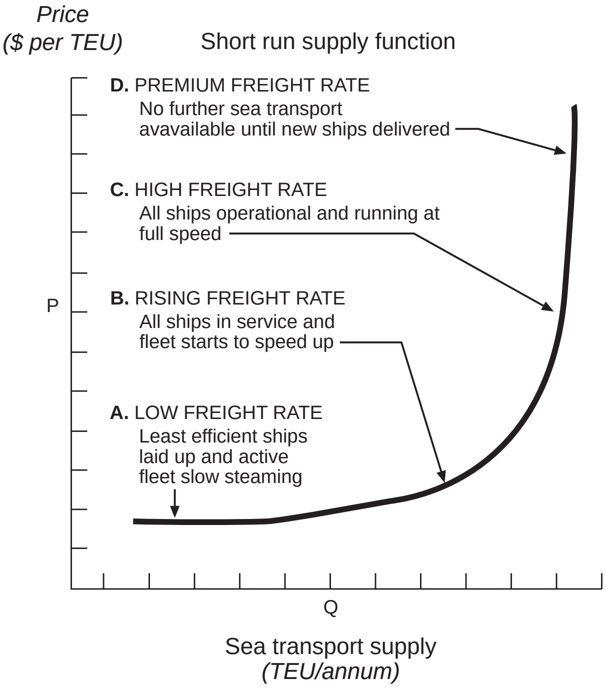
Taiwan's Yangming Marine Transport Corp. said it will upgrade its Pacific Southwest service to the U.S. West Coast, while Japan's "K" Line plans larger ships in its trans-Pacific service.

Yang Ming will phase five 5,551-TEU vessels into its Pacific Southwest Service, known as the Y-PSW loop, starting late next month, replacing ships of the 3,266 TEUs. The Y-PSW service, operated as part of a Cosco-"K" Line-Yang Ming alliance and using Yang Ming vessels, will see one-way capacity increase by about 70% to 289,000 TEUs a year, a spokesman said.

Yang Ming also will revise the rotation to improve transit times with deployment of the new 25-knot vessels. It will serve Yantian, China; Hong Kong; Koahsiung and Keelung, Taiwan; Los Angeles; Oakland; and some yet-to-be-named Japanese ports.

The revamped Y-PSW service will employ five vessels instead of six but will have shorter transit times from Asia to the United States, a spokesman said. He said the Yantian-Los Angeles transit time will now be 14 days instead of 17.

Forecasting container demand is often problematic because much can go awry in the global markets; among other things, there is the lag between orders, the incorporation of new vessels into the fleet, and changing schedules. The market — vessels and demand — is rarely in equilibrium for long; the industry seems to be plagued with a “feast or famine” with regard to slot demand, with rather more of the latter for its good. As an example, the introduction of mega-containerships will drive slot availability (supply) up at a rate faster than international trade growth, with such an effect exacerbated if there is a slowdown in the global economy (as is now forecasted). A series of recent articles in the *Trade Press* attests to an over capacity of slots in the sector and a cutback in service frequency on many routes (*JOC*, September 3, 2000).



Source: Modified from Stopford, 1977

Figure 2.3. Sea Transport Supply

How does this affect the supply curve? Clearly, the introduction of large containerships over time will alter the long-term supply function and market equilibrium; yet because the industry news we read is rather more focused on the short-term supply function, we must address questions about what is happening to trade passing through Texas ports to European and Latin American markets. Figure 2.4 shows a typical maritime short-run supply function with several steps that are linked to market conditions. The figure looks at the price-per-container move versus the demand for containers to be moved over a specific liner schedule. When demand is low, there is a low freight rate that results in a number of ships being either laid up or moved on a slower schedule in order to conserve fuel; this is shown at A. At B, the demand starts to bring most of the available ships into service and, as a consequence, speed on the liner schedules begins to move up. At point C, all ships are operational and running at full speed. Thereafter, as with most supply curves, there is a steep cost associated with marginal increases in container demand. Ships are full and ports are crowded; the overtime required for moving boxes has to be paid at the port and landside, forcing general rates to increase. This effect is shown as point D, where premium rates are available on the liner routes and where no further supply is possible until new ships are delivered. For Texas container ports, the supply function has been somewhere in the B-C part of the function over the period 1994–2000.

b) Short run adjustment

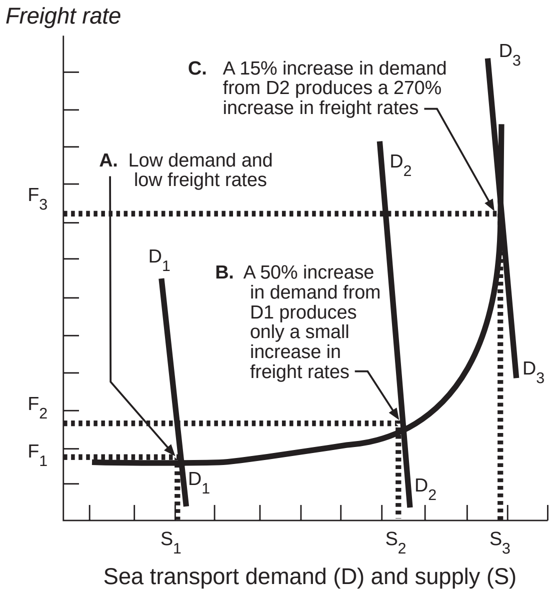


Figure 2.4. Sea Transport Demand and Supply

In reality, the supply curve is not the smooth transitional function shown in Figure 2.3; rather, the line is stepped in accordance with the complexities of the market and the financial problems of the maritime sectors. In essence, profitability is not good and margins are relatively poor. During the 1990s, the amount of revenue spent on overall operating costs often exceeded 95 percent for most of the large companies; and the costs of new ships, particularly mega-containerships, continue to be extremely high.

It has been suggested that mega-containership construction is not aimed at reducing capital costs per TEU, given that these have flattened; yet economies of scale are to be gained in the reduction of operating costs per slot (Drewery, 1996). As noted in the first report, the introduction of mega-containerships will focus on those routes that have both sufficient demand and port capacity (i.e., the northern hemisphere routes). These new vessels will also generate new types of related containership service, ranging from transshipment to fast-feeder vessels. Thus the various supply curves that will make up a regional liner market — like the Gulf to Europe — are complex. However, as already noted, it is likely that new route structures will permit a wider variety of ports to handle the volumes of containers going to regional and local markets. The financial challenges facing the maritime sector have encouraged many operators to charter (lease) rather than to purchase vessels. Because such strategies allow money to be diverted to port and landside activities, companies will be able to address much more of the supply chain and, presumably, to compete more effectively.

Finally, Box 2.2 highlights remarks made by Paul Richardson in the *Journal of Commerce* (*JoC Week,* March 26–April 1, 2001) on the increases in containership capacity on the main trade lanes and the (ever present) threat of weakness in freight rates. It offers insight into the marketing opportunities offered by larger and possibly faster ships in the growing world container demand. It also demonstrates the interplay between new ships, new routes, and new markets, while at the same time showing the difficulty of predicting demand on established line routes beyond the near term.

SUMMARY

The world's container fleet continues to grow in both ship numbers and slot capacity. The growth that has been particularly strong recently in three classes of ships, two of them relatively small, would seem to confirm the likelihood that shipping needs will be related to the new hub and spoke route systems that will be necessary once the large mega-containerships begin operations. At the same time, it is also true that many of these systems are not yet implemented, though the expectation is that they will be undertaken over the next few years. Transhipment, however, is growing rapidly; this growth, along with hub and spoking at ports serving regional markets, will substantially revise how containers are moved, both in the global marketplace and in the central-southern Atlantic.

Maritime companies, when fixing container liner schedules, make decisions on size, speed, numbers, and service frequency — a process that translates into a supply function for specific markets, such as the market around Houston. In considering likely changes in the current supply function to Texas ports, the Gulf is likely to be affected first by the introduction of faster, more efficient, and smaller containerships serving regional and Latin American ports. Mega-containership operations in the northern pendulum route (Europe to West Coast U.S. via Suez Canal) are likely to displace fast Panamax vessels that will move onto Atlantic routes and may well displace the slower vessels now serving ports like Houston on the European route.

Box 2.2. "A Money-Making Industry"
(Paul Richardson, *JoC Week,* March 26–April 1, 2001)

There have been increases in capacity on the big shipping lanes, and skeptics have feared the onslaught will have adverse effects on the industry by causing weakness in freight rates.

I'm not one of those skeptics, and here's why. I believe carriers are reaping the benefits of better fleet deployment. Simply, if you operate eight 3,000-TEU ships with 20-knot service speed between Asia and Europe, and then replace them with seven 5,500-TEU ships sailing at 25 knots, you must save on the operational costs, even though your fuel costs increase slightly.

And transit times improve with the 25-knot ships. So a few more ports can be called on the way, assuming a carrier's customers are happy with the existing product.

So what do you do? Tap into a new marketplace en route. And for those lines in the Asia-Europe trades, there's a certain subcontinent market about halfway along the route that has more and more to offer. If that doesn't work, there is always the beckoning of Aden, the Middle East, and the Red Sea.

And there's always the Mediterranean.

Overcapacity? Not so far. A carefully planned introduction of eight ships that don't run Asia to Europe at 20 knots anymore, but seven ships that run Asia to Europe via the Indian subcontinent, Middle East and the Mediterranean, offers various opportunities to fill a ship. And from there, all it takes is a few feeder networks, and the world is your oyster.

This does not suggest that there won't be overcapacity in some trade lanes as a surge of giant ships enters service in the next two years. It's well understood that container slot capacity will grow faster than world trade volumes this year and possibly next year as well. That means the potential for weakness in rates, but it may not be as severe as it has been in past cycles of overcapacity.

Finally, when many containerships arrive in the Atlantic, it is more likely that spoke links to the chosen regional load center hub will first affect Gulf container services. Direct routes to Texas ports are unlikely in the near term. The current thinking on mega-containership load centers is that a TEU demand of around 5 million is needed (for example, New York/New Jersey), suggesting that Houston, for example, needs to increase its annual container throughput by a factor of at least 4. Even if the breakeven levels for load centers fall, Texas Gulf mega-containership operations may still be 10 to 20 years away.

Chapter 3. Operating Characteristics of the World Containership Fleet

INTRODUCTION

This chapter looks in greater detail at the world container fleet and how the operating characteristics of such fleets have changed over the last decade. In order to address the North Atlantic and Gulf routes, the research team purchased a database from Lloyd’s of London (Lloyd’s, 1998, 1999) that provided details of all the containership calls to the U.S. North Atlantic and Gulf ports in 1998 and 1999. This chapter also examines issues related to containership capacity and dimensions (i.e., length, breadth, and draught) and to the deployment of vessels in the world markets. Data from Lloyd’s (in the form of a CD) and formulae from the literature review enabled the team to examine relationships between dead weight draught and channel depth (the latter a key issue among North Atlantic and Gulf ports).

WORLD CONTAINERSHIP FLEET CAPACITY

Table 3.1 shows the composition of the World Container Fleet at the end of 1992, 1997, and 2000 (Containerisation International, 2000). This container fleet differs from that described in Table 2.1 because it excludes roll-on/roll-off and general cargo or hybrid vessels. A broad size range is used to show changes in the fleet during the decade of the 1990s. From the four sub-tables in Table 3.1, it is noted that capacity in TEUs has more than doubled in the 8 years from 1992 to 2000. All ship categories have increased both in their number and in their TEU capacities, although the large vessels — those over 4,000 TEUs — have increased by more than 600 percent during the same period. Post-Panamax ships comprised around 4 percent of the fleet and 11 percent of the fleet capacity in 1997; by 2002, it is estimated that they will have around 15 percent of the fleet capacity, a percentage that assumes the actual fleet plus the order book numbers at 1999, which are now known to be somewhat conservative. There is a clear trend toward bigger ships, with ship sizes increasing at the top end of each of the capacities. As an example, the typical feeder ship in the 1970s was less than 500 TEUs; it is now closer to 900 TEUs and has even progressed into the 1,500 TEU range. Moreover, there is a move in the world fleet towards non-geared, cellular vessels. From the 1960s to the 1970s, geared ships (the gearing refers to the handling systems on the vessel) were popular because they could adapt to different route/port characteristics, particularly those serving the developing nations of Latin America and the Far East. Table 3.2 shows that geared ships still dominate the smaller capacities (under 2,000 TEU capacity) and account for about a quarter of the vessels in the 2,000–3,000 TEU category, though they thereafter drop dramatically as ship size increases. In other words, all post-Panamax and mega-containerships are non-geared.

Table 3.1. Composition of World Container Fleet at the End of 1992, 1997, and 2000

Containership Fleet
(excluding Ro-Ro and General Cargo)

	December 1992			
Size Range	**No.**	**TEU**	**No.(%)**	**TEU (%)**
0-999	630	304,616	45	16
1,000-1,999	435	627,868	31	32
2,000-2,999	218	550,790	15	28
3,000-3,999	96	324,236	7	17
4,000+	35	150,063	2	8
Total	1,414	1,957,600	100	100

	December 1997			
Size Range	**No.**	**TEU**	**No.(%)**	**TEU (%)**
0-999	810	425,181	36	11
1,000-1,999	733	1,034,289	33	28
2,000-2,999	333	834,419	15	23
3,000-3,999	178	618,246	8	17
4,000+	165	765,586	8	21
Total	2,219	3,677,721	100	100

	November 2000			
Size Range	**No.**	**TEU**	**No.(%)**	**TEU (%)**
0-999	1,007	521,028	37	11
1,000-1,999	829	1,161,694	30	25
2,000-2,999	400	987,213	15	21
3,000-3,999	226	773,750	8	16
4,000+	261	1,272,462	10	27
Total	2,723	4,716,147	100	100

	Growth 1992-2000			
Size Range	**No.**	**TEU**	**No.(%)**	**TEU (%)**
0-999	377	216,412	66	72
1,000-1,999	394	533,826	91	86
2,000-2,999	182	436,423	84	80
3,000-3,999	130	449,514	136	139
4,000+	226	1,122,399	646	748
Total	1,309	2,758,574	1,023	1,125

The early 2000 containership order book represented in Table 3.3 shows significant growth in the 5,000–6,000 TEU category. The effect on the total fleet is not great: The order book for large post-Panamax vessels represents about 5 percent of the capacity of the current fleet. It is believed that the mega-containerships will be placed on the high-density routes connecting the main container markets and that they will call at dedicated load centers in each of the regional areas. As a purely competitive response, containership companies wishing to serve these dense routes and trying to take advantage of size have placed similar orders. This is equivalent to a short term equilibrium impact, because once the vessels enter service, the order numbers are likely to level out (or even decline) as equilibrium on the high-density routes is reached.

Table 3.2. Geared Versus Non-Geared Cellular Vessels

Breakdown of Geared/Non Geared Cellular Vessels

Size Range	Geared (%)
0-499	26
500-999	51
1,000-1,999	50
2,000-2,999	24
3,000-3,999	1
4,000-4,999	1
5,000-5,999	0
6,000+	0
Total	34

(Lloyds, 1999)

Table 3.3. Containership Order Book in 1999

Containership Orderbook

	Delivery 1999		Delivery 2000		Delivery 2001		Delivery 2002		Total Orderbook		Orderbook as % of existing size		Orderbook as % of existing fleet	
Size Range	**No.**	**TEU**	**No.**	**TEU**	**No.**	**TEU**	**No.**	**TEU**	**No.**	**TEU**	**No.**	**TEU**	**No.**	**TEU**
0-499	9	3,740	1	411	0	0	0	0	10	4,151	3	4	0	0
500-999	31	22,159	2	1,004	0	0	0	0	33	23,163	8	7	1	1
1,000-1,999	51	72,072	12	19,658	3	4,854	2	3,236	68	99,820	9	9	3	2
2,000-2,999	25	58,012	10	23,515	0	0	0	0	35	81,527	9	9	1	2
3,000-3,999	2	7,974	6	22,200	0	0	0	0	8	30,174	4	5	0	1
4,000-4,999	6	25,250	16	73,400	0	0	0	0	22	98,650	16	16	1	2
5,000-5,999	9	48,800	18	97,064	5	27,330	0	0	32	173,194	110	112	1	4
6,000 +	5	32,090	6	37,418	0	0	0	0	11	69,508	58	57	0	2
Total Orderbook	138	270,097	71	274,670	8	32,184	2	3,236	219	580,187	9	15	9	14
% of Orderbook	63	47	32	47	4	6	1	1						
Panamax	13	75,490	16	87,082	4	21,830	0	0	33	184,402	41	45	1	5
% of Orderbook	6	13	7	15	2	4	0	0	15	32				

Box 3.1 reports the latest available data on the world containership fleet and confirms the continuing growth in slot capacity through 2000. An interesting note is the growth of the Panamax vessels, indicating a demand for smaller containerships. This is predictable given

the emergence of hub and spoke routes, transshipment and the need to service smaller, but growing, regional markets.

SHIP DIMENSIONS IN THE U.S. ATLANTIC AND GULF

The Lloyd's MIS database was examined to identify different types of operating characteristics that are relevant to port operators; this examination, in turn, allowed the research team to identify the likelihood of large ships being serviced by ports in the North Atlantic and Gulf area. In late 1998, the Regina-Maersk (6,400 TEUs) sailed to both New York and Charleston to give port authorities an impression of the type of large ships being then introduced on the northern hemispheric routes. This event appears in the data set and is kept in the analysis, although it represented only one call and was a demonstration, not a new liner schedule. Figure 3.1 shows the relationship between length, breadth, draught, and speed for the vessels calling on the U.S. North Atlantic and Gulf routes in 1998. We also examined the database for 1999 and found it to be consistent with 1998 figures.

BOX 3.1. "Shipowners Booked 1m TEU in '00"
(*JOC Online,* March 21, 2001)

London— The capacity of the world's container shipping fleet is set to increase by nearly 25% by the end of 2002, thanks to a $13 billion spending spree in 2000 when ship owners ordered more than 1 million TEUs worth of capacity for the first time.

"Last year, the liner industry took a very serious position indeed in terms of managing future capacity," according to data from Clarkson Research, a unit of H. Clarkson, London's leading shipbroker. Containership orders totaled 1.046 million TEUs in 2000 compared with 543,000 TEUs in 1999, 417,000TEUs in 1998 and only 202,000 TEUs in 1997.

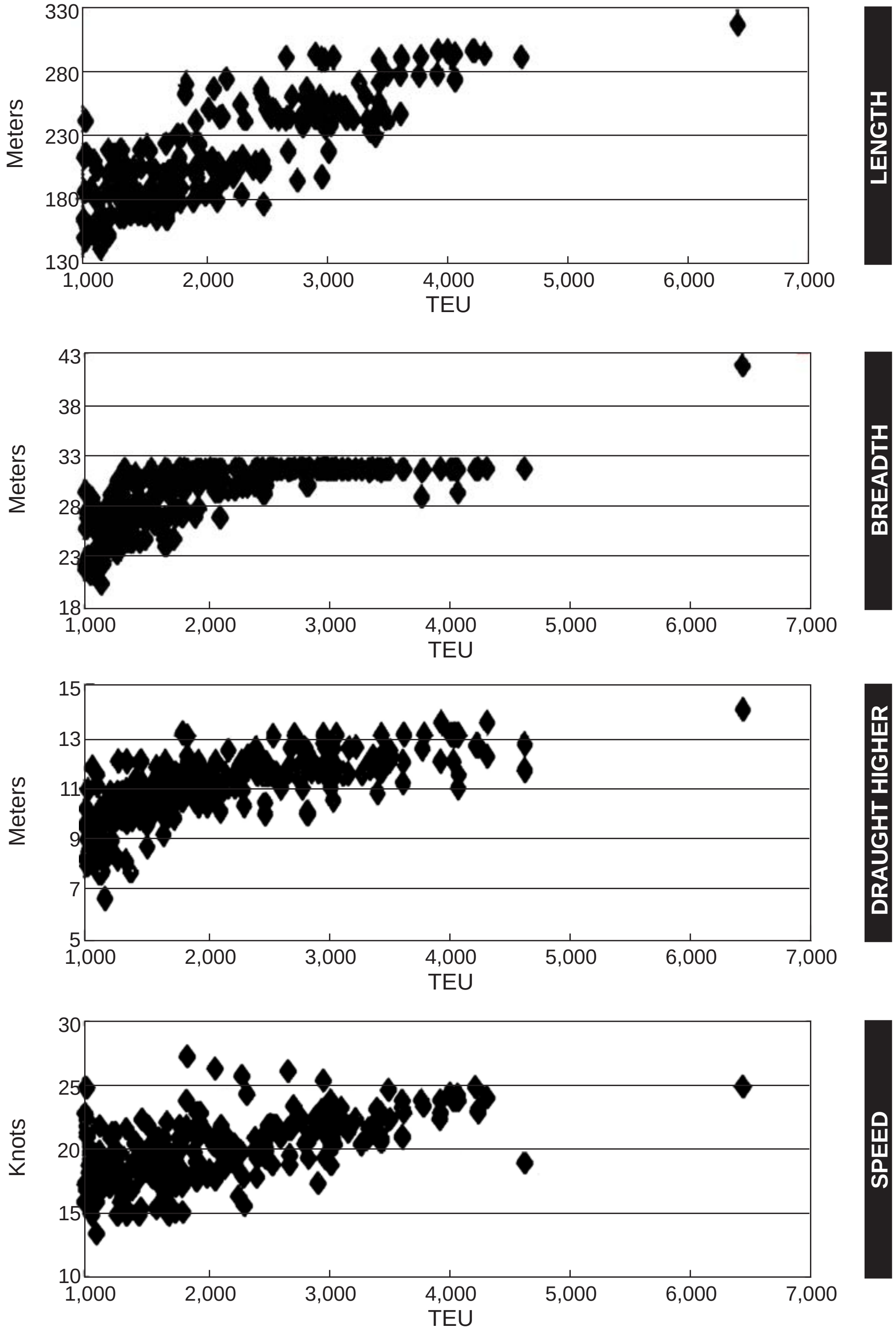
"Owners spent a cool $13.3 billion ordering almost as much tonnage in 2000 as in the previous three years," Clarkson noted. As a result, the containership fleet will add an additional 22.9% of capacity by the end of 2002, an annual rise of 11% over three years. This is not as big a leap, however, as in 1995 when orders reached 24% of a much smaller fleet. Most attention focused on the rush for the largest container vessels, with contracts for so-called post-Panamax ships that are too big to transit the Panama Canal totaling 418,000 TEUs in 2000, a rise of 20% over 1999. But they accounted for only 40% of the investment in container tonnage, and paled in comparison with the 400% surge in orders for Panamax vessels to 308,000 TEUs.

First, length (in meters) is plotted against TEU capacity. In general, it can be seen that there are two categories of length: that between 130 m (426 ft) and 230 m (754 ft) (approximating a maximum of about 2,500 TEUs) and that between 180 m (590 ft) and 280 m (918 ft), which accounts for both Panamax and post-Panamax categories. The single data point at 330 m (1,082 ft) is the Regina Maersk, which shows that it is between 26 m (85 ft) and 36 m (118 ft) longer than the current ships serving these ports. In some areas, like Barbours Cut, this may not be an issue. In other instances, it is a severe constraint; but the impact of the mega-containership can clearly be seen.

The same is true of breadth and here the effect is substantially greater because ships were then restricted in breadth to 32 m (105 ft) in order to travel through the Panama Canal. We can see that all of the ships calling at the U.S. Atlantic and Gulf ports in 1998 were within 33 m (108 ft), while the mega-containership is at 43 m (141 ft). For port operators, such sizes mean new and improved cranes are needed to unload the vessel. The new "extra post-Panamax" cranes with a reach of 48-52 m (157-171 ft) are designed to do just that (Containerisation International, 1999).

The draught of these vessels is generally less than 13 m (43 ft), although some are 13.5 m (44 ft). That of the Regina-Maersk is 14 m, translating to approximately 46 ft, a depth that is challenging to those regional ports wishing to offer services to this type of vessel. Because a draught of about 46 ft requires another 4 ft (2 ft for floatation and 2 ft for tidal movement) in order to allow safe passage, a mega-containership requires a draught of 50 ft, which is beyond the reach of most port operators in the region. However, it must be remembered that channel depth is related to cargo weight, the percentage of empty and full containers, the amount of fuel, and other ship characteristics that affect displacement. Research team members were informed by one of the Sealand captains that in 10 years of sailing to Houston, he had never brought a fully loaded vessel into Houston because it was at the end of a twelve-port outward route. The route characteristics, or the "string" as it is termed, is therefore critical in the deployment of containerships. This topic will be examined in a later chapter.

Finally, we move to ship speed, which does not (of course) influence port design. Speed is limited only by the impact of fuel consumption on the vessel operating costs. As a rule, fuel consumption increases exponentially with speed at a cubic rate. Following the oil crisis of 1972, high speed containerships (over 30 knots) could not be profitably operated at the higher fuel costs that resulted from the oil crisis. During the 1980s, ships were designed at a lower speed — around 19 knots — in order to improve fuel consumption; but now higher efficiency internal combustion engines have provided naval architects with the motive power to design new generations of containerships that operate in the 25–26 knot range. Examining Figure 3.1, it can be seen that the speed varies fairly closely with capacity, with a large number of vessels under 20 knots in the 1,000–3,000 TEU capacity. The mega-containership, Regina-Maersk, sits at the 25 knot mark. It should be remembered that an older fleet serves many Gulf ports on the North Atlantic, Europe and Mediterranean routes, some operating in the 19 knot range.



Source: Lloyds Maritime Information Services, 1999

Figure 3.1. Vessels Calling on the U.S. North Atlantic and Gulf Routes in 1998

REGIONAL IMPACTS, INCLUDING THE U.S. NORTH ATLANTIC AND GULF

Table 3.4 lists the various characteristics of the origins and destinations of containerships calling at North Atlantic ports (including the Gulf) in 1998, based on the Lloyd's data set. The table identifies the number of calls, the total capacity of the vessels calling, and both a maximum and average TEU capacity. The table also shows the maximum characteristics recorded in 1998 — characteristics that correspond to those identified in the previous section's discussion of length, breadth, draught, and speed.

The data show that ships operating along the east coast of South America have the smallest maximum draught, which reflect the port characteristics average of 12 m. This clearly is an impediment to the introduction of mega-containerships in this region. The size of the largest vessel that goes to the east coast of South America is also relatively small at around 3,000 TEUs. The average TEU in the table suggest the sizes of vessels working in the different regions. For example, the U.S. Atlantic average TEU is around 2,000, while it is almost 3,000 for the China-Far East; 3,000 for Japan; and 2,900 for the U.S. Pacific. This confirms that, on average, the larger ships are found in areas with long-distance routes to either the U.S. Atlantic or the Pacific links of the Far East, Japan, and U.S. West Coast. Finally, the smaller markets like the Caribbean show a small average vessel of 900 TEUs, which reflects the composition of the markets and container demand in that region.

Table 3.5 gives a list of all the ships over 4,000 TEUs that called at U.S. Atlantic and Gulf ports during 1998. The table is broken down into the capacity in TEUs; dead weight; year of construction; speed; operator; the number of arrivals; and then length, breadth, and draught. Table 3.6 identifies the list of ships over 3,000 TEUs calling at U.S. Gulf ports during the same period.

Excluding the Regina-Maersk from the analysis, the characteristics of the biggest ships calling in the Atlantic seem to be the same as those calling in the Gulf. All the ships that called in the Gulf called also at Atlantic ports, but not vice versa. Again, this is an issue of route characteristics, but it suggests that container demand from the Gulf alone is not sufficient to fill a vessel so that it may continue directly to Europe and the Mediterranean. Rather, it must call at other U.S. Atlantic ports to collect boxes to make up the load. It also appears that on the way to the Gulf, containerships unload some boxes having Texas destinations. This is particularly true of time-sensitive materials that are often taken by double-stack rail or trucked to destinations in Texas, leaving less-time-sensitive material or commodities to move through the Greater Houston area. The Atlantic, with its myriad ports, shows a greater number of ships and services though the vessels are not especially large. During the 1998–1999 period, the Gulf had two services with ships over 3,000 TEUs that called at least once a week (Sea-Land-Maersk and Lykes), while the Atlantic had seven (Sealand-Maersk, Evergreen, DRS Senator, Zim, Cosco, Lykes, and OOCL).

Table 3.4. Characteristics of North Atlantic Origins and Destinations in 1998

Area	Calls	Capacity	Max-TEU	Avg-TEU	Max-Length	Max-Breadth	Max-Draught	Avg-Speed
U.S. ATLANTIC	10,991	21,550,213	4,614	1,961	294.1	32.3	13.5	19.4
CHINA FAR EAST	3,660	10,883,189	4,306	2,974	294.1	32.3	13.5	21.6
NORTH CONT. EUROPE	3,926	10,469,735	4,614	2,667	294.1	32.3	13.5	20.3
SOUTHERN EUROPE	3,898	9,496,930	4,306	2,436	294.1	32.3	13.5	20.4
SOUTH AMERICA ATL.	6,954	9,164,599	3,029	1,318	236.0	32.2	12.0	18.3
JAPAN	2,779	8,406,880	4,306	3,025	294.1	32.3	13.5	21.7
CENTRAL AMERICA	5,154	8,269,636	4,229	1,605	294.1	32.3	13.5	18.9
IBERIA	2,609	6,174,077	4,306	2,366	294.1	32.3	13.5	20.6
US PACIFIC	1,911	5,553,697	4,306	2,906	294.1	32.3	13.5	21.3
U. KINGDOM/EIRE	2,199	5,448,712	4,614	2,478	294.1	32.3	13.5	19.6
SOUTH EAST ASIA	1,915	4,879,929	4,306	2,548	294.1	32.3	13.5	20.6
CARIBBEAN	5,061	4,557,134	4,229	900	294.1	32.3	13.5	17.4
NORTH AFRICA	1,235	3,328,587	4,306	2,695	294.1	32.3	13.5	21.0
SOUTH AMERICA PAC.	2,289	3,069,980	2,852	1,341	244.8	32.2	12.5	18.5
U.S. GULF	1,953	2,867,485	4,614	1,468	292.1	32.3	13.1	18.4
CANADA	768	2,037,455	4,614	2,653	294.1	32.3	13.5	20.4
INDIA	542	1,490,105	4,306	2,749	294.1	32.3	13.5	21.1
AUSTRALIA	832	1,308,756	3,501	1,573	289.6	32.3	13.0	19.3
RED SEA	453	1,264,253	4,306	2,791	294.1	32.3	13.5	20.8
EAST MEDITERRANEAN	640	1,174,851	3,765	1,836	275.7	32.3	13.1	19.2
ARABIAN GULF	368	939,979	4,306	2,554	294.1	32.3	13.5	20.9
S. & E. AFRICA	561	756,108	2,966	1,348	269.0	32.2	13.1	19.9
W. AFRICA	589	576,257	2,068	978	264.5	32.3	12.0	17.4
SCANDINAVIA/BALTIC	296	370,648	2,908	1,252	292.0	32.3	12.3	17.3
BLACK SEA	164	152,959	2,602	933	240.5	32.2	13.1	17.4

Source: Lloyds Maritime Information Services, 1999

Table 3.5. Ships over 4,000 TEUs Calling at U.S. Atlantic and Gulf Ports during 1998

Ship Name	TEU	DWT	Year	Speed	Operator	Arrivals	Length	Breadth	Draught
REGINA MAERSK	6,418	84,900	1996	25.00	MAERSK	6	318.24	42.80	14.00
SEA-LAND ATLANTIC	4,614	58,943	1985	19.10	SEA-LAND	37	289.52	32.22	11.68
OOCL INSPIRATION	4,614	58,869	1985	19.10	SEA-LAND	45	289.52	32.22	11.67
OOCL INNOVATION	4,614	58,943	1985	19.10	SEA-LAND	40	289.52	32.22	12.68
SEA-LAND INTEGRITY	4,614	58,943	1984	19.10	SEA-LAND	38	289.52	32.22	11.67
SEA-LAND PERFORMANCE	4,614	58,869	1985	19.10	SEA-LAND	47	289.52	32.22	11.67
SEA-LAND QUALITY	4,614	58,869	1985	19.10	SEA-LAND	46	289.52	32.22	11.68
GALVESTON BAY	4,614	58,943	1984	19.10	SEA-LAND	41	289.52	32.22	12.68
NED LLOYD HOLLAND	4,614	58,943	1984	19.10	SEA-LAND	48	289.52	32.22	12.68
NEWARK BAY	4,614	58,869	1985	19.10	SEA-LAND	45	289.52	32.22	12.68
DORTHE MAERSK	4,306	62,400	1996	24.20	MAERSK	12	292.05	32.25	13.50
GRETE MAERSK	4,306	62,229	1998	24.20	MAERSK	6	292.07	32.25	13.50
DRAGOR MAERSK	4,306	62,441	1995	24.20	MAERSK	12	292.15	32.25	13.50
DIRCH MAERSK	4,306	62,418	1996	24.20	MAERSK	12	292.12	32.25	13.50
DAGMAR MAERSK	4,306	62,399	1996	24.20	MAERSK	13	292.07	32.25	12.20
EVER ROYAL	4,229	58,048	1993	23.00	EVERGREEN	15	294.03	32.22	12.63
EVER RENOWN	4,229	58,912	1994	23.20	EVERGREEN	18	294.13	32.22	12.60
EVER REWARD	4,229	58,912	1994	23.20	EVERGREEN	12	294.13	32.22	12.60
EVER REPUTE	4,229	58,912	1995	23.00	EVERGREEN	15	294.13	32.22	12.60
EVER RESULT	4,229	58,912	1995	23.20	EVERGREEN	17	294.13	32.22	12.60
EVER RIGHT	4,229	57,904	1993	23.00	EVERGREEN	17	294.03	32.22	12.63
EVER RACER	4,229	57,904	1994	23.20	EVERGREEN	14	294.13	32.20	12.63
EVER REFINE	4,229	58,912	1995	23.00	EVERGREEN	12	294.13	32.24	12.60
EVER REACH	4,229	57,904	1994	23.00	EVERGREEN	14	294.03	32.22	12.63
EVER ROUND	4,229	57,904	1993	23.00	EVERGREEN	18	294.03	32.22	12.63
EVER DAINTY	4,211	55,604	1997	25.00	EVERGREEN	18	294.13	32.20	12.60
EVER DECENT	4,211	55,604	1997	25.00	EVERGREEN	15	294.13	32.20	12.60
EVER DIVINE	4,211	55,604	1998	25.00	EVERGREEN	4	294.13	32.20	12.60
EVER DELUXE	4,211	54,300	1998	25.00	EVERGREEN	6	294.13	32.20	12.60
EVER DEVELOP	4,211	55,515	1998	25.00	EVERGREEN	6	294.13	32.20	12.64
EVER DIADEM	4,211	55,604	1998	25.00	EVERGREEN	6	294.13	32.20	12.60
EVER DEVOTE	4,211	55,604	1998	25.00	EVERGREEN	6	294.13	32.20	12.60
EVER DYNAMIC	4,211	55,515	1998	25.00	EVERGREEN	6	294.13	32.20	12.64
EVER DELIGHT	4,211	55,515	1998	25.00	EVERGREEN	6	294.13	32.20	12.64
EVER DIAMOND	4,211	55,515	1998	25.00	EVERGREEN	6	294.13	32.20	12.64
SEA-LAND METEOR	4,065	59,940	1996	24.00	SEA-LAND	12	271.42	29.90	11.50
SEA-LAND MERCURY	4,065	59,961	1995	24.00	SEA-LAND	8	292.15	32.20	13.03
SEA-LAND CHAMPION	4,065	59,840	1995	24.00	SEA-LAND	3	292.15	32.20	13.03
SEA-LAND COMET	4,065	59,840	1995	24.00	SEA-LAND	12	273.00	32.20	11.50
SEA-LAND LIGHTNING	4,062	59,840	1997	24.00	SEA-LAND	15	292.15	32.20	13.00
SEA-LAND EAGLE	4,062	48,151	1997	24.00	SEA-LAND	9	292.15	32.20	11.00
SEA-LAND RACER	4,062	59,964	1996	24.40	SEA-LAND	11	292.15	32.20	13.03
SEA-LAND INTREPID	4,062	59,840	1997	24.00	SEA-LAND	8	292.15	32.20	13.00
HANJIN TOKYO	4,042	62,742	1994	24.00	HANJIN	5	289.50	32.20	13.02
HANJIN NAGOYA	4,024	62,500	1998	24.00	HANJIN	7	289.50	32.20	12.00
HANJIN OSAKA	4,024	62,681	1992	24.00	HANJIN	2	289.50	32.20	13.00
HANIN PORTLAND	4,024	62,716	1993	24.00	HANJIN	10	289.50	32.20	13.02
HANJIN SHANGHAI	4,024	62,799	1995	24.00	HANJIN	18	289.50	32.20	13.02
HANJIN LOS ANGELES	4,024	62,500	1997	24.00	HANJIN	13	289.50	32.20	13.02
HANJIN MARSEILLES	4,024	62,681	1993	24.04	HANJIN	3	289.50	32.20	13.02
MARSTAL MAERSK	4,000	55,971	1990	24.50	MAERSK	11	294.06	32.20	13.02
MUNKEBO MAERSK	4,000	56,049	1990	24.50	MAERSK	9	294.06	32.20	13.02

Source: Lloyds Maritime Information Services, 1999

In examining the effect of these services on different ports in the region, the research team evaluated ship size and frequency at three ports: Houston, New York, and Charleston. The results are shown in Figure 3.2. The tables comprise a TEU capacity, the annual frequency of ships in this category calling at the port with a percentage of total frequency, the number of weekly trips, the total TEUs, and the percent for each category as a percentage of total TEUs. This last one is shown as a histogram which shows that the North Atlantic ports cater to much larger ships than those in the Gulf. The numbers of ships arriving at Houston are substantially higher in the 501–1,500 TEU capacity, which is not surprising given the previous comments about the size of the Caribbean and Latin American markets. The North Atlantic ports of Charleston and New York show the impact of substantially larger vessels, with Charleston having a greater call frequency in the 3,501-5,000 TEUs then New York, a somewhat surprising fact. However, it should be remembered that New York is a load center distributing to areas such as Canada, the Caribbean, and Latin America. The main deduction to draw from this information is that the Gulf ports cater to smaller vessels, reflecting the needs of the regional markets of the ports served.

Table 3.6. Ships over 3,000 TEUs Calling at U.S. Gulf Ports During 1998

SHIPS > 3,000 TEU CALLING IN THE US GULF (1998)

Port	Operator	Ship Name	TEU	Year	Speed	Arrivals	Length	Breadth	Draught
Houston	SEA-LAND	NEWARK BAY	4,614	1985	19.10	8	290	32	12.7
Houston	SEA-LAND	OOCL INNOVATION	4,614	1985	19.10	2	290	32	12.7
Houston	SEA-LAND	OOCL INSPIRATION	4,614	1985	19.10	6	290	32	11.7
Houston	SEA-LAND	SEA-LAND ATLANTIC	4,614	1985	19.10	1	290	32	11.7
Houston	SEA-LAND	SEA-LAND PERFORMANCE	4,614	1985	19.10	11	290	32	11.7
Houston	SEA-LAND	SEA-LAND QUALITY	4,614	1985	19.10	9	290	32	11.7
Houston	SEA-LAND	GALVESTON BAY	4,614	1984	19.10	4	290	32	12.7
Houston	SEA-LAND	NEDLLOYD HOLLAND	4,614	1984	19.10	10	290	32	12.7
Galveston	MAERSK	DAGMAR MAERSK	4,306	1996	24.20	1	292	32	12.2
Houston	SEA-LAND	SEA-LAND LIGHTNING	4,062	1997	24.00	1	292	32	13.0
Houston	LYKES	LYKES DISCOVERER	3,322	1987	21.00	15	259	32	11.9
Houston	LYKES	LYKES EXPLORER	3,322	1987	21.00	15	259	32	11.9
Houston	LYKES	LYKES LIBERATOR	3,322	1987	21.00	12	259	32	11.9
Houston	LYKES	LYKES NAVIGATOR	3,322	1987	21.00	14	259	32	11.9
Orleans	LYKES	LYKES DISCOVERER	3,322	1987	21.00	7	259	32	11.9
Orleans	LYKES	LYKES EXPLORER	3,322	1987	21.00	7	259	32	11.9
Orleans	LYKES	LYKES LIBERATOR	3,322	1987	21.00	6	259	32	11.9
Orleans	LYKES	LYKES NAVIGATOR	3,322	1987	21.00	7	259	32	11.9
Houston	NYK	SATURN	3,152	1987	22.00	12	250	32	11.5
Orleans	NYK	SATURN	3,152	1987	22.00	6	250	32	11.5

Source: Lloyds Maritime Information Services, 1999

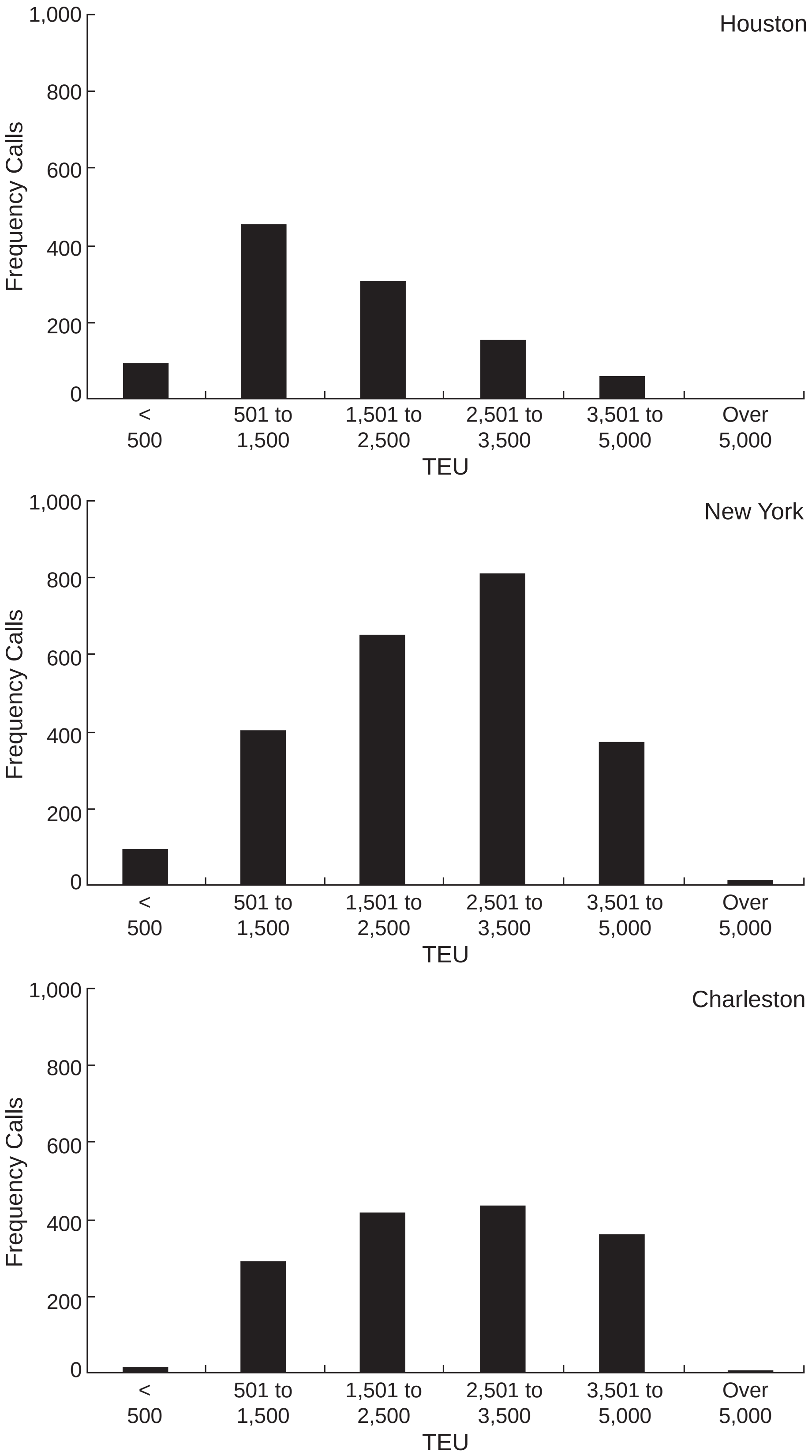


Figure 3.2. Evaluation of Ship Size and Frequency: Houston, New York, and Charleston

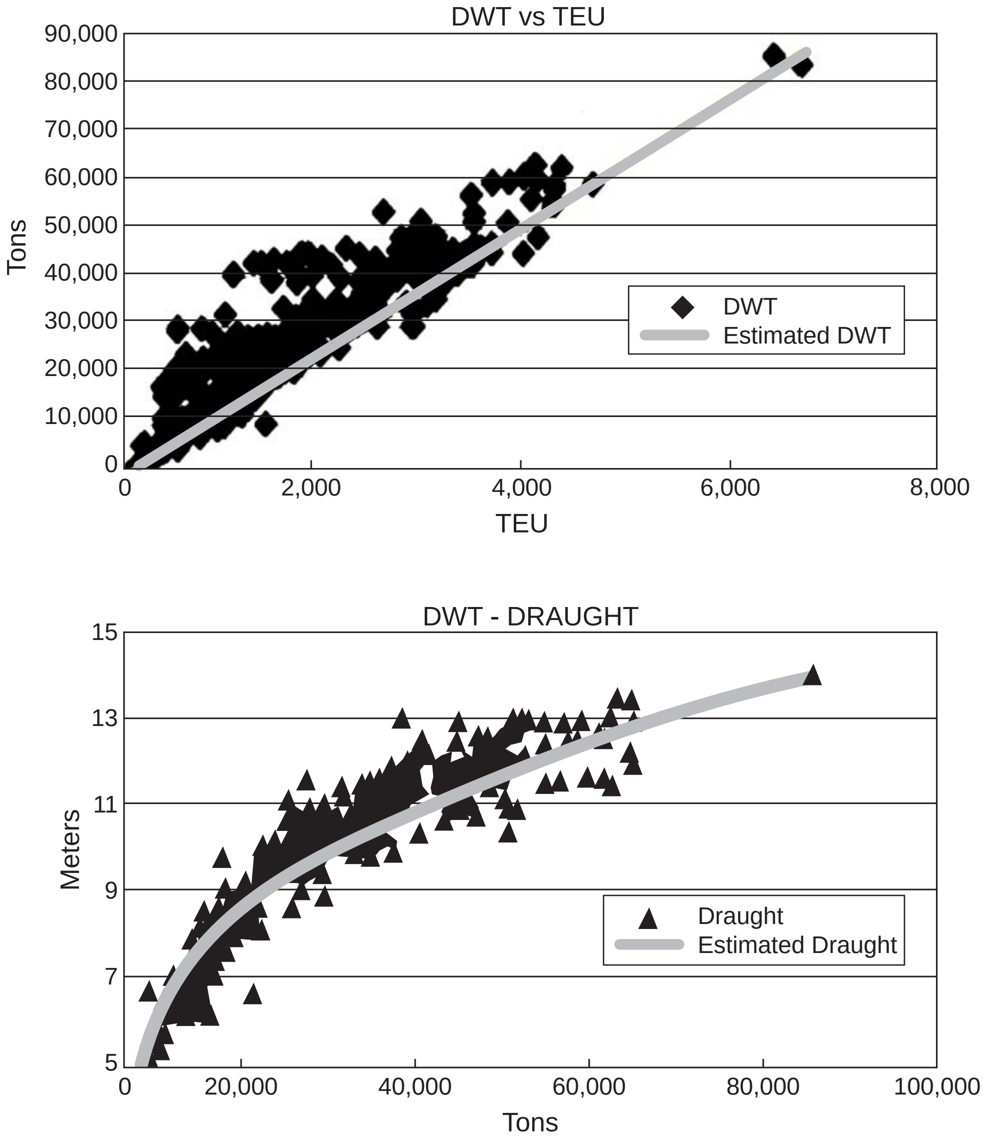
DEAD WEIGHT, DRAUGHT, AND CHANNEL DEPTH

In terms of containership design, the number of containers that can be carried on a ship is limited by several factors, including the dead weight of the vessel and the total weight of containers that can be carried by the ship; the number of containers (because vessels can carry both empty and full boxes, a ship can be full well below its weight capacity); and finally, the stability of the ship if a number of boxes are carried on deck (*Practical Ship Design*, 1998).

The dead weight (DWT) of a ship measures the total weight of cargo that the vessel can carry when loaded to its safety marks. This total includes the weight of fuel, stores, water ballast, fresh water, crew, passengers, and baggage (Stopford, 1997). Lightweight (LWT) is the weight of the vessel as-built, including boiler water, lubricating oil, and the cooling system water (Stopford, 1997). Full displacement is the sum of DWT and LWT (Watson, 1998).

The relationship between these various factors was evaluated using the Lloyd's data set noted earlier in this chapter. The relationship between DWT and displacement in containerships seems to be around 0.65 and 0.78 for smaller and larger ships, respectively. An empty ship is about a third of the weight of that when it is fully loaded. Figure 3.3 shows that there is a relationship between TEU capacity and DWT, based on ships calling at the North Atlantic ports in 1998 and 1999. It would seem that a linear approximation works reasonably well between DWT and TEU capacity, including the 80,000 ton DWT of Regina-Maersk with its 6,600 TEUs capacity. There also appears to be a nonlinear relationship between DWT and draught, again based on the same data source. These findings are perhaps good news to any port with a 15 m (49.5 ft) or greater channel, insofar as such depths can handle the largest ship contemplated at present.

Of course, this is not good news to North Atlantic and Gulf port operators because the necessary dredging is problematic, costly, and environmentally troublesome. When considering the recorded draught of the ship, a 4 ft clearance is necessary from the bottom of the keel to the bed of the channel, as previously noted. The precise clearance depends on the port and varies with wave oscillations, water density, bed clearance, and hardness (UNCTDAD, 1985). It has already been noted that Texas ports, owing to their location on the inner portion of the Gulf, are likely to be the last port on an outward route, or string, to unload and the first to load when en route to North Europe or the Mediterranean Middle and Far East. This means that ships rarely need to have the full channel depth that their design requires when fully loaded.



Source: Lloyds Maritime Information Services, 1999

Figure 3.3. TEU Capacity and DWT Relationship of Vessels Calling at North Atlantic Ports 1998-1999

While draught requirements for partially loaded ships clearly translate into a reduction in channel depths, the exact determination of the number of containers in the required draught varies with a large number of factors, including the ship characteristics (the draught replacement relationship), water density, the percentage of empty containers on board, the average weight by loaded container, the percentage of 20 ft containers, and the tons of fuel and supplies that are needed to get the ship to the next port. These factors are now frequently handled using sophisticated models developed for each ship, allowing ship crews to load the vessel in the most efficient way and to take on only that amount of fuel needed to get to the next refueling point, should channel depth become an issue. Finally, the data set was used to develop a model that identifies the channel depth and the clear keel depths — both in feet and in meters — for a variety of capacity categories for containerships. The results appear in Table 3.7, along with a variety of assumptions that were used to develop the table. The table shows, for example, that a 3,000 TEU vessel with a DWT of 38,340 tons needs a channel depth of between 37.5 and 40 ft, with a clear keel of around 35 ft, approximating to 10.6 m. It also indicates that a 45 ft channel depth should accommodate ships up to 6,000 TEUs, which may be of interest to ports in the Houston area. For example, a Texas City channel of 45 ft should be adequate to serve the smaller mega-containerships being introduced today.

Table 3.7. Relationship between TEU Capacity and DWT Based on Ships Calling at the North Atlantic Ports between 1998-1999

Channel depth		27.5	30.0	32.5	35.0	37.5	40.0	42.5	45.0	47.5	50.0
Clear keel ft		23.5	26.0	28.5	31.0	33.5	36.0	38.5	41.0	43.5	46.0
Clear keel m		7.2	7.9	8.7	9.5	10.2	11.0	11.7	12.5	13.3	14.0
TEU	DWT (tons)										
1,000	12,780		F.L.	F.L.	F.L.	F.L.	F.L.	F.L.	F.L.	F.L.	F.L.
2,000	25,560				F.L.	F.L.	F.L.	F.L.	F.L.	F.L.	F.L.
3,000	38,340						F.L.	F.L.	F.L.	F.L.	F.L.
4,000	51,120							F.L.	F.L.	F.L.	F.L.
5,000	63,900								F.L.	F.L.	F.L.
6,000	76,680								F.L.	F.L.	F.L.
7,000	89,460									F.L.	F.L.

Note on assumptions:

75% loaded (40ft)	20.0 tons	
loaded (20 ft)	10.0 tons	50% 40 ft containter
25% empty (40 ft)	3.7 tons	50% 20ft container
empty (20 ft)	2.1 tons	TEUs per box 1.5
Assumed weight per TEU	11.98 Tons/TEU	

Chapter 4. Containership Size and Costs

INTRODUCTION

This chapter describes the approach taken by the study team to address transportation system costs and to consider the trade-off between cost and time, an issue for commodities moved by container. The chapter describes the various categories of cost associated with a maritime move, and offers a model illuminating some of the key issues that shipping owners figure in when ship size and port calls (the objectives of this study) are evaluated. A note of caution should be raised at this point. Actual costs, current at the time of the research undertaking, are very difficult to obtain. In the competitive maritime environment, it is these costs that determine the choices, so this problem is not unexpected. The model input costs, however, have been assembled in the same approximate time period and can be used to (a) show the inter-relationship of cost elements, and (b) identify cost differentials between choices, while not reproducing actual market values for shipping costs. In any event, it is the cost differentials, not the actual rates that are of interest to transportation planners addressing the problem of differences in ship size and the number of port calls, so it is considered an appropriate approach for the purposes of this study.

The first part of the chapter describes the relationship between the different cost components that are encountered as containerized goods move from the manufacturer to the local distribution point where it is unloaded. This contributes to an understanding of the issues facing a ship owner considering what size of containership to deploy on a specific route, such as one linking to a Gulf port. The next section of the chapter considers the modeling of the containership operating costs when at sea—the equivalent of vehicle operating costs on highways. This then leads to some conclusions about optimal ship size and how these impact decisions related to deployment on Gulf coast container routes.

MODELING TRANSPORTATION COSTS

In the global context, the decision-making process for a liner company involves all stages of transportation related to a container move, which means that the model should address maritime costs, port costs, land transport costs, container rent, and shipper requirements.

Figure 4.1 summarizes these cost categories into two broad types — transport and shippers — and provides some of the characteristics that impact the cost structure. It can be readily appreciated from the figure why accurate cost estimating for commodity/route/ship size combinations can be challenging and difficult to accomplish.

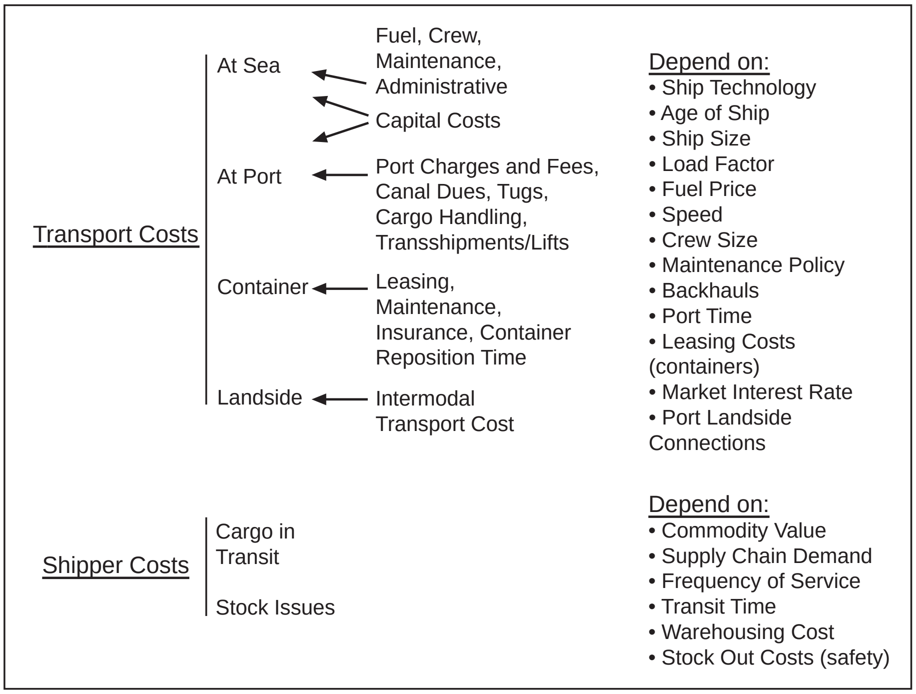


Figure 4.1. Container Transport Cost Breakdown

Total costs for container shipment can be expressed as:

$$\text{Total Cost} = SOC + PC + CC + LSC + IC \qquad (\textit{Equation 1})$$

Where:

SOC = Ship Operating Costs
PC = Port Costs
CC = Container Costs
LSC = Landside Costs
IC = Inventory Costs

Box 4.1 details the formulae that can be used to estimate ship operating costs. Using these equations, a spreadsheet of ship operating costs was developed for a base containership of 2,000 TEU capacity. Five cost components were used to derive total operating cost, comprising fuel (main engine), fuel (auxiliary engine), capital cost, crew cost, and overhead cost. The costs in each component were then adjusted to reflect various sizes of ship (from 1,000 to 7,000 TEU, by 1,000 TEU increments) by using elasticities reported in the literature. The various outputs within each component/ship size were finally converted into U.S./day costs, enabling total costs to be estimated. Table 4.1 reports the full output from the ship operating cost spreadsheet.

Box 4.1. Ship Operating Costs

$$SOC = \frac{Trt \times (Cc[v,S] + Cl[S] + Ca[S]) + Ts \times Cf[S] + Tp \times Cfa[S]}{Sl}$$

Equation 2

$$Cc = \alpha_0 \times S^{\alpha 1} \times v^{\alpha 2}$$

Equation 3

$$Cf = \beta_0 \times S^{\beta 1} \times v^{\beta 2} \times pf$$

Equation 4

$$Cfa = \chi_0 \times S^{\chi 1} \times pd$$

Equation 5

$$Cl = \delta_0 \times S^{\delta 1}$$

Equation 6

$$Ca = \varepsilon_0 \times S^{\varepsilon 1}$$

Equation 7

$$Tp = (Np \times Te) + \frac{4 \times l \times S}{H(S)}$$

Equation 8

$$Ts = \frac{Dr}{v \times 24}$$

Equation 9

$$Trt = Ts + Tp$$

Equation 10

$$v = k_0 \times S^{k1}$$

Equation 11

Where:
SOC: ship operating costs ($/TEU)
Cc: capital Costs per day
Cl: labor Costs per day
Ca: administrative costs per day
Cf: fuel costs main engines per day at sea
Cfa: fuel costs auxiliary engines per day at port
Ts: time at sea
Tp: time at ports
Trt: total roundtrip time
Dr: roundtrip distance by sea (nm: nautic miles)
Te: time to berth/unberth at each port in average
v(S): ship operational speed as a function of ship size (knots)
H(S): handling speed to load/unload containers as a function of ship size
l: load factor
S: size of the ship in TEUs
Np: number of ports in the string
Te: time to berth/unberth at each port in average
Pf: fuel price ($/ton)
Pd: auxiliary fuel price ($/ton)
α, β, χ, δ, ε, and κ : parameters to be estimated from available data

Table 4.1. Ship Operating Costs

Fuel Consumption Main Engine

Ship Size	2000	TEU
Speed	22	knots
Consume	75	tons/day
HFO cost	$90	per ton
Elasticity	0.147	Speed / Size
	0.350	Fuel Comp. / Size
	3.000	Fuel Comp. / Speed

per day
$6,750

Ship Size (TEUs)	Speed (knots)	Fuel (Tons/Day)	Cost/Day
1,000	20	43	$3,901
2,000	22	75	$6,750
3,000	23	103	$9,302
4,000	24	130	$11,679
5,000	25	155	$13,934
6,000	26	179	$16,096
7,000	26	202	$18,183

Fuel Consumption Auxiliary Engine

Ship Size	2000	TEU
Consume	0.9	tons/day
Diesel	$160	per ton
Elasticity	1.250	Fuel Auxiliary / Size

per day
$144

Ship Size (TEUs)	Tons/Day		Cost/Day
1,000	0.4		$61
2,000	0.9		$144
3,000	1.5		$239
4,000	2.1		$342
5,000	2.8		$453
6,000	3.6		$569
7,000	4.3		$689

Capital Cost

Ship Size	2000	TEU
Value	$37,000,000	
Speed	22	knots
Life	20	years
Interest Rate	8%	
Insurance	1%	
Maintenance	2%	
Repair Time	4%	
Elasticity	0.300	Cap. Cost / Soize
	1	Cap. Cost / Design Speed

Cap. Rec. Fac.
0.132
Days working
350

per day
$13,939

Ship Size (TEUs)	Speed (knots)	Value	Cost/Day
1,000	20	$27,141,967	$10,225
2,000	22	$37,000,000	$13,939
3,000	23	$44,352,134	$16,708
4,000	24	$50,438,496	$19,001
5,000	25	$55,728,956	$20,994
6,000	26	$60,460,944	$22,777
7,000	26	$64,773,914	$24,402

Crew

Ship Size	2000	TEU
Crew Size	16	people
Work Hour	18	per day
Wage	$5	per hour
Elasticity	0.000	Crew / Size

per day
$1,440

per year
$504,000

Ship Size (TEUs)	Crew		Cost/Day
1,000	16		$1,440
2,000	16		$1,440
3,000	16		$1,440
4,000	16		$1,440
5,000	16		$1,440
6,000	16		$1,440
7,000	16		$1,440

Overhead

Ship Size	2000	TEU
Value	$50,000,000	
% of Value	5.4%	
Elasticity	0.151	Overhead / Size

Days working
350

per day
$7,714

Ship Size (TEUs)	Cost/Year		Cost/Day
1,000	$2,431,016		$6,946
2,000	$2,700,000		$7,714
3,000	$2,870,939		$8,203
4,000	$2,998,746		$8,568
5,000	$3,101,786		$8,862
6,000	$3,188,599		$9,110
7,000	$3,263,891		$9,325

Inventory costs play an important role in shipper choice because they affect the levels of service associated with container moves along the supply chain. They affect the choices in modes and ports, and the composition of the supply chain itself. Box 4.2 defines some of the more important inventory cost items (though they were not estimated as part of this report).

Box 4.2. Inventory Costs

Cargo in Transit

$$Ct = \frac{Tt \times V \times i}{365} \qquad \textit{(Equation 7)}$$

Safety Stock

$$Sb = \sqrt{\frac{Q \times (Tt + Ti)}{2 \times P}} \qquad \textit{(Equation 8)}$$

Safety stock cost

$$Cb = \frac{Sb \times \left(V \times i + W\right)}{Q \times 365} \qquad \textit{(Equation 9)}$$

Inter arrival stock

$$Ci = \frac{Ti}{365} \times (V \times i + W) \qquad \textit{(Equation 10)}$$

Tt: average transit time per consignment
Ti: inter arrival time elapsed between two consecutive ship calls
Sb: safety stock
V: value per container in average ($/TEU)
I: interest rate
W: warehousing cost ($/TEU/Year)
Q: average daily demand per commodity per customer (TEUs/day)
P: accepted risk of running out of stock

Port Costs

Port costs vary according to the location of the port, local labor costs (including union strength), the equipment available, and volumes of TEUs handled by the port. There are different costs if a vessel owner (like Maersk) owns its own terminal and equipment, or if the vessel moves the containers through the port authority for landside processing. Equipment and facility costs for large containerships are more expensive and represent a larger financial risk. Major load centers are attractive as ship size increases because they have a lower cost per TEU handled as a result of higher utilization and productivity. From a regional perspective, the concentration of resources in load centers increases productivity and efficiency. As an example, port costs for moving a box may be estimated between $250 and $350 per TEU (Stopford, 1997) and this appears to hold true for Houston where a cost of around $250 was quoted to the study team.

Box 4.3. Latest generation of big container ships will pose new problems for terminal operators (*JoC Week,* Jan. 15-21, 2001)

China Shipping plans to order two 9,800-TEU ships and to operate them on a shuttle service between Hong Kong and Los Angeles beginning in 2004. The carrier plans to discharge all inbound containers and load all outbound containers at those ports. That will simplify cargo stowage because there'll be no need to worry about putting containers bound for a particular port in a particular hold of the ship. But it could create a surge of containers that terminal operators today don't get from a single ship.

The ports of Los Angeles and Long Beach are getting ready. They're designing future terminals and cranes to handle 10,200-TEU ships that carry containers 22 rows across. Today's 6,000-TEU ships require four to five cranes and up to 26 crane drivers to discharge and load vessels in two to three days. The new-generation ships could require as many as eight cranes and 32 to 40 crane drivers, and it will still take four to five days to turn the vessel, depending upon how many shifts each day the carrier is willing to pay for.

Even with new technology and more productive work practices, 9,000-TEU ships will present shipping lines and shippers with important decisions to make. One will be whether to store containers on chassis at terminals, or to stack containers as many as four high. Terminal operators prefer to keep containers on chassis until they are picked up because such "wheeled" operations require less labor.

However, wheeled operations require more land, which isn't always available. Even the 265-acre APL Ltd. facility in Los Angeles, the nation's largest proprietary terminal, must stack most of its containers during the peak shipping season. A large vessel at a totally wheeled terminal requires more than 100 acres for container storage. A heavily stacked operation requires about 60 acres of storage. Stacking containers not only requires more labor, but forces terminal operators to invest in rubber-tired gantry cranes to move containers around in the yard. Each rubber-tired gantry costs $1.3 million, and labor costs run $1,800 a day.

Time is money, especially for importers of high-value cargo. Vessels of 9,000 TEUs and greater will require 72 hours of continuous work to be completely unloaded and reloaded. Ship lines and terminal operators will have to decide whether to work around the clock, and incur the costly nighttime wages specified by the ILWU contract, or to continue working mostly daytime shifts. Even with two shifts a day, the new generation of vessels will take about five days to discharge and reload. Importers whose containers are unloaded on the fifth day may not be pleased with the service they are receiving. Pushing large volumes of containers through limited terminal space is technologically feasible, as is seen at ports like Hong Kong, which handles more than 15 million TEUs a year. Hong Kong handles that massive volume by operating its gates round the clock and running a tight appointment system for trucks.

Box 4.3 identifies some of the operational difficulties facing port operators wishing to service mega-containerships. The information provides interesting data on crane use and other container lift issues. It also addresses the problem facing operators as they move high volumes of boxes through their terminals. There is no simple transferable process and each site operation has to be determined on a case-by-case basis. However, seven day, 24 hour operations (7/24) seem important, and therefore challenging to U.S. ports. Tight appointment systems (like Hong Kong) suggest demand management strategies, while New York-New Jersey is looking to Inland port links to handle the large volumes of boxes created by world demand and large containerships.

Tables 4.2 and 4.3 show the relative weight of each component of ship costs while in port and at sea. Capital costs are dominant in both cases, however its importance grows considerably with ship size when the ship is at port either loading or unloading. It is clear therefore, why larger containerships require a rapid port turnaround in order to remain economically viable. An extra day spent at the port for the largest ship can represent an extra cost of $25,000 in capital costs alone.

At sea, the importance of fuel costs becomes more important. As ship size and speed increases, fuel costs can be as large as 35 percent of the daily ship cost at sea. Obviously ships with newer technologies, improved hull design and the latest engine designs have a competitive edge over older ships. The advantage is not only in the reduced fuel cost and higher speeds, but also in improved ship utilization and service level for shippers. This advantage becomes more important when fuel prices rise, as they did in 2000.

Table 4.2. Ship Cost per Day at Sea

Ship Size	Capital %	Labor %	Admin. %	Fuels %	TOTAL %
1,000	45	6	31	17	100
2,000	46	5	26	23	100
3,000	47	4	23	27	100
4,000	46	4	21	29	100
5,000	46	3	19	31	100
6,000	46	3	18	33	100
7,000	45	3	17	35	100

Table 4.3. Ship Cost per Day at Port

Ship Size	Capital %	Labor %	Admin. %	Fuels %	TOTAL %
1,000	55	8	37	0	100
2,000	60	6	33	1	100
3,000	63	5	31	1	100
4,000	65	5	29	1	100
5,000	66	5	28	1	100
6,000	67	4	27	2	100
7,000	68	4	26	2	100

Transshipment Costs

Transshipment costs now comprise almost 25 percent of the total container lifts in the world market and are a consequence of larger ships stopping at fewer ports and requiring relays to take boxes to ports serving their final destination. A transshipment cost may range from $75 to $225 per TEU. The large difference is explained by different port costs, with higher costs at U.S. ports. Again, this critically affects the cost structure of specific route structures and a transshipment cost of $225 equals 2,500–10,000 miles of sea travel, 475–1,735 miles by rail double stack, or 100–350 miles by truck. This suggests that transshipments or relays will level out at some point, as the cost of relays exceeds direct shipment on a smaller vessel. However, it would seem that relays will continue to grow over the next five year period until that point is reached.

Box 4.4 provides some recent information on Korean transshipments, showing the importance of relays in the routing of containers in the Far East as well as the Mediterranean. At Pusan, transshipments are critically linked to Chinese and Japanese markets and it is thought that once equilibrium is reached in the routing of containers to these markets, transshipment share will become more stable.

Box 4.4. Transshipment Jumps at Korean Ports (JoC Online April 24, 2001)

South Korea's efforts to become the primary Northeast Asian transshipment and logistics hub appear to be making headway.

The Ministry of Maritime Affairs and Fisheries in Seoul said 2.3 million TEUs of containerized cargo moved through the country's main ports during the first quarter, up 6.9% from a year earlier. But transshipments jumped 30% to 702,000 TEUs of the total, a spokesman said.

Pusan in the southeast, the main port, handled 1.89 million TEUs in the first quarter, of which transshipments accounted for 674,000, an increase of nearly 27% from last year.

Pusan became the world's third-largest container port last year with 7.54 million TEUs, up 17% from 1999. Its transshipments grew 34.5% to 1.63 million TEUs.

The government wants South Korea to become the region's main logistics center, competing with Kobe and Yokohama for transshipment cargo from China, Russia and northwestern Japan. Northeastern China and western Japan have no ports suitable for larger container ships and use Pusan for transshipment.

Container Costs

Table 4.4 identifies the most important container leasing companies, together with their fleet holdings for the period 1997 to 1999. During that period, the strong procurement program of these companies helped maintain the lessor's holding of world container inventories at around 46 percent. The total purchase of equipment for operational lease was expected to top 650,000 TEU in 1999 with a similar number going directly to ocean carriers, either on finance lease or as an outright acquisition, with a balance of around 100,000 TEUs destined for intermodal and regional container operations. This gives a world wide output of 1.4 million TEUs (all types) from container manufactures in 1999.

The costs for the containers are based both on demand and interest rates. Those leasing containers have not performed strongly, in financial terms. Per diem lease rates have fallen substantially since 1995, in step with the corresponding decline in new container prices. This has led to a decline in the master lease sector (where boxes are leased over their lifetime) to a term lease. And carriers, realizing that box prices might rise in the early 2000s, have been locking into low priced deals for at least three to five years. As a result, the overall proportion of rental TEU tied to term lease agreements has risen sharply and is currently put at almost 50 percent. A further 35 percent of TEU is fixed on master lease and the remainder (15 percent) is hired (Containerisation International, 2000).

In 1999, the manufacturing cost of a standard 20 ft box fell below $1,350, bringing down the term lease rate to around $0.65 per day. In early 2001, the current 20 ft box costs around $1,500 to build and is generating a daily rental return of about $0.75. These values compare with around $130 generated per day in 1995 when equipment prices peaked at over $2,500. These are term lease prices. Master lease rates have traditionally earned a premium of around 30 percent on those generated from term lease, although the differential has narrowed since 1997. The 2001 20 ft master lease rates are estimated at under $1.00 per day, which compares with $1.65 generated per 20 ft box in 1995. Though these costs have been falling, they remain an important part of the total cost, compared with ship costs per day per TEU; it is also important on longer trips where turnaround time is longer and the container spends more time on land or sitting in port.

Landside Costs

Landside costs were taken from intermodal freight transportation (Muller, 1999) and are estimated at $0.20 for double stack (load/unload and delivery not included) and $0.90 for a container truck mile cost. This latter figure is low compared with Texas data where the truck mile cost exceeds $1.00. Landside costs can be an important component of the total cost for inland destinations, however it is not affected by changes in container ship characteristics or port operations and they are not analyzed further in this report.

Table 4.4. Container Leasing Company Fleet Holdings for 1997-99 (‘000 TEU)

Leasing Company	Mid-1999	Mid-1998	Mid-1997
Transamerica Leasing	1175	1180	1244
GESeaCo*	1150	1135	1245
Textainer Group*	860	605	445
Interpool Group	505	440	340
Interpool-CAI*	330	255	200
Triton Cont. International	661	530	460
Florens Container Corp.	460	440	430
Cronos Group	335	360	360
Xtra International*	—	230	223
Gateway Container Corp.	180	150	48
Capital Lease	150	120	45
Gold Container Corp.	95	65	40
Other	524	455	435
TOTAL	6425	5965	5515
Operational Lease	6055	5590	5150

** = GESeaCo formed as joint venture between GE Capital Corp and Sea Containers during 1997-98, Interpool acquired 50% stake in CAI in 1998, Textainer took management control of Xtra International box fleet in 1999.*
Source: Containerisation International 2001

Shipper Inventory Costs

This report has focused on the costs associated with the movement of a container from origin to destination and how they impact the transportation cost per TEU. Given a choice set of transportation modes (e.g. air, maritime) and different service attributes (transportation cost, frequency of service, transit time, reliability, losses and damage, etc.), a shipper faces a different problem, namely how to minimize the total costs that comprise the specific inventory and transportation costs for a particular commodity move.

Shipper’s choice is affected by the value of the commodity, supply chain characteristics, and responsiveness (LBJ School, 1995; Strong, 1996). For a high value commodity supply chain, user costs are minimized by using services that provide short transit times and high reliability. On the contrary, for low value commodities shipped in large quantities, transportation costs are relatively more important when minimizing total user costs, so commodities stay on the cheaper mode as long as possible.

The basic model for inventory costs was adapted from Simme Veldman and represents an important part of total transportation costs. Inventory costs increase with total trip time, the value of cargo, frequency of calls, and issues related to time reliability. For a container carrying $30,000 of commodities, the cost may vary between $20 and $30 per day and for a figure of $10,000 it may range between $10 and $18. These values are illustrative because the exact value is given in the context of each company operation with its own inventory and production cost system. However, they should not be ignored because they may account for an important part of the total cost and explain why particular routes are chosen, even though it is not a cost paid to the carrier by the shipper, it is a cost for the shipper and remains critical when making a shipping choice. Inventory costs increase with larger ships because to maintain the same shipload factor, the frequency of port calls must decrease.

Economies of scale in total costs can be reached if either the demand or maritime alliances result in high load factors for large ships, or if high utilization of port operations can be achieved through regional load centering or finally, if double stack trains or river barges can be used to feed domestic markets. Diseconomies occur if the frequency is reduced to maintain load factor, direct calls are reduced as a result of the concentration of call routes and services to load centers and longer truck hauls are necessary to carry containers to and from load centers. Container rental cost does not figure into these calculations unless there are significant changes in turn-around time.

COSTS AND OPTIMAL SHIP SIZE

We have seen how ship size impacts different cost elements and their relative importance in the total cost of transportation. A liner company, in its quest for efficiency, sizes each ship to best serve each market and route. Technology and costs play an important part in choosing the appropriate size of container vessel for a particular route. There are at least three different optima in regard to ship size, and these comprise

a. the point where total vessel operating cost per TEU is minimized,
b. the point where net operating surplus per TEU is maximized, and
c. that size which promotes the greatest return on the capital invested by the shipping company.

We examined the first approach because the other two are extremely sensitive to market fluctuations and are therefore more difficult to estimate. The conclusions to be drawn from the study model can be summarized as:

a. the larger the ship, the cheaper per TEU mile;
b. the less time a ship remains in port, the larger it can be;
c. high fixed costs lead to the selection of larger ships; and finally
d. the longer the route distance between ports, the larger the optimum ship size becomes.

It is important to understand that while this cost analysis can be applied to each specific route, it would be wrong to analyze a market or route such as the U.S. Gulf by itself. Though the cost analysis would be correct, it is not the way the liner companies operate. As stated earlier, the Gulf market is part of a global shipping network. Therefore costs, service requirements, and demand characteristics of the whole network need to be analyzed to determine service and route design issues, as well as fleet deployment.

The ship operating cost spreadsheet (shown in Table 4.1) was used to estimate total costs at sea for various sizes of containerships, and cost per TEU, again for the same range of ship size. Figure 4.2 gives the cost per day and shows that the cost per day is higher for a larger ship and there are economies of scale in almost all cost components, but especially those related to crew and overhead costs. When fully loaded, economies of scale are particularly impressive for larger ships, but when container volumes are weak, smaller vessels become most economical.

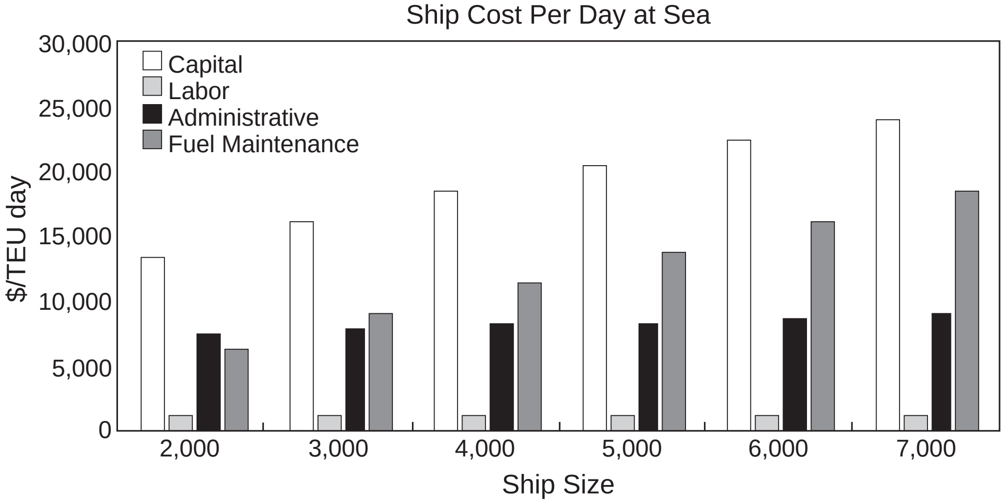


Figure 4.2. Ship Cost per Day at Sea

Figure 4.3 provides information on the TEU cost per day and per sea mile. The cost per day, using a load factor (LF) of 100 percent, ranges from $17 to $8 per TEU/ day for a 2,000 and 6,000 TEU ship respectively. This translates to approximately $0.04/TEU per mile and $0.02/TEU per mile for the two ship sizes. If we assume that the cost of a double stack TEU move is $0.20 and for a truck $0.95 per mile, a mile of sea is between six and thirty times cheaper than rail and truck respectively. Though the precise numbers will vary, the magnitudes of the cost differentials for the various ship sizes explain the rapid growth of post-Panamax container ships in the world fleet.

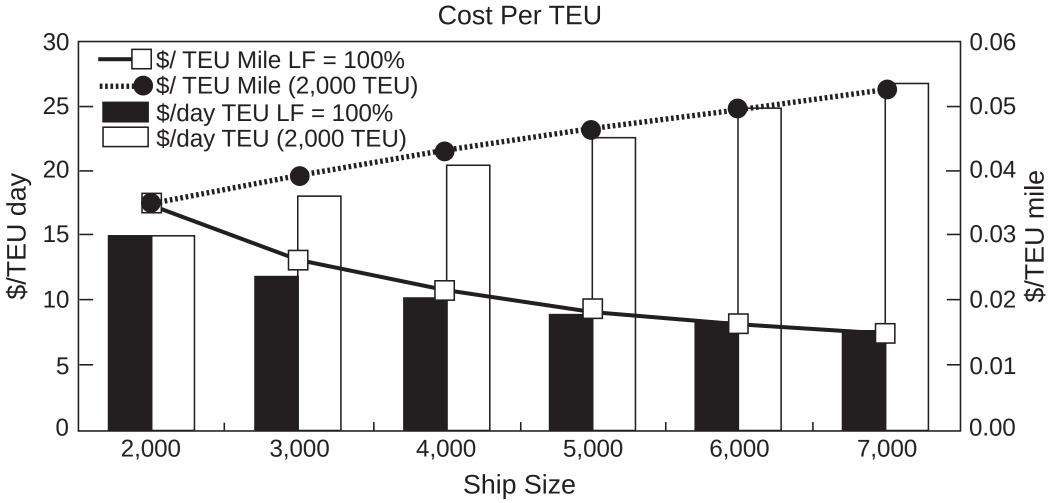


Figure 4.3. Ship Cost per TEU

SUMMARY

Ship owners make four key decisions on ship route selection: the speed of service, the cost that the market can bear on the commodities moved along that route, the volume of container moves on the route, and the frequency of ship calls on various ports. This chapter has examined aspects related to costs and speed; the next chapter discusses the issue of routes and Gulf Coast port scheduled calls.

Chapter 5. North Atlantic and Gulf Containership Routes

INTRODUCTION

Previous chapters have examined aspects of the growth in world containership deployment and related these aspects to the rise of global trade. Containership operating characteristics and costs have been identified and some examined in order to explore how liner companies are affected by such costs when choosing different sized containerships. This chapter now moves to aspects of container demand and considers the routes over which containerships are deployed, particularly in the North Atlantic and the Gulf. The latter are of interest to TxDOT planners and this is reflected in the structure of the chapter.

WORLD ROUTES

Table 5.1 presents 1997 values for trade (in U.S. dollars) among five U.S. coastal areas and different world regions based on trade data supplied by Professor John McCray (McCray, 1999). From this data, it can be deduced that the Pacific Far East areas have the most important sea trade routes. The U.S. North and South Pacific ports account for over 85 percent of the total U.S. trade with the Far East. The magnitude of the trade value can be clearly seen and this immediately demonstrates why large, fast containerships are implemented first on these routes. The second most important area is the North Atlantic to Northern Europe, Far East, and Mediterranean, which constitutes part of the Northern Pendulum routes. The third area is the South Atlantic ports and their connections to the Far East and Northern Europe. It is noted that the Gulf ports are very low, when ranked by value. The most important link is the Gulf to North Europe and this is number nine by value ranking, which is eighteen times smaller than the South Pacific-Far East area. Table 5.2 examines these trade flows by weight and TEUs and provides a more detailed breakdown of the container flows between these major geographic regions.

Naturally, similar patterns to those shown in Table 5.1 are seen, although the differences are not so pronounced because West Coast trade has much higher values per TEU than those in other regions, particularly those in the U.S. South Atlantic and Gulf port structure. This analysis by weight shows that the South Atlantic ports have a different profile than compared to those in the Gulf. Because of the position of U.S. South Atlantic ports on the major trading routes, the Far East and northern Europe draw a substantial volume of sea borne trade, which is not entirely replicated from Gulf ports. In the Gulf ports, the main trading areas are Northern Europe, Central America and the Caribbean, the West Coast ports of South America, and finally Mediterranean ports. It is probably true that the numbers for Central America and the Caribbean may be influenced by relays from other West Coast, South American ports. In other words, this data source may not reflect the true supply chain between South American and Gulf ports. In any event, it is useful in showing the variety of tons per TEU that are present on the different routes, as well as the values. Of interest is the total trade between U.S. ports and West Coast, South American ports with regard to containers. Though the containers are somewhat few in number, they are relatively heavy and have a high value associated with their contents, presumably influenced in part because of the weight. This relationship between tons per TEU and value per TEU is also reflected in containers form Africa.

Table 5.1. 1997 Values for Trade among Five U.S. Coastal Areas and World Regions (McCray, 1999)

US District	Gulf	South Atlantic	North Atlantic	South Pacific	North Pacific	Total
World Region	**Value**	**Value**	**Value**	**Value**	**Value**	
Far East	356,768,706	14,448,952,141	19,000,405,129	154,935,626,047	48,752,993,136	237,494,745,159
Northern Europe	8,720,622,292	14,593,224,960	39,773,960,984	5,180,293,337	318,122,469	68,586,224,042
Other	345,193,344	238,184,585	168,292,085	202,391,865	97,110,073	1,051,171,952
Mediterranean	2,175,723,186	4,260,768,146	12,080,195,041	1,788,635,138	501,445,414	20,806,766,925
South America (West)	3,010,326,146	8,406,028,308	7,419,627,986	462,158,719	147,498,024	19,445,639,183
Centeral America and Caribbean	3,088,702,237	10,660,168,354	1,872,236,546	698,740,023	59,376,329	16,379,223,489
South America (East)	945,054,405	1,939,855,750	1,627,959,738	859,622,177	127,172,300	5,499,664,370
Australia	328,377,382	846,628,377	1,492,971,903	5,164,866,461	395,525,704	8,228,369,827
Middle East	1,038,188,109	1,902,548,670	3,892,039,355	699,694,605	80,065,722	7,612,536,461
Africa	696,400,023	1,291,001,677	2,931,284,357	253,877,595	41,903,179	5,214,466,831
Total	20,705,355,830	58,587,360,968	90,258,973,124	170,245,905,967	50,521,212,350	390,318,808,239

Table 5.3 reports the first quarter 1998 imports and exports from the world markets and the United States ports. Both tables report the TEUs lifted from each trade lane to U.S. ports, the deployed capacity in terms of vessel slots, and a utilization rate based on the ratio of lifted TEUs to deployed capacity. It is noted that the imbalance in the Trans Pacific routes contrasts with a better balance in Trans Atlantic route flows that makes it easier to establish prices for the Atlantic routes. In addition, the deployed TEU capacity of the vessels on the

Trans Pacific routes are more than twice that deployed in the Trans Atlantic routes, again showing the importance and the densities of the West Coast container routes. Of the critical areas identified in Table 5.2 for the Gulf, several appear to have balanced import and export TEU lifts. Northern Europe and the Mediterranean have around a 70 percent utilization rate for both imports and exports, while East South American ports are relatively close, with a 52/57 rating. The other two critical areas linked to Gulf ports are not in such good balance with the Central American ports having a 68/58 ranking and the Caribbean ports a 31/54 import to export utilization rate. Again, we would expect that where there is good balance between utilization rates, there is the prospect for more stable marine revenues that will impact supply chain decisions.

Table 5.2. Trade Flows by Weight and TEU (McCray, 1999)

U.S. District	**Gulf**	**South Atlantic**	**North Atlantic**	**South Pacific**	**North Pacific**	**Total**	**TEUs**	**Tons/ TEU**	**$/ TEU**
World Region	**Weight**	**Weight**	**Weight**	**Weight**	**Weight**				
Far East	625,864,998	6,177,499,463	6,692,726,036	33,483,397,718	13,067,767,940	60,047,256,155	8,362,814	7.2	28,399
Northern Europe	3,229,105,771	4,297,443,727	8,876,457,662	1,635,933,299	104,123,791	18,143,064,250	2,438,396	7.4	28,128
Other	173,138,223	117,232,867	118,553,813	183,835,999	291,397,265	884,158,167	28,141	31.4	37,353
Mediterranean	1,152,223,321	1,807,392,714	3,703,592,494	824,931,483	338,831,110	7,826,971,122	778,070	10.1	26,742
South America (West)	1,550,245,873	2,933,113,455	2,472,579,139	230,419,444	78,801,958	7,265,159,869	296,146	24.5	65,662
Centeral America and Caribbean	2,181,760,515	3,131,865,140	1,109,553,056	497,961,144	24,185,734	6,945,325,589	1,207,897	5.7	13,560
South America (East)	602,172,580	749,996,236	719,735,886	649,474,766	99,818,533	2,821,198,001	589,234	4.8	9,334
Australia	206,621,182	271,959,652	531,332,966	1,500,275,775	204,355,267	2,714,544,842	255,964	10.6	32,147
Middle East	339,943,786	628,454,088	912,564,390	179,600,671	72,219,158	2,132,782,093	142,443	15.0	53,443
Africa	385,003,855	519,945,987	840,556,814	90,884,565	15,037,089	1,851,428,310	82,452	22.5	63,242
Total	10,446,080,104	20,634,903,329	25,977,652,256	39,276,714,864	14,296,537,845				
TEUs	1,268,938	2,532,970	3,089,586	5,360,127	1,929,936				
$/TEU	16,317	23,130	29,214	31,762	26,178				
Tons/TEU	8.2	8.1	8.4	7.3	7.4				

Table 5.4 provides information derived from the Lloyd's database and examines U.S. Atlantic and U.S. Pacific ports to the world's trading regions. For these linked routes, the tables show voyages completed, the average ship size in TEU, and the total ship TEU capacity for three periods taken from the database. The table shows that the bigger vessels tend to be deployed over longer routes and shows, for example, that the U.S. Pacific to North Europe routes (the so called Pendulum route) shows a larger average than that from Atlantic ports to Northern Europe. In addition, it can be seen that substantial volumes on different links do not necessarily result in large ships being deployed. From the Atlantic ports to the

Caribbean, the average ship size is under 2,000 TEUs despite the large capacity on the route. This route network has substantial numbers of liner schedules that produce the large route capacity.

Table 5.3. First Quarter 1998 Imports and Exports (McCray, 1999)

Imports, First Quarter 1998

Trade Lane	TEUs Lifted	Capacity Deployed	Utilization
Northeast Asia	999,433	1,351,560	73.9
Southeast Asia	118,463	150,039	79
Total Trans-Pacific	1,117,896	1,501,599	74.4
North Europe	281,383	407,769	69
Mediterranean	120,924	173,311	69.8
Total Trans-Atlantic	402,307	581,080	69.2
Central America	76,687	112,993	67.9
Caribbean	33,257	108,916	30.5
East Coast South America	56,625	108,748	52.1
West Coast South America	36,753	55,206	66.6
Total Latin America	203,322	385,863	52.7
Less Caribbean	170,065	276,947	61.4
Total South America	93,378	163,954	57
Mideast	1,642	2,408	68.2
India/Other Asia	19,976	25,900	77.1
Africa	8,653	15,258	56.7
Oceania	21,649	54,285	39.9
Other Regions	1,830	3,035	60.3
Total Imports	1,777,275	2,569,428	69.2

Exports, First Quarter 1998

Trade Lane	TEUs Lifted	Capacity Deployed	Utilization
Northeast Asia	612,631	1,116,108	54.9
Southeast Asia	67,330	120,380	55.9
Total Trans-Pacific	679,961	1,236,488	55
North Europe	286,253	407,983	70.2
Mediterranean	89,979	131,729	68.3
Total Trans-Atlantic	376,232	539,712	69.7
Central America	69,611	119,266	58.4
Caribbean	107,041	198,982	53.8
East Coast South America	74,399	129,967	57.2
West Coast South America	37,378	67,680	55.2
Total Latin America	288,429	515,895	55.9
Less Caribbean	181,388	316,913	57.2
Total South America	111,777	197,647	56.6
Mideast	14,235	20,139	70.7
India/Other Asia	1,896	2,965	63.9
Africa	9,398	13,953	67.4
Oceania	37,954	78,501	48.3
Other Regions	1,987	3,399	58.5
Total Exports	1,410,092	2,411,052	58.5

Table 5.4. U.S. Atlantic and U.S. Pacific Ports to the World's Trading Regions (Lloyds, 1999)

	Voyages Completed			**Average Ship TEU**			**Total Ship TEU**		
U.S. Atlantic To	**16/11/97 to 19/12/97**	**19/10/98 to 16/11/98**	**16/11/98 to 19/12/98**	**16/11/97 to 19/12/97**	**19/10/98 to 16/11/98**	**16/11/98 to 19/12/98**	**16/11/97 to 19/12/97**	**19/10/98 to 16/11/98**	**16/11/98 to 19/12/98**
Far East	56	65	66	3,189	2,981	3,045	178,584	193,765	200,970
North Europe	54	78	81	2,673	2,442	2,305	144,342	190,476	186,705
U.S. Pacific	27	38	35	3,102	3,051	3,104	83,754	115,938	108,640
Australasia	5	12	8	1,394	1,485	1,759	6,970	17,820	14,072
C. America/Caribbean	82	205	203	1,840	1,250	1,298	150,880	256,250	263,494
Indian Sub-Continent	16	11	11	3,524	2,725	3,461	56,384	29,975	38,071
Mediterranean/Iberia	56	49	63	2,500	2,593	2,350	140,000	127,057	148,050
Red Sea/Mid-East	12	20	17	3,292	2,868	3,453	39,504	57,360	58,701
South America	131	260	252	1,022	715	686	133,882	185,900	172,872
South Africa	4	8	8	1,052	1,072	986	4,208	8,576	7,888
West Africa	1	10	4	428	652	545	428	6,520	2,180
Sum/Weighted Avg.	444	756	748	2,115	1,574	1,606	938,936	1,189,637	1,201,643

	Voyages Completed			**Average Ship TEU**			**Total Ship TEU**		
U.S. Pacific To	**16/11/97 to 19/12/97**	**19/10/98 to 16/11/98**	**16/11/98 to 19/12/98**	**16/11/97 to 19/12/97**	**19/10/98 to 16/11/98**	**16/11/98 to 19/12/98**	**16/11/97 to 19/12/97**	**19/10/98 to 16/11/98**	**16/11/98 to 19/12/98**
Far East	157	167	165	3,212	3,212	3,229	504,284	536,404	532,785
North Europe	29	28	29	3,359	3,265	3,551	97,411	91,420	102,979
U.S. Atlantic	26	41	37	3,197	2,866	2,984	83,122	117,506	110,408
Australasia	12	27	22	1,162	1,524	1,395	13,944	41,148	30,690
C. America/Caribbean	32	44	42	2,552	2,238	2,283	81,664	98,472	95,886
Indian Sub-Continent	27	25	22	3,373	3,541	3,680	91,071	88,525	80,960
Mediterranean/Iberia	39	29	37	3,238	3,485	3,503	126,282	101,065	129,611
Red Sea/Mid-East	7	13	10	2,661	3,121	3,227	18,627	40,573	32,270
South America	15	28	16	1,625	1,172	1,511	24,375	32,816	24,176
South Africa	1	1	1	2,728	390	390	2,728	390	390
West Africa	0	1	1	0	390	390	0	390	390
Sum/Weighted Avg.	345	404	382	3,025	2,843	2,986	1,043,508	1,148,709	1,140,545

The top ranking world regional markets for Gulf containers have already been identified as Northern Europe, the Mediterranean, Central America/Caribbean, and the South American West Coast regions. Again, looking at Table 5.4 we see that there is a substantial variation in vessel size on these routes, both within the U.S. Atlantic group and then between the U.S. Atlantic and U.S. Pacific links. The average TEU ship for Northern Europe and the Mediterranean is slightly under 2,500 TEUs, while those from the Pacific port average around 3,400 TEUs. The average vessel size for the Central American and Caribbean markets from Atlantic ports is under 1,500 TEUs while from the U.S. Pacific ports the vessel size rises to around 2,400 TEUs. Finally, the average vessel size from U.S. Atlantic ports to South American West Coast ports is around 800 TEUS whilst the average size from U.S. Pacific ports serving the same South American West Coast ports is over 1,400 TEUs. This shows the subtleties of commodity, service levels, and trip length between the various markets and also reinforces the fact that Atlantic ports in general, and Gulf ports in particular, serve a range of vessel sizes, most of them smaller than 2,500 TEUs.

ATLANTIC AND GULF ROUTES

Tables 5.5, 5.6, and 5.7 show the main container operators and the total available TEU string capacities, as well as ship sizes calling at the ports of Houston, New York-New Jersey, and Charleston. These ports were selected from the Lloyd’s database to represent an important port in the Gulf, North Atlantic, and South Atlantic regions respectively. Containership calls and the average ship size (in TEU) on U.S. Atlantic and Gulf ports in 1999 were also calculated from the Lloyd’s data and are reported in Appendix 2. Together they combine to give a snapshot of the North Atlantic routes and their importance to global trade.

In Houston, the main strings (as already confirmed) are with Northern Europe, the Caribbean, and Latin America. The largest vessel calling at the Houston port is the 4,600 TEU Econoship class, which has a regular weekly liner service scheduled with the port. While showing economies of scale in size, this vessel type is relatively slow (19 knots versus 25 knots for the latest ships) and is a clear candidate for replacement as the faster vessels of similar size are displaced from the Northern Pendulum routes by the mega-containerships. Again, Table 5.5 confirms the importance of Panamax and smaller vessels for the ports operations.

Table 5.5. Main Container Operators, String Capacities, and Ship Sizes Calling at the Port of Houston (Lloyds, 1999)

HOUSTON

Operator	Capacity	%	String	TEU Cap.	Max. Ship	Min. Ship	Avg. Ship	Calls
Sea-Land	341,213	20	North Europe - U.S. Atlantic	235,314	4,614	4,614	4,614	51
			North America - South America (NAT)	57,964	1,526	964	1,317	44
			Far East - Europe - Red Sea (AE2)	19,776	2,472	2,472	2,472	8
Lykes	258,175	15	Gulf Atlantic Sprint	245,092	3,322	2,409	3,102	79
			North Atlantic Sprint	11,055	2,409	1,914	2,211	5
TMM	181,850	10	North Europe - U.S. Gulf	179,550	2,394	2,394	2,394	75
Maersk	130,480	7	Mediterranean - U.S. Gulf/Mexico	63,802	2,952	1,325	2,552	25
			Venezuela/Gulf Service	43,045	1,140	851	957	45
			East Coast North America - West Africa (FLEXCON)	11,014	902	350	648	17
MSC	113,293	6	North Europe - East Coast North America (SAS)	67,966	2,987	1,838	2,427	28
			North Europe - East Coast North America (NAS)	22,104	2,456	2,456	2,456	9
Ivaran	82,235	5	East Coast South America Service	56,808	1,742	1,504	1,535	37
			East Coast North America - Central America	25,427	1,120	563	820	31
Crowley	62,527	4	Gulf Express Service	49,430	1,608	1,334	1,412	35
			Virgin Islands/Eastern Caribbean	10,835	907	900	903	12
			East Coast North America -South America	2,262	754	754	754	3
Hapag-Lloyd	61,638	4	North Europe - U.S. Gulf	53,910	2,602	2,480	2,567	21
			North Europe - U.S. Gulf (GUMEX)	7,728	1,932	1,932	1,932	4
Atlantic Cargo	52,672	3	North Europe - East Coast North America	52,672	1,588	1,064	1,351	39
NSCSA	52,645	3	East Coast North America - Far East	52,645	2,025	1,417	1,815	29
NYK	37,824	2	Pendulum Service (PAX)	37,824	3,152	3,152	3,152	12
Columbus Line	28,663	2	East Coast North America - Australia	21,471	1,337	1,114	1,263	17

Table 5.6. Main Container Operators, String Capacities, and Ship Sizes Calling at the Port of New York-New Jersey in 1998 (Lloyds, 1999)

NEW YORK

Operator	Capacity	%	String	TEU Cap.	Max. Ship	Min. Ship	Avg. Ship	Calls
Maersk	684,849	12.1	Panama (TP3)	415,732	3,922	3,922	3,922	106
			Suez Express (SZX)	95,360	4,306	3,922	4,146	23
			East Coast North America - East Coast South America	64,128	2,480	2,064	2,290	28
Sea-Land	529,916	9.3	North Europe - US Atlantic	249,156	4,614	4,614	4,614	54
			Suez Express (SZX)	101,583	4,065	4,062	4,063	25
			North America - South America (NAT)	63,748	1,526	964	1,275	50
Evergreen	444,814	7.8	RTW West	278,700	4,229	4,211	4,223	66
			RTW East	119,254	4,229	3,428	3,727	32
			East Coast North America - East Coast South America	25,084	1,334	1,122	1,194	21
ZIM	408,760	7.2	Round The World Service	362,848	3,429	3,029	3,240	112
			Asia - Mediterranean	19,840	2,480	2,480	2,480	8
MSC	376,099	6.6	North Europe - East Coast North America (NAS)	206,548	2,900	2,456	2,791	74
			North Europe - Far East	51,360	3,424	3,424	3,424	15
			East Coast North America - West Coast South America	27,012	1,743	1,452	1,589	17
			East Coast North America - South America	23,187	988	795	927	25
COSCO	349,470	6.2	North Europe - East Coast North America (TAS)	172,190	2,480	2,386	2,460	70
			Pendulum - Far East - Europe - ECNA	169,752	3,765	3,400	3,464	49
DSR/Senator	289,063	5.1	Asia - America - Europe (AWE-PDM)	174,358	3,007	3,005	3,006	58
			America - Europe - Asia (AMA)	102,637	3,017	2,232	2,701	38
ACL	279,168	4.9	North Europe - East Coast North America	279,168	2,908	2,908	2,908	96
Hapag-Lloyd	198,796	3.5	Pendulum Service (PAX)	145,004	3,607	2,602	2,843	51
			East Coast North America - MED - Far East (AEX)	51,312	3,430	2,984	3,207	16
Cho Yang	193,474	3.4	Asia - America - Europe (AWE-PDM)	113,078	3,032	2,797	2,899	39
			America - Europe - Asia (AMA)	25,548	3,330	2,966	3,194	8
			RTW West	25,173	2,797	2,797	2,797	9
Lykes	179,630	3.2	North Atlantic Sprint	160,611	2,409	1,914	2,033	79
			Gulf Atlantic Sprint	19,019	3,322	2,409	3,170	6
P&O Ned Lloyd	173,057		East Coast North America - MED - Far East (AEX)	102,514	3,424	2,952	3,106	33
			Pendulum Service (PAX)	18,998	2,714	2,714	2,714	7
NYK	152,823		East Coast North America - MED - Far East (AEX)	61,472	3,103	3,054	3,074	20
			Asia - West Coast North America (JCX)	35,118	2,977	2,500	2,701	13
			Pendulum Service (PAX)	21,586	3,152	2,547	2,698	8

Table 5.7. Main Container Operators, String Capacities, and Ship Sizes Calling at the Port of Charleston in 1998 (Lloyds, 1999)

CHARLESTON

Operator	Capacity	%	String	TEU Cap.	Max. Ship	Min. Ship	Avg. Ship	Calls
Maersk	797,188	20	Panama (TP3)	407,888	3,922	3,922	3,922	104
			Mediterranean - U.S. Gulf/Mexico	133,064	2,952	1,325	2,376	56
			Suez Express (SZX)	91,054	4,306	3,922	4,139	22
			Andean Europe Service	45,501	1,900	1,106	1,300	35
Sea-Land	716,994	18	North Europe - U.S. Atlantic	475,242	4,614	4,614	4,614	103
			Suez Express (SZX)	105,645	4,065	4,062	4,063	26
			North Asia Express (TP2)	79,004	2,829	2,816	2,822	28
Evergreen	408,034	10	RTW West	278,700	4,229	4,211	4,223	66
			RTW East	115,808	4,229	3,428	3,736	31
Lykes	345,132	9	Gulf Atlantic Sprint	329,259	3,322	2,409	3,077	107
			North Atlantic Sprint	15,873	2,409	1,914	2,268	7
MSC	274,617	7	North Europe - East Coast North America (SAS)	121,121	2,987	1,838	2,422	50
			North Europe - East Coast North America (NAS)	44,208	2,456	2,456	2,456	18
Cosco	240,370	6	Pendulum - Far East - Europe - ECNA	166,352	3,765	3,400	3,466	48
			North Europe - East Coast North America (TAS)	66,490	2,480	2,386	2,463	27
MOL	178,821	4	Asia - Panama - USEC (ECS)	141,021	2,914	2,118	2,612	54
			North Europe - Asia (CEX)	37,800	3,780	3,780	3,780	10
TMM	167,580	4	North Europe - U.S. Gulf	167,580	2,394	2,394	2,394	70
Atlantic Cargo	116,040	3	North Europe - East Coast North America	116,040	1,588	1,064	1,365	85
NYK	94,360	2	Pendulum Service (PAX)	37,824	3,152	3,152	3,152	12
			East Coast North America - MED - Far East (AEX)	30,736	3,103	3,054	3,074	10
Hapag-Lloyd	94,098	2	North Europe - U.S. Gulf	61,594	2,602	2,480	2,566	24
			East Coast North America - MED - Far East (AEX)	22,672	3,430	2,984	3,239	7
P&O Ned Lloyd	84,129	2	East Coast North America - MED - Far East (AEX)	55,685	3,424	2,952	3,094	18
			East Coast North America - West Coast South America	17,970	1,797	1,797	1,797	10

SUMMARY

NewYork/New Jersey and Charleston present different profiles to that of Houston. In addition to Northern Europe and Latin America, the Far East is an important trading region, (especially for New York) as well as services to the Mediterranean and onward through the Pendulum route to the Middle and Far East regions. In addition, round the world services provided in the Northern hemisphere together with pendulum services from key load centers [Central East Coast U.S. (CECUS), Mediterranean (MED), Far East (FE), West Coast U.S. (WCUS) services] characterize the larger North Atlantic ports.

Regarding ship sizes calling at the three ports, the highest percentage of containership calls at Houston is in the 500 to 1,500 TEU range, while that of New York and Charleston are in the 1,500 to 2,500 range. As already noted, Houston has a weekly liner service for a vessel over 3,500 TEUs (the Maersk service to North Europe), while New York and

Charleston have almost seven weekly calls of ships in this category, representing one a day. The number of large vessels calling at New York and Charleston is almost the same (359 to 360), which confirms that both ports are on the same string for these larger vessels (see Figure 3.2).

Of course, this may change once the mega-containerships are introduced into the North Atlantic. A multi-stage process might then be set in action, first using New York-New Jersey as the sole North Atlantic load center for such ships and then, a southern U.S. port load center as demand reaches levels that can sustain such vessels. At that time capacity would tend to shift to New York-New Jersey, which would then relay or transship containers onto other ports. Charleston still has the potential for load centering containers in the Southern Atlantic region but its throughput will be affected by the introduction of the mega-containerships calling at New York-New Jersey in ways that are difficult to predict at this time.

This chapter identified containership routes linking the North Atlantic and Gulf ports, which handle containers as part of a liner service. The previous chapter demonstrated the economies in vessel costs gained when size is increased, and this chapter showed that U.S. South Atlantic volumes, though substantial at a few key ports, are below those required for the operation of the largest ships. But might this change in the future as container demand grows? The next two chapters seek to answer that question by analyzing container demand in the region and using several scenarios to forecast future demand.

Chapter 6. Analyzing the Demand for Container Movements in the U.S. Gulf

INTRODUCTION

The growth in container movements in the last two decades is a derived demand, based on trading patterns between members of the global economy. In research report 1833-1, a section on international trade and maritime economics gave the arguments for both the growth and the changes in container demand. World trade is influenced by a range of factors, including comparative advantage (first identified by David Ricardo over 200 years ago), factor endowments, technological differences, and differences in taste. These are addressed in Appendix 1, which comments on international trade. There are also the issues of trade cycles and the interaction between local economies and the global system, which make it difficult to forecast growth over a prolonged period.

When evolving transportation strategies, policies, and investment levels (whether private or public), it must recognize that container movements are a system where both supply—reported in earlier chapters—and demand needed to be jointly considered. In the case of containership deployment, the economies of various sizes of ships, together with port and land transportation costs, need to be balanced against the numbers of containers moving through a region and the type of commodities carried.

So, how many container boxes move through North Atlantic U.S. and Gulf ports and what do they carry? In this chapter, all U.S. ports are considered with respect to container imports and exports; North Atlantic U.S. ports and U.S. Gulf ports are then examined in an effort to address issues now facing some Texas ports considering future container business.

DATA SOURCES

Because no individual source covers all aspects of the container movements required for this project, the researchers used several data sources to study container movements. The four main sources of data — the Sea Trade Database, the Containerization International Annual Book 2000, the Lloyd's of London Database, and data from the Port Import Export Reporting Service — are described below.

Sea Trade Database *(McCray, 1999)*

This database provides value, tonnage, commodity classification, U.S. port, and country of origin-destination data. Our analysis uses 1997 data with a commodity classification focused on U.S. Gulf ports using data provided by Professor John McCray of The University of Texas at San Antonio. This database does not include the number of TEUs, insofar as it is difficult to estimate TEUs given their variations in weight, value, and the percentage of empties by commodity and route.

Containerization International Annual Book 2000 *(Containerisation International, 2000)*

This useful annual contains data collected from a survey of ports and is published approximately 18 months in arrears. It is an important source of data that contains a brief description of the world containership fleet, containers under construction, liner company services, and their ship/schedule composition. The data are accurate, but have no route or market description, either by port or by liner company.

Lloyd's of London Database *(Lloyd's, 1999)*

The project team purchased an LMIS data set from Lloyd's of London, which provided information on containerships calling at U.S. Atlantic and Gulf ports, as well as their routes (string), during 1998 and 1999. These data are useful in studying route structure and port calls, including both the characteristics of the ships and their frequency of service. While the information provided by Lloyd's does not provide actual movement of TEUs loaded or unloaded at each port, it does give the TEU capacity of each ship calling at a U.S. Atlantic or Gulf port.

Port Import Export Reporting Service (PIERS) Data *(PIERS, 1999)*

PIERS is an information service provided by the *Journal of Commerce* and is a critical marketing tool for all containerports. It provides TEU movements through U.S. ports, country of origin and destination, value, and other characteristics. The port of Houston provided the research team with data regarding TEU movements in the South Atlantic and

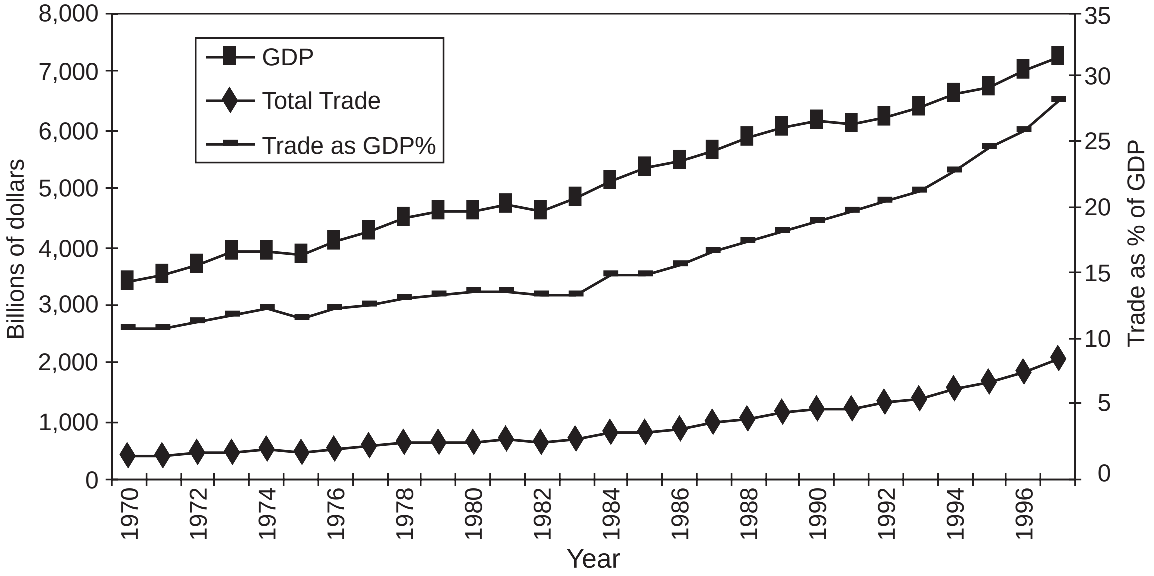
Gulf areas, with region of origin and destination from 1988 to 1998. It should be noted that these data are not completely accurate. In its collection of data, PIERS excludes certain types of shipments from its records and also uses several extrapolation methods to address gaps and other needs. The data from the Containerization International Annual records should always be higher than those reported in the PIERS data set (Nobles, 1999). The differences may be significant. PIERS reported a 1997 container movement for Houston of 607,000 TEUs, while the port itself reported 935,600 TEUs. Nonetheless, PIERS data are an important source used to estimate trends and trade patterns in TEUs with overseas countries or world regions.

U.S. FOREIGN TRADE

U.S. imports and exports have grown significantly in the last 30 years, as calculated either by evaluating the actual growth in both categories or by expressing total imports and exports as a percentage of the U.S. gross domestic product (GDP) of the U.S. Figure 6.1 gives the growth of U.S. exports and imports in terms of billions of dollars from 1960, while Figure 6.2 expresses it as a percentage of GDP. U.S. foreign trade now accounts for almost 30 percent of the GDP, whose rate of increase still appears to be strong (Office of Trade and Commerce Analysis, 1999).

Source: Office of Trade and Commerce Analysis, 1999

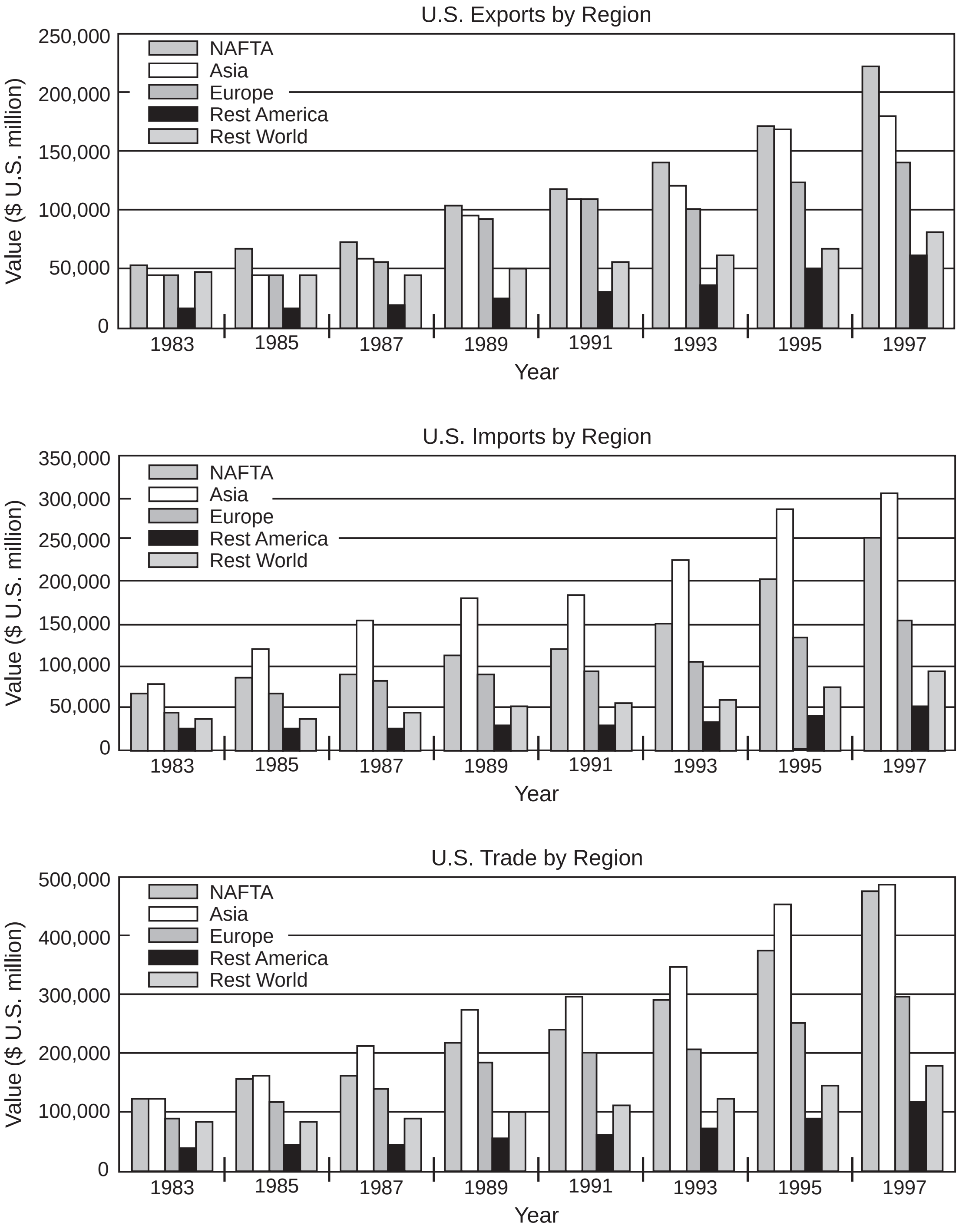
Figure 6.1. Growth of U.S. Exports and Imports Expressed in Billions of Dollars



Source: Office of Trade and Commerce Analysis, 1999

Figure 6.2. Growth of U.S. Exports and Imports Expressed as Percent of the GDP

Part of the increase in trade is related to the significant impact the North American Free Trade Agreement (NAFTA) has had (44 percent), although trade with other overseas countries is large and accounts for 56 percent of total U.S. trade. Of this sector, the most important areas are Asia (46 percent), Europe (28 percent), and Latin America (11 percent). These data are shown in Figure 6.3.



Source: Office of Trade and Economic Analysis, 1999

Figure 6.3. U.S. Exports, Imports, and Total Trade by Region 1983-1997

U.S. overseas trade is carried by water and air transportation systems, much of it now in containerized form. Container trade, since its introduction in the early 1960s, has grown substantially. In 1997, U.S. container trade reached 396 billion and 112 billion tons (Sea

Trade Database); this represents 37 percent of the U.S. foreign trade by value, as shown in Table 6.1.

Table 6.1. Exports, Imports, and Trade by Region (McCray, 1999)

IMPORTS

Name	Cont Value	Cont Weight	% Value	% Weight
North Atlantic	53,517,251,332	14,964,131,979	21	27
South Atlantic	29,344,651,525	8,409,174,526	11	15
Gulf	8,580,785,747	4,218,259,217	3	8
South Pacific	128,425,037,857	21,662,433,327	50	39
North Pacific	35,548,717,155	4,773,043,394	14	9
Great Lakes	352,273,161	178,690,554	0	0
Hawaii	114,262,569	60,767,403	0	0
Alaska	14,873,577	68,132,903	0	0
Puerto Rico-Pac. Islands	1,754,779,399	757,550,960	1	1
Total	257,652,632,322	55,092,184,263	100	100

EXPORTS

Name	Cont Value	Cont Weight	% Value	% Weight
North Atlantic	36,741,721,792	11,013,520,277	27	19
South Atlantic	29,242,709,443	12,225,728,803	21	21
Gulf	12,715,800,233	6,227,820,887	9	11
South Pacific	41,820,868,110	17,614,281,537	30	31
North Pacific	14,972,495,195	9,523,494,451	11	17
Great Lakes	1,319,197,805	287,492,025	1	1
Hawaii	36,618,997	61,473,970	0	0
Alaska	292,969,725	158,734,539	0	0
Puerto Rico-Pac. Islands	1,374,985,128	314,746,242	1	1
Total	138,517,366,428	57,427,292,731	100	100

ALL

Name	Cont Value	Cont Weight	% Value	% Weight
North Atlantic	90,258,973,124	25,977,652,256	23	23
South Atlantic	58,587,360,968	20,634,903,329	15	18
Gulf	21,296,585,980	10,446,080,104	5	9
South Pacific	170,245,905,967	39,276,714,864	43	35
North Pacific	50,521,212,350	14,296,537,845	13	13
Great Lakes	1,671,470,966	466,182,579	0	0
Hawaii	150,881,566	122,241,373	0	0
Alaska	307,843,302	226,867,442	0	0
Puerto Rico-Pac. Islands	3,129,764,527	1,072,297,202	1	1
Total	396,169,998,750	112,519,476,994	100	100

These figures suggest the importance of container movements in the growth of the U.S. economy. Most of this container trade is with the industrialized areas of Asia and Europe through key ports located in the Pacific and Atlantic regions, respectively. In 1997, South Pacific ports handled 44 percent of the container port and North Atlantic ports handled 23 percent. Container trade in the U.S. Gulf in 1997 amounted to around $21 billion (U.S.), accounting for around 2 percent of U.S. foreign trade and 5 percent of U.S. container trade. Table 6.1 reduces U.S. imports and exports by value and weight to continental locations in North America.

While monetary evaluation is necessary to place container trade within the context of the U.S. economy and its foreign trade performance; port operations, their revenues, and the impacts in terms of landside access are more focused on the numbers of containers being moved through the system. These containers have been standardized in terms of 20 foot equivalent units (TEUs), which breaks down the various container sizes into a standard unit which is 20 ft long, 8.5 ft high, and 8 ft wide.

Not surprisingly, most of the container trade is focused on regions in Asia and Europe and is reflected in the importance of both U.S. trade routes and world trade routes. Four countries handle almost 50 percent of the world container trade: the United States, China, Singapore, and Japan. Including the U.S., China, Singapore, and Japan, the top ten countries — which also include Taiwan, the United Kingdom, South Korea, the Netherlands, Germany, and Italy — account for over 65 percent of the world container movements.

It is difficult to discuss average dimensions for containers, insofar as they reflect a wide variety of characteristics. There are important variations per port owing to differences in commodities; different percentages of empty containers; the different percentages of 20 ft, 40 ft, and refrigerated containers; and how all of the above interact significantly on trade routes and even between directions. Not withstanding this caveat, the average value per container landed in Texas is around $16,300, with an average weight of 8.2 tons (McCray, 1999).

KEY U.S. CONTAINER PORTS

While there are several ways to classify the importance of a container port, it is customary to stress the movement of loaded containers in TEUs. Other methods of classification that are important to transportation analysts include the number of ship calls, the number of other ports on each ship’s route or string, the capacities of these ships, and the maximum size of ship currently serving the port. At this time, we concentrate on TEU throughput. Table 6.2, showing the latest data reported by Containerization International, underscores the importance of the West Coast ports in moving the flows of containers associated with that part of the U.S. economy trading with Pacific Rim countries. Associated with this analysis is the deployment of large containerships which, in the last few years, has focused almost entirely on the U.S. Pacific ports. This Pacific deployment has resulted in Long Beach and Los Angeles both overtaking New York/New Jersey in terms of container flows. To some degree, each of the top U.S. container ports has achieved the category of a load center, by which we mean that the port has a regional role in bringing in containers to the port in order to serve liner schedules. The variation in the size of load centers depends on the regional needs (which can include both industrial and consumer markets); the ability of the load center to serve national routes such as continental double stack land bridge traffic; and, finally, how the port is sited vis-à-vis the critical trade lanes in the world. In regard to the latter, Gulf ports are at a clear disadvantage because they lie well off the established world containerized maritime routes.

Table 6.2. TEU Throughput (in Millions) at Major North American Ports (1997-1999)

Port	1999	1998	1997
Long Beach	4.408	4.098	3.505
Los Angeles	3.829	3.378	2.960
New York/New Jersey	2.863	2.466	2.519
Oakland	1.664	1.575	1.531
Seattle	1.490	1.545	1.456
Charleston	1.483	1.278	1.151
Hampton Roads	1.307	1.252	1.233
Tacoma	1.271	1.156	1.143
Vancouver	1.070	0.840	0.724
Houston	1.007	0.968	0.936
Montreal	0.993	0.933	0.870

Source:
Containerization International, 2001 and 2000.

In the Atlantic and Gulf area, the load centers are New York/New Jersey, Hampton Roads, Charleston, Houston, and Miami. Using Lloyd's data, which is given in Table 6.3 and shows the number of container arrivals at each port, the researchers calculated the average size of the ship in TEUs and finally the total ship capacity in TEUs for the port (by multiplying number of arrivals times average size).

Table 6.3. Containership Movements over the U.S. North Atlantic and Gulf Regions in 1998 (Lloyd’s, 1999)

Name	**Area**	**Arrivals**	**Average Ship TEU**	**Total Ship Capacity in TEU**
New York	USA	2,294	2,484	5,690,975
Charleston	USA	1,519	2,687	4,080,818
Norfolk	USA	1,553	2,398	3,720,031
Houston	USG	1,050	1,666	1,746,116
Miami	USA	1,074	1,409	1,456,578
Savannah	USA	649	2,186	1,418,505
Baltimore	USA	591	2,153	1,272,651
Port Everglades	USA	1,365	921	1,210,687
Jacksonville	USA	713	1,304	928,669
New Orleans	USG	469	1,615	757,405
Philadelphia	USA	639	1,105	703,999
Wilmington (NC)	USA	194	2,548	494,226
Boston	USA	130	2,937	381,845
Mobile	USG	105	1,163	122,087
Palm Beach	USA	166	494	81,931
Freeport (Texas)	USG	105	737	77,417
Fernandina	USA	64	753	48,216
Galveston	USG	26	1,796	46,708
Brunswick	USA	30	1,345	40,348
Lake Charles	USG	69	549	37,905
Gulfport	USG	65	486	31,606
Bermuda	USA	83	302	25,042
Tampa	USG	31	508	15,757
Port Arthur	USG	12	1,239	14,870
Eastport	USA	8	1,426	11,407
New Haven	USA	8	872	6,976
Annapolis Anch.	USA	3	1,977	5,931
Corpus Christi	USG	4	1,224	4,895
Texas City	USG	2	1,672	3,344
Providence	USA	2	1,244	2,487
Pascagoula	USG	2	1,072	2,143
Beaumont	USG	4	523	2,092
Portland(Me)	USA	1	1,810	1,810
Panama City	USG	1	1,708	1,708
Brownsville	USG	4	411	1,644
Delaware Bay	USA	1	1,472	1,472
Morehead City	USA	1	1,344	1,344
Montauk light. area	USA	1	1,334	1,334
Florida	USG	4	273	1,090
Texas	USG	1	510	510
New Jersey	USA	3	164	493
New London	USA	1	386	386
Georgetown (SC)	USA	1	380	380
Pensacola	USG	1	188	188
Salem (Mass)	USA	1	180	180

The port ranking is New York/New Jersey, Norfolk, Charleston, Houston, Miami, and Port Everglades. Of greatest interest to this report is the average ship size, which shows remarkable differences. Ports that are linked to long-distance markets (New York, Charleston, and Norfolk) have ships that are substantially larger than those linked to smaller markets (Houston, Miami, and Port Everglades). The change in ship size for these ports merely reflects the appropriate efficiencies that can be achieved on many of the routes that these ports serve. Where route distances are relatively short, commodities are relatively timeinsensitive, and ports on the string are relatively small or technologically unable to serve large vessels, more efficient, smaller vessels make sense. Strategically, the operation of smaller, efficient containerships makes perfect sense when considering the implications of the introduction of mega-containerships. As already noted, such ships will call infrequently to regional load centers, which must consequently be served by smaller but highly efficient containerships. It is therefore important to stress that efficiencies can be gained at all levels of ship size and that specific efficiencies are based on route, commodity, and service characteristics.

U.S. GULF CONTAINERIZED TRADE AND COMMODITIES

Analysis of a variety of characteristics related to the Gulf are given in Tables 6.4 and 6.5. Table 6.4 provides a regional breakdown of container flows through key North Atlantic and Gulf ports in 1998. Table 6.5 provides a schedule of containership arrivals and their average TEU capacity for Texas ports in the same year. It can be seen that Gulf container movement is a highly concentrated market with two ports accounting for almost 90 percent of the regional movement. Gulf container movement is clearly dominated by the Port of Houston, with over 60 percent of the total container value and container movements passing through this authority, followed by New Orleans, with over 20 percent of TEU movements and value. Other Texas ports include Galveston and Freeport, which each account for around 2 percent of Gulf container trade. Again, it should be noted that this is the current data flow and that opportunities for increasing trade in container movements through other Texas ports remain a distinct possibility. This increased trade will be based on liner services of large containerships load centering outside the Gulf, the growth of regional container movements centered through Texas, and other intermodal opportunities such as the movement of containers on GIWW barges.

Table 6.4. Container Flows through North Atlantic and Gulf, Gulf, and Texas Ports (PIERS, 1999)

NORTH ATLANTIC & GULF

Port Name	TEUs
Charleston	950,950
Miami	613,544
Houston	607,617
Port Everglades	436,573
New Orleans	230,332
Jacksonville	195,209
Gulfport	119,734
W. Palm Beach	89,913
Freeport (TX)	29,519
Lake Charles	26,634
Mobile	13,060
Tampa	10,759
Manatee	10,759
Galveston	7,186
Pascagoula (MS)	2,015
Gramercy (LA)	1,007
Brownsville	292
Corpus Christi	168
Orange	12
Baton Rouge	9
Panama City (FL)	8
Port Arthur	2
Total	3,345,302

GULF

Port Name	TEUs
Houston	607,617
New Orleans	230,332
Gulfport	119,734
Freeport (TX)	29,519
Lake Charles	26,634
Mobile	13,060
Tampa	10,759
Manatee	10,759
Galveston	7,186
Pascagoula (MS)	2,015
Gramercy (LA)	1,007
Brownsville	292
Corpus Christi	168
Orange	12
Baton Rouge	9
Panama City (FL)	8
Port Arthur	2
Total	1,059,113

TEXAS

Port Name	TEUs
Houston	607,617
Freeport	29,519
Galveston	7,186
Corpus Christi	168
Brownsville	168
Orange	12
Port Arthur	2
Total	644,672

Table 6.5. Containership Arrivals at Texas Ports in 1998 (Lloyd's, 1999)

Name	Area	Arrivals	TEU Average	Sum TEU
Houston	USG	1,050	1,666	1,746,116
New Orleans	USG	469	1,615	757,405
Mobile	USG	105	1,163	122,087
Freeport	USG	105	737	77,417
Galveston	USG	26	1,796	46,708
Lake Charles	USG	69	549	37,905
Gulfport	USG	65	486	31,606
Tampa	USG	31	508	15,757
Port Arthur	USG	12	1,239	14,870
Corpus Christi	USG	4	1,224	4,895
Texas City	USG	2	1,672	3,344
Pascagoula	USG	2	1,072	2,143
Beaumont	USG	4	523	2,092
Panama City	USG	1	1,708	1,708
Brownsville	USG	4	411	1,644
Florida	USG	4	273	1,090
Texas	USG	1	510	510
Pensacola	USG	1	188	188
Total				2,867,485

Commodities in the Gulf are shown in Table 6.6. Gulf imports and exports have the lowest value per TEU in the U.S. at $16,300 per TEU.

Table 6.6. Gulf Commodities, by Export and Import, Moved by Container in 1997 (McCray, 1999)

GULF EXPORTS

Description	Value Container	Weight Container
CHEMICAL OR ALLIED INDUSTRY PRODUCTS	2,997,077,168	1,411,847,355
MACHINERY AND MECHANICAL APPLIANCES	2,639,421,889	306,683,220
PLASTIC AND RUBBER PRODUCTS	2,053,410,130	1,605,073,107
WOOD, PULP, FURNITURE, AND PAPER PRODUCTS	665,671,374	772,881,825
ELECTRICAL MACHINERY AND EQUIPMENT	605,395,833	51,787,765
METAL PRODUCTS	595,858,197	226,619,188
VEHICLES, AIRCRAFT, AND VESSELS	488,346,041	52,177,609
TEXTILE PRODUCTS	439,076,328	197,350,343
INSTRUMENTS	404,159,412	12,159,416
FOOD	375,975,913	474,008,211
AGRICULTURAL PRODUCTS	361,286,682	376,937,587
APPAREL	350,669,876	76,616,917
MINERAL PRODUCTS	255,989,937	425,531,842
OTHER PRODUCTS	167,269,955	28,219,688
STONE, CERAMIC, AND GLASS PRODUCTS	136,017,778	127,055,627
SKINS AND LEATHER	69,635,307	14,667,910

GULF IMPORTS

Description	Value Container	Weight Container
MACHINERY AND MECHANICAL APPLIANCES	1,378,713,556	174,660,819
AGRICULTURAL PRODUCTS	1,307,414,379	1,224,005,613
CHEMICAL OR ALLIED INDUSTRY PRODUCTS	1,202,146,618	454,987,191
METAL PRODUCTS	893,917,552	595,679,314
APPAREL	877,829,652	93,750,189
FOOD	608,263,247	404,197,526
PLASTIC AND RUBBER PRODUCTS	543,248,859	282,286,831
WOOD, PULP, FURNITURE, AND PAPER PRODUCTS	479,986,380	420,048,237
OTHER PRODUCTS	301,688,391	63,880,261
ELECTRICAL MACHINERY AND EQUIPMENT	275,649,885	30,999,318
VEHICLES, AIRCRAFT, AND VESSELS	248,557,471	30,602,927
STONE, CERAMIC, AND GLASS PRODUCTS	240,772,116	289,262,295
TEXTILE PRODUCTS	97,631,073	30,795,258
INSTRUMENTS	70,991,859	4,207,149
SKINS AND LEATHER	25,202,467	3,062,395
MINERAL PRODUCTS	24,776,125	94,358,097

As a comparison, TEU value in the South Pacific is almost double that figure, which is driven by electronic products and time-sensitive commodities. The key Gulf commodities currently being moved by container include chemical and associated products, plastics, and rubber products (with over 30 percent of the value in weight), which together reflect the importance of the chemical and petrochemical industry in the Texas Gulf region. Machinery, composed of electrical and mechanical commodities, is also critical and accounts for around 23 percent by value, although only comprising 6 percent by weight. These figures confirm the observation that Atlantic time-sensitive products on route to regions served by the Texas Gulf ports are generally off-loaded earlier on the route string. This finding suggests that time-sensitive products are being off-loaded at New York/New Jersey and at other ports such as Charleston/Savannah for either double stack or truck movement to Texas industries and markets. Much of the commodities passing through the Port of Houston are moving to the Houston industrial area, which reflects the importance of petrochemical and heavy industrial machinery. Again, these are not time-sensitive products. Commodities from Latin America, which may be transshipped at other ports such as Freeport in the Bahamas, may include time-sensitive materials that have no alternative, faster schedule.

Chapter 7. Forecasting Scenarios

In this chapter, Gulf container trade is further evaluated and current flows form a basis for forecasting likely demand over a twenty-year horizon. This evaluation has to be done with great care because many assumptions have to be made. The use of assumptions means that precise estimates cannot be made. Rather, the process is focused on predicting likely orders of magnitude based on the performance of the world economy. The forecasting is based on three scenarios developed from current flows on Gulf Coast routes. Finally, some conclusions are drawn on both container growth and the potential deployment of mega-containerships on Gulf container routes.

GULF AND SOUTH ATLANTIC BACKGROUND

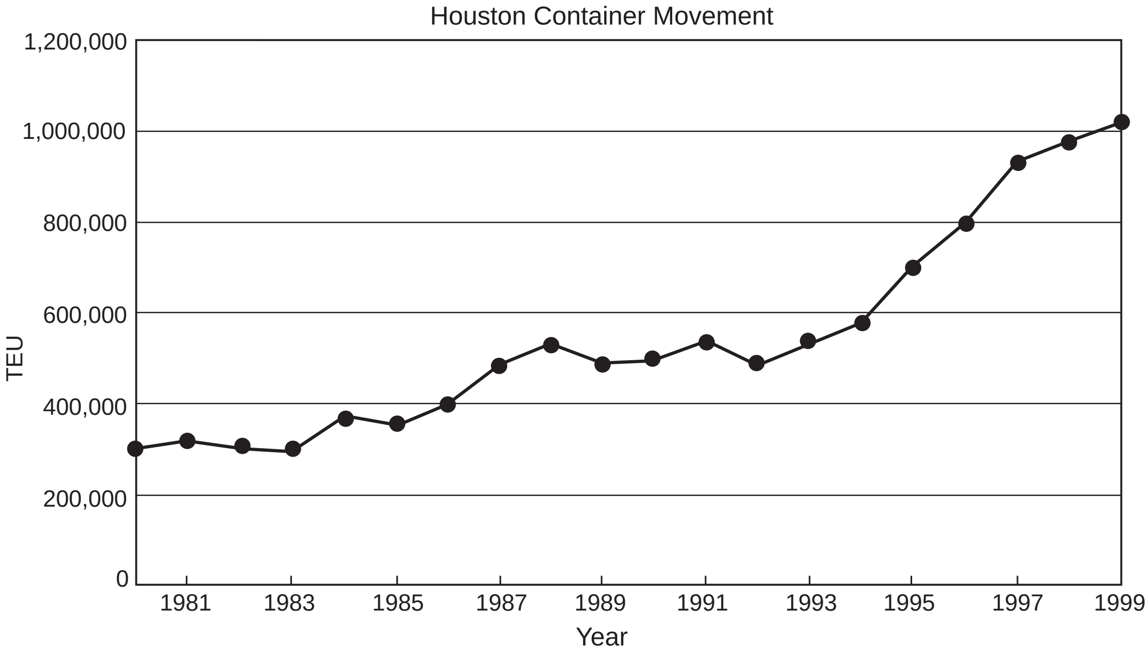
The status of containerports in the global market is changing together with the traditional concept of what constitutes a hinterland. Global alliances and door-to-door logistics give the shipping companies a varied choice of ports of call (Slack, 1993). An analysis of trends is undertaken at a multi-regional level (South Atlantic and Gulf) for the following reasons:

a. routing is based on a region to region demand basis;
b. changes at port level may be pronounced due to strong interport competition, changes in ship routing, new terminals, and rail connections;
c. the regional analysis shows a general trend where the impacts at port level are mitigated in the sum of the individual effects; and
d. most of the long distance routes (strings) that call at the Gulf also call at South Atlantic ports.

During 1998, the south Atlantic grew faster (9.2 percent) than the Gulf (5.8 percent) and Texas ports (5.3 percent) as shown in Table 7.1. Houston, the main containerport on the Texas Gulf has experienced periods of negative, slow, and fast growth during the last twenty years as shown in Figure 7.1. The average annual growth rate for the period of 1980 to 1998 was 6.7 percent with a boom from 1994 onward shown in an average annual growth rate of almost 14 percent for the period of 1994-1998. Table 7.2 shows the demand for container moves in the years of 1988 and 1998. The table has three elements. The first element gives information for the South Atlantic and Gulf ports, the second element for Gulf ports, and the final element for Texas ports alone. For each of these groups, an average annual growth rate is calculated together with the market shares in 1988 and 1998 and TEUs lifted in 1988 and 1998.

Table 7.1. Average Annual Growth for Containerports

Year	Total	South Atlantic	Gulf	Texas
1988	1,550,954	947,457	603,497	386,147
1989	1,659,595	1,063,454	596,141	374,269
1990	1,773,364	1,128,005	645,359	403,982
1991	1,863,604	1,215,498	648,106	405,445
1992	2,050,577	1,342,829	707,748	420,052
1993	2,189,143	1,423,506	765,637	453,157
1994	2,407,158	1,601,028	806,130	469,273
1995	2,715,288	1,846,596	868,692	511,697
1996	2,816,938	1,927,932	889,006	534,531
1997	3,244,543	2,246,202	998,341	605,184
1998	3,345,302	2,286,189	1,059,113	644,672
Average Annual Growth	**8.0%**	**9.2%**	**5.8%**	**5.3%**



Source: Port of Houston, 2000

Figure 7.1. Houston Container Movement During the Last 20 Years

Table 7.2. Demand for Container Moves in 1988 and 1998 (PIERS, 1999)

SOUTH ATLANTIC + GULF

Region	Average Annual Growth (%)	1998 Market (%)	1988 Market (%)	1988 TEUs	1998 TEUs
North Europe	5.4	24.5	31.2	484,141	820,938
Central America	12.4	19.3	13.0	201,408	646,478
East Coast South America	13.2	12.6	7.8	121,732	421,639,4
Caribbean	8.9	12.1	11.1	172,234	403,578
Northeast Asia	0.4	7.5	15.6	242,240	251,053
West Coast South America	15.0	7.2	3.9	59,789	242,002
Mediterannean	5.7	7.0	8.7	134,294	233,384
Southeast Asia	8.0	3.0	3.0	46,857	101,627
Africa	12.5	2.2	1.5	23,156	74,985
Middle East	8.7	2.1	2.0	30,326	69,713
Other Asia	20.9	1.7	0.5	8,487	56,410
Oceania	-1.1	0.7	1.7	26,290	23,495
Total	8.0	100.0	100.0	1,550,954	3,345,302

GULF

Region	Average Annual Growth (%)	1998 Market (%)	1988 Market (%)	1988 TEUs	1998 TEUs
North Europe	4.2	34.2	40.0	241,225	362,463
Central America	9.4	27.2	19.5	117,800	288,544
East Coast South America	11.6	10.1	5.9	35,614	106,513
Caribbean	10.6	3.7	2.4	14,462	39,576
Northeast Asia	-16.4	0.7	7.3	44,114	7,339
West Coast South America	13.3	6.2	3.1	18,863	65,689
Mediterannean	3.2	8.8	11.2	67,455	92,824
Southeast Asia	3.2	0.5	0.7	4,238	5,8111
Africa	5.4	3.1	3.2	19,190	32,404
Middle East	4.6	3.3	3.7	22,218	34,912
Other Asia	7.5	0.9	0.8	4,726	9,731
Oceania	-0.2	1.3	2.3	13,592	13,307
Total	5.8	100.0	100.0	603,497	1,059,113

TEXAS

Region	Average Annual Growth (%)	1998 Market (%)	1988 Market (%)	1988 TEUs	1998 TEUs
North Europe	4.4	43.5	47.2	182,341	280,251
Central America	6.3	8.2	7.4	28,499	52,663
East Coast South America	14.3	12.7	5.6	21,496	81,780
Caribbean	21.5	3.3	0.8	3,023	21,269
Northeast Asia	-19.9	0.7	10.7	41,493	4,513
West Coast South America	14.3	7.0	3.1	11,792	44,812
Mediterannean	3.6	12.2	14.2	54,854	78,395
Southeast Asia	3.4	0.7	0.8	3,160	4,402
Africa	8.9	4.2	3.0	11,466	26,877
Middle East	4.6	4.3	4.5	17,548	27,597
Other Asia	9.3	1.4	1.0	3,678	8,956
Oceania	6.8	2.0	1.8	6,797	13,157
Total	5.3	100.0	100.0	386,147	644,672

The tables show a number of interesting trends. Northeast Asia has lost market share and had negative or little growth, probably as a result of the growth of the U.S. double stack land bridge and mini-bridge operations. Trade growth with Europe, the Mediterranean, and Middle East has been growing at a comparatively modest rate of around 5 percent. This growth may reflect the maturity of the container and trade markets between the developed countries in Europe and the U.S. and it may also reflect the relatively modest performance of the European Union countries in terms of economic growth in the period 1995 to 1998.

Finally, trade with Latin America and the Caribbean has gained market share from 1988 to 1998 and has had an important impact on container movements in the region, exhibiting over a 10 percent annual growth. This figure may simply reflect the early stages of container development in this region, and may not be sustainable at this rate unless there are new economic incentives and strong growth in the Latin American and Caribbean markets.

Exports and imports between the major world regions and two Atlantic regions (the first South Atlantic and Gulf ports and the second Texas ports alone) show some interesting aspects as the data in Tables 7.3 and 7.4 demonstrate. These data show that exports are more important than imports, Europe and the Mediterranean show modest growth rates and a relatively balanced trade between exports and imports, while the rest of the regions show important imbalances especially in South America and the Caribbean, which are particularly significant.

FORECASTING SCENARIOS

Scenarios were developed to analyze how different demand levels, routes, and ship costs might affect future Gulf containership operations. It was not the intention of the team to establish an accurate forecast of container flows in the Gulf markets. Rather, the idea was to look at three levels of demand which were termed “pessimistic, normal, and optimistic,” over a twenty year planning horizon, broken into five-year increments. Details on the approach, together with tables of projected TEU volumes by region (South Atlantic, Gulf, and Texas) and route are given in Appendix 3. Scenarios involving South Atlantic and the Gulf, the Gulf, and Texas ports (similar to Table 7.2) were developed to address the demand. Given the problem of identifying variables, collecting information from the various shipping and logistics sources and addressing a wide range of uncertainties over this period of time, it was decided to analyze three different demand levels. These demand levels would show a slowing down in container moves (pessimistic), the maintenance of modest growth (normal), and sustaining strong growth (optimistic). The team recognizes that there are issues related to how alliances may concentrate cargo into larger ships and reduce the number of port calls and how there is an interrelationship between the shipping variables of string composition, ship size, ship speed and numbers, and service frequencies. There is also the additional challenge of examining the growth of relays or transshipments versus direct calls, which addresses the route distance, number of port calls, and the time sensitivity of cargos in the markets. It is worth recalling that the Gulf lies off of the main container routes of the North and South Atlantic and is generally at the end of the current routes, or strings. This position has implications for both shipload and channel depth. The Gulf is also a significant distance from other important South Atlantic ports; for example, it is a 2 to 3 day trip each way between Charleston and Houston. When one considers the chartering costs of modern large containerships, which can be in the range of $20,000 to $30,000 a day, one can see that this cost has strong implications on route structure for the Gulf ports.

Table 7.3. South Atlantic and Gulf Regions Exports and Imports (PIERS, 1999)

South Atlantic and Gulf

		Exports		**Imports**		**Total**	
Region	**Year**	**Average Annual Growth (%)**	**TEUs**	**Average Annual Growth (%)**	**TEUs**	**TEUs**	**Trade Balance (%)**
North Europe	1988	5.6	259,589	5.3	224,552	484,141	7.2
	1998		446,345		374,593	820,938	8.7
Centeral America	1988	14.8	82,672	10.3	118,736	201,408	-17.9
	1998		328,945		317,533	646,478	1.8
East Coast South America	1988	18.1	57,778	6.1	63,954	121,732	-5.1
	1998		305,711		115,928	421,639	45.0
Caribbean	1988	8.6	144,043	10.5	28,191	172,234	67.3
	1998		327,357		76,221	403,578	62.2
Northeast Asia	1988	-1.3	154,992	2.8	87,248	242,240	28.0
	1998		136,448		114,605	251,053	8.7
West Coast South America	1988	19.2	28,004	9.6	31,785	59,789	-6.3
	1998		162,324		79,678	242,002	34.2
Mediterannean	1988	4.7	63,650	6.5	70,644	134,294	-5.2
	1998		100,430		132,954	233,384	-13.9
Southeast Asia	1988	7.6	24,177	8.5	22,680	46,857	3.2
	1998		50,116		51,511	101,627	-1.4
Africa	1988	11.2	18,210	16.2	4,946	23,156	57.3
	1998		52,793		22,192	74,985	40.8
Middle East	1988	9.2	24,479	6.2	5,847	30,326	61.4
	1998		59,040		10,673	69,713	69.4
Other Asia	1988	12.8	5,416	28.7	3,071	8,487	27.6
	1998		18,047		38,363	56,410	-36.0
Oceania	1988	2.5	15,243	-9.6	11,047	26,290	16.0
	1998		19,488		4,007	23,495	65.9
Total	1988	8.6	878,253	7.1	672,701	1,550,954	13.3
	1998		2,007,044		1,338,258	3,345,302	20.0

Table 7.4. Texas Exports and Imports (PIERS, 1999)

Texas

		Exports		Imports		Total	
Region	**Year**	**Average Annual Growth (%)**	**TEUs**	**Average Annual Growth (%)**	**TEUs**	**TEUs**	**Trade Balance (%)**
North Europe	1988	3.4	103,680	5.6	78,661	182,341	13.7
	1998		145,115		135,136	280,251	3.6
Centeral America	1988	19.3	9,781	7.8	11,715	21,496	-9.0
	1998		56,935		24,845	81,780	39.2
East Coast South America	1988	2.8	25,829	4.3	29,025	54,854	-5.8
	1998		34,104		44,291	78,395	-13.0
Caribbean	1988	14.1	6,330	2.7	22,169	28,499	-55.6
	1998		23,734		28,929	52,663	-9.9
Northeast Asia	1988	13.9	9,291	15.5	2,501	11,792	57.6
	1998		34,218		10,594	44,812	52.7
West Coast South America	1988	5.7	14,404	-2.3	3,144	17,548	64.2
	1998		25,100		2,497	27,597	81.9
Mediterannean	1988	8.1	9,693	12.7	1,773	11,466	69.1
	1998		21,027		5,850	26,877	56.5
Southeast Asia	1988	21.3	2,557	23.0	466	3,023	69.2
	1998		17,568		3,701	21,269	65.2
Africa	1988	6.0	5,738	10.5	1,059	6,797	68.8
	1998		10,292		2,865	13,157	56.4
Middle East	1988	7.6	2,633	12.8	1,045	3,678	43.2
	1998		5,461		3,495	8,956	22.0
Other Asia	1988	-22.7	36,260	-10.3	5,233	41,493	74.8
	1998		2,758		1,755	4,513	22.2
Oceania	1988	4.9	2,599	-9.1	561	3,160	64.5
	1998		4,187		215	4,402	90.2
Total	1988	5.2	228,795		157,352	386,147	18.5
	1998		380,499	5.3	264,173	644,672	18.0

NORTH ATLANTIC CONTAINER ROUTES

The Lloyd's databases from 1998 and 1999 were evaluated to identify the major container routes present on the U.S. Atlantic seaboard. As established in previous sections of this chapter, three components were identified. The first, a general group covering all Atlantic ports; a second, narrower category composed of Gulf ports; and finally, a category specifically related to Texas ports. In this way, it is possible to identify differences between the three categories and it is hoped that this will assist TxDOT planners in their understanding of container flows through Texas ports. Six route categories were identified, which were used for all three groups. These are:

a. U.S.-Northern Europe (USG-NEU);
b. U.S.-Mediterranean-Middle East-Southeast Asia (MED-ME-FE-AF)—including subcategory of Gulf-Mediterranean-Africa;
c. U.S. West Coast-Northeast Asia-Southeast Asia-Oceania (USWC-FE-OC);

d. U.S.-Caribbean and Central America (CAR-CAM);
e. U.S.-South American West Coast (WCSA); and finally
f. U.S.-South America East Coast (ECSA).

There are three routes to the Far East, eastbound through the Suez Canal, westbound through Panama, and westbound using a land bridge or mini bridge linking the U.S. East and West Coasts.

Table 7.5 shows some of the characteristics for the six Atlantic containership routes in terms of distance, restrictions, and port infrastructure. For each of the six routes, some qualitative characteristics are given. On the first route, the biggest ships are most efficient, even though the distance is not particularly long. For the second route, this again attracts larger ships, possibly in some form of pendulum route, which can be deployed through the Mediterranean to the Far East. On the third route, there are lock restrictions on the Panama Canal, which limit ship size and, at times, also limit the weight of the ship (due to scarcity of water). For this market, the double stack land bridge creates effective competition and has a substantial market share. In the fourth category, the route is short and comprises multiple port service calls, which suggests the suitability of much smaller ships. Routes in category five are limited by the port infrastructure in South America and are also limited by medium distance, so a medium to small ship can be very effective in providing liner services. Finally, in category six there are restrictions again from the Panama Canal that limit size.

Table 7.5. Characteristics for Six Atlantic Containership Routes

Route	Demand	Distance	Restrictions	Port Infrastructure	Other Characteristics
1. USG-NEU	High	Medium	–	Good	–
2. MED-ME-FE-AF	Medium	Long	–	Good[1]	Important transshipment ports on the route
3. USWC-FE-OC	Important	Long	Panama Canal	Good	Landbridge reduces demand for sea route
4. CAR-CAM	Potentially High	Short	–	Poor	–
5. WCSA	Potentially High	Medium	Panama Canal	Poor	–
6. ECSA	Potentially High	Medium	–	Poor	–

Note: [1]Except for African ports, which are generally poor.

Scenarios for the three groups were developed based on PIERS data, supplied by the Port of Houston. For each of the major categories- South Atlantic, Gulf, and Texas- the same world regional markets used in earlier tables are employed. For each of the major groups, three growth categories are used and comprise pessimistic, normal, and optimistic scenarios. Using the PIERS data, different rates of growth are employed for each of the world markets and these are then applied over a 20 year time period, which is split into 5 year time periods. Details on these tables are given in Appendix 3 and summarized in Tables 7.6-7.8.

The output is in TEU per route and some conclusions can be drawn about the likely use of larger ships. If the South Atlantic ports are regarded as a group (Table 7.6), it can be seen that total TEU demand rarely reaches the levels that are normally associated with the mega-containerships. Only in routes 1 and 2 are the numbers of a sufficient level to attract the interest of maritime companies offering liner services using the largest ships. If such a liner service is offered, it will be done through a load center, with the most likely site being New York/New Jersey. The Caribbean and Central American markets have substantial TEU volumes but as already described, they are unlikely to be served through load centers and are the result of high call frequencies and high service characteristics by a large number of smaller liner vessel schedules. Now, moving specifically to Texas (Table 7.8), we observe that even with a normal growth rate, the numbers are hardly likely to attract mega-containership liner service. Even in the most optimistic scenario, it is only in the 15 to 20 year period that there is the likelihood of serving very large containerships over the European and Mediterranean routes.

Table 7.6. South Atlantic/Gulf Container Routes under Three Different Forecasting Scenarios

Pessimistic

ROUTES	PLANNING HORIZON			
	5 years	**10 years**	**15 years**	**20 years**
1 NEU	906,382	1,000,719	1,104,874	1,219,871
2 MED-ME-ASIA-AF-OC	617,859	682,166	753,167	831,557
3 USWC-ASIA-OC	477,609	527,319	582,202	642,799
4 CAR-CAM	1,159,347	1,280,012	1,413,237	1,560,328
5 WCSA	267,190	294,999	325,703	359,602
6 ECSA	465,524	513,976	567,471	626,533

Normal

ROUTES	PLANNING HORIZON			
	5 years	**10 years**	**15 years**	**20 years**
1 NEU	998,797	1,215,189	1,478,463	1,798,776
2 MED-ME-ASIA-AF-OC	680,856	828,365	1,007,833	1,226,183
3 USWC-ASIA-OC	526,306	640,331	779,061	947,847
4 CAR-CAM	1,277,554	1,554,339	1,891,092	2,300,802
5 WCSA	294,432	358,222	435,832	530,256
6 ECSA	512,988	624,129	759,348	923,863

Optimistic

ROUTES	PLANNING HORIZON			
	5 years	**10 years**	**15 years**	**20 years**
1 NEU	1,098,600	1,470,175	1,967,426	2,632,859
2 MED-ME-ASIA-AF-OC	748,890	1,002,183	1,341,148	1,794,758
3 USWC-ASIA-OC	578,896	774,694	1,036,715	1,387,359
4 CAR-CAM	1,405,212	1,880,490	2,516,520	3,367,672
5 WCSA	323,853	433,389	579,972	776,133
6 ECSA	564,248	755,091	1,010,482	1,352,253

Table 7.7. Gulf Container Routes under Three Different Forecasting Scenarios

	Pessimistic			
ROUTES	**PLANNING HORIZON**			
	5 years	**10 years**	**15 years**	**20 years**
1 NEU	400,188	441,840	487,827	538,601
2 MED-ME-ASIA-AF-OC	208,659	230,377	254,354	280,828
3 USWC-ASIA-OC	39,954	44,113	48,704	53,773
4 CAR-CAM	362,271	399,976	441,606	487,569
5 WCSA	72,526	80,075	88,409	97,610
6 ECSA	117,599	129,839	143,352	158,273

	Normal			
ROUTES	**PLANNING HORIZON**			
	5 years	**10 years**	**15 years**	**20 years**
1 NEU	440,992	536,534	652,775	794,201
2 MED-ME-ASIA-AF-OC	229,934	279,750	340,359	414,098
3 USWC-ASIA-OC	44,028	53,567	65,173	79,292
4 CAR-CAM	399,208	485,698	590,926	718,951
5 WCSA	79,921	97,236	118,302	143,933
6 ECSA	129,589	157,665	191,824	233,383

	Optimistic			
ROUTES	**PLANNING HORIZON**			
	5 years	**10 years**	**15 years**	**20 years**
1 NEU	485,057	649,116	868,664	1,162,468
2 MED-ME-ASIA-AF-OC	252,910	338,451	452,923	606,113
3 USWC-ASIA-OC	48,428	64,807	86,727	116,060
4 CAR-CAM	439,099	587,613	786,359	1,052,325
5 WCSA	87,907	117,639	157,428	210,674
6 ECSA	142,538	190,749	255,265	341,602

Table 7.8. Texas Container Routes under Three Different Forecasting Scenarios

	Pessimistic			
ROUTES	**PLANNING HORIZON**			
	5 years	**10 years**	**15 years**	**20 years**
1 NEU	309,420	341,624	377,181	416,438
2 MED-ME-ASIA-AF-OC	175,973	194,288	214,510	236,836
3 USWC-ASIA-OC	34,257	37,823	41,760	46,106
4 CAR-CAM	81,627	90,123	99,503	109,859
5 WCSA	49,476	54,626	60,311	66,588
6 ECSA	90,292	99,689	110,065	121,521

	Normal			
ROUTES	**PLANNING HORIZON**			
	5 years	**10 years**	**15 years**	**20 years**
1 NEU	340,968	414,840	504,716	614,064
2 MED-ME-ASIA-AF-OC	193,915	235,927	287,042	349,230
3 USWC-ASIA-OC	37,750	45,929	55,880	67,986
4 CAR-CAM	89,950	109,437	133,147	161,994
5 WCSA	54,521	66,333	80,704	98,189
6 ECSA	99,498	121,054	147,281	179,190

	Optimistic			
ROUTES	**PLANNING HORIZON**			
	5 years	**10 years**	**15 years**	**20 years**
1 NEU	375,039	501,887	671,638	898,803
2 MED-ME-ASIA-AF-OC	213,292	285,432	381,973	511,166
3 USWC-ASIA-OC	41,522	55,566	74,360	99,511
4 CAR-CAM	98,938	132,401	177,182	237,110
5 WCSA	59,969	80,251	107,395	143,718
6 ECSA	109,440	146,456	195,991	262,280

SPECIFIC ROUTES FOR POST PANAMAX AND MEGA-CONTAINERSHIPS

Becasue large containerships were an important focus of this TxDOT study, the team examined the likelihood of large ships over the route network of the Gulf and found that the likelihood for use would be on the Northern European and Mediterranean services as already identified. Currently the biggest ships that call regularly at Gulf ports go to Northern Europe and the ports along that string are likely to grow in the future. While this may be appropriate for a Post Panamax vessel—say 4,500 TEUs traveling at 25 knots—a mega-containership will only call once or twice in the North and Central Atlantic area if it is to maintain efficiencies gained from economies of scale.

The second route, which is the Atlantic through the Mediterranean and on to the Far East, is the pendulum route, which was the first to deploy the largest containerships. The possibility of connecting to one of the world's highest volume container routes with important transshipment ports in the Eastern Mediterranean (Algeciras), Western Mediterranean (Gioa Tauro), Middle East (Dubai), Singapore, and Hong Kong. But, there is little traffic (particularly time sensitive commodities) that comes via the Gulf to these areas because of the effectiveness of the double stack rail bridge linking the ports of New York/New Jersey with L.A./Long Beach on the U.S. West Coast. Unless the Panama Canal successfully widens the locks, the usefulness to the larger vessels may be limited in the near future, which effectively disbars route categories three and six from the potential large containership use. Plans have been identified to have load centers on the East and West Coasts of Panama and to link these with a mini-double stack rail bridge and the first shipment of locomotives and rolling stock for this venture has been made (see Box 7.1).

Box 7.1. Trains Take the Ship with Intermarine (*JoC Online,* April 24, 2001)

The Panama Canal Railway gave new meaning to the old New York Central slogan, "The Water Level Route," when it moved its first shipment of locomotives and cars to their new home in Central America via ocean carrier.

Intermarine's new vessel, Industrial Challenger, loaded the five locomotives and four executive passenger cars at the Nashville Avenue Terminal in New Orleans, the beginning of the final phase of a two-year project to build a new high-speed rail link to the Panama Canal.

The railroad, a joint venture of the Kansas City Southern Railway and Mi-Jack Products, the Chicago based maker of intermodal terminal equipment, will connect Hutchison Terminal in Balboa with the MIT Terminal in Cristobal. The new rail service will carry containers double-stacked as well as passengers at an operating speed of 60 mph.

The locomotives and passenger cars were loaded directly from rail sidings in New Orleans and will be discharged directly to the railroad's track in Cristobal. Unitcargo of Houston provided logistics management and all export formalities. In all, Intermarine will transport more than 60 railcars for the new railroad.

In its initial phase of operation, the railroad will make up to 10 crossings in each direction, each day. The railroad will have an annual capacity for the movement of more than 500,000 containers between the two terminals. In addition, the trains will have passenger coaches for both executive and tourist classes. The executive cars, outfitted to resemble Europe's Orient Express, will primarily cater to the daily commuter traffic between Panama City and Cristobal.

Central America and the Caribbean ports and markets are close to the U.S. Gulf and the South Atlantic ports and suggest that they need to be analyzed separately, owing to the short distance, the larger number of ports, and the service frequencies, which together impede the deployment of large containerships. In addition, there are severe infrastructure limitations at Central American and Caribbean ports, except for the potential load centers at Freeport in the Bahamas. Finally, the East Coast South American ports are limited by ports, cranes, and channel depths, which effectively take out route categories four and five.

This suggests that the only North Atlantic route that has the potential to deploy containerships over 5,000 TEUs is from a load center on the U.S. North Atlantic coast through to Northern Europe, although smaller ships (in the range of 3,500 to 4,500 TEUs) may also provide very effective and competitive services over these distances. The second category through the Mediterranean has the potential to connect to the Europe/Far East Pendulum services via the use of large transshipment ports. Again, it is noted that most U.S. exported commodities employing this route will do so through northern ports perhaps using double stack service. There is no clear advantage to moving these products through Gulf ports.

Finally, a note of caution needs to be stated about the mergers and takeovers now occurring in the shipping industry that will have important consequences on route structure, ship size, and call frequencies. If the market becomes highly concentrated, it may be possible to have large ships (not necessarily mega-containerships) calling at Atlantic and Gulf ports on a vessel-sharing agreement. However, again we note that, as vessel size increases, call frequency must decrease, which limits the ability of the widespread implementation of the ships without specifying a small number of load centers at which they would call.

Chapter 8. Summary and Conclusions

SUMMARY

Drewry Shipping Consultants, in its first quarter 2001 industry review, reported that the container shipping industry is healthy, although the twin issues of a slowing world economy and over capacity of industry slots will affect 2001 earnings and growth (*JoC*, April 30, 2001). A summary of its findings is shown in Table 8.1, which estimates 2001 container trade growing at 8.4 percent, while capacity is growing at 12.5 percent—and which will likely continue its strong growth in 2002. Much of this growth is associated with mega-containership construction and development.

Table 8.1. World Container Shipping 1999–2001

Container Shipping

	1999	2000	% change	2001 est	% change
World container trade *(in millions of TEUs)*	62.3	68.7	10.27	74.5	8.44
World port throughput *(in millions of TEUs)*	207	229.3	10.77	247.9	8.11
World cellular fleet capacity *(in thousands of TEUs)*	4,335	4,799	10.70	5,398	12.48
World shipbuilding capacity* *(in thousands of TEUs)*	1,235	1,697	37.41	1,385	-18.39
Average revenue/per TEUs** *(in U.S. dollars)*	1,387	1,414	1.95	n/a	n/a
Gross carrier revenues *(revenues in billion U.S. dollars)*	81	92	13.33	n/a	n/a

**This does not take into account likely new orders placed in 2001.*
***Trans-Pacific, trans-Atlantic and Europe/Asia/Europe trades only.*

Source:
Drewry Shipping Consultants Ltd., JoC WEEK

The previous decade, especially since 1995, shows substantial growth in the numbers and sizes of ships exceeding 4,500 TEUs, as well as in world containership slot capacity. More recently, there has been strong growth in orders for vessels in the 1,000 to 2,000 TEUs categories, which provide the relays to the load centers serving the large container vessels.

Vessel operating costs dramatically fall with size, though the regular deployment of a mega-containership must be based on greater system efficiencies, which, together with operating costs, incorporate the costs of port handling, transshipment, and the final delivery of boxes carried by the various classes of containership. A model of vessel operating costs was offered, together with a systemic identification of the full supply chain costs and how they might be estimated.

Current North Atlantic and Gulf routes were then described. Most have long strings—that is, they have a fairly large number of ports on their route structure on both sides of the Atlantic. This route structure suggests that there are relatively small numbers of containers being picked up and/or unloaded at each site. The long strings are particularly true for the Gulf ports; a number of Houston strings have over twelve ports of call on their liner schedule. Such a route structure does not favor mega-containership deployment.

The demand for container movements, particularly as they impact the Gulf, was evaluated in the report. Essentially, time-sensitive commodities from Europe having Texas destinations were unloaded prior to the ship’s arrival in the Gulf. Commodities from South American markets were not segregated in this fashion, although some were transshipped in the Caribbean, particularly through Freeport in the Bahamas.

Demand will continue to grow in the land bridge and mini-bridge doublestack rail services that connect the East and West Coast U.S. ports. As container growth expands with South America, there may be a potential for a mini-bridge operation from Houston, linking the East-West doublestack infrastructure. These surface modes could essentially close the loop for the post-Panamax pendulum services that connect the three major world markets composed of Europe, the Far East, and the United States. Plans for widening the locks on the Panama Canal, or providing a land bridge through the Panama peninsula, are also important factors that will play a role in whether a Houston mini-bridge is viable.

U.S. surface doublestack services might well provide adequate service for time-sensitive cargo from East Coast South American Ports and the Caribbean, and non-time-sensitive cargo from European, Mediterranean, and Middle East regions with the U.S. West Coast ports.

Various scenarios were used to forecast future changes in container demand at the North Atlantic and Gulf ports. The results suggest that there is not a clear case for mega-containership deployment to Gulf ports in the next 15, or possibly 20, years. A mega-containership costs around $30,000 a day to operate, so demand has to be high at the few ports that it is able to service in order to justify its deployment, which in the Gulf, represents around a 3-day return trip from the North Atlantic to the Texas coast.

CONCLUSIONS

The degree of consolidation in the containership liner market, together with the growth of container demand, will heavily influence the size of containership that is placed on any of the North Atlantic and Gulf routes. The deployment of large, post-Panamax vessels might well take place in stages, beginning in the North Atlantic (at New York-New Jersey) and moving down to the Mid-Atlantic (Charleston or Savannah), as market conditions permit. It is clear from the analysis that the key ports in the North and Mid-Atlantic regions are better positioned than Gulf ports to service mega-containerships, because they already have the demand, routes, geographic location, and markets to serve larger containerships.

Box 8.1 reports key issues surrounding Maersk's choice of a South Atlantic load center. Part of the decision process is the ability of the chosen site to serve mega-containerships, if and when they are brought into service on South Atlantic routes. Such a decision might further delay the implementation of these large vessels on Texas Gulf port schedules.

Box 8.1. Maersk Sealand is trying to decide on a South Atlantic load center. Which port will win? (*JOC Week,* July 17-23, 2000)

Tommy Thomsen, president of Maersk, Inc., says his company expects to decide in the next six to 12 months whether to put its South Atlantic load center in Charleston or in Savannah.

Maersk Sealand's regional hub now is at Charleston, but the carrier is renegotiating its contract with the South Carolina State Ports Authority and working under a six-month extension.

A key issue will be the ports' progress toward dredging their shipping channels to 50 feet—deep enough to accommodate the new generation of 6,000-TEU-plus ships.

Thomsen said carriers can switch ports more easily than they could a few years ago. Many ports agree, if the 1998-1999 competition for Maersk Sealand's North Atlantic load center is any indication.

Maersk and Sea-Land, which had an operating alliance before they merged last December, sought bids from seven ports, then narrowed the list to three before accepting a sweetened deal with the Port of New York and New Jersey. Maersk Sealand's TP-2 string is made up of 10 2,500-TEU vessels and represents about 25,000 containers a year to Charleston. That's a small portion of Maersk Sealand's Charleston volume. But local maritime leaders are nervous.

Charleston's concern is heightened by Evergreen Line's choice last month of Savannah for a new weekly service to Asia. "The Maersk Sealand service was a loss, and the Evergreen service was a missed opportunity," said Byron Miller, a Charleston port spokesman.

In the race to deepen its channels, Charleston has an early edge. Congress in 1996 authorized deepening the port's 42-foot entrance channel to 47 feet and its40-foot inner harbor to 45 feet. Work began a year ago. The project will cost $159 million with costs shared by the state and federal governments. The port is still seeking $26 million in state money to finish the project by its target date of 2002.

The geographic position of the Gulf Coast, which is some distance from the main Atlantic trade routes, together with the limitations of the regional markets served by Gulf ports, means that Texas locations are not obvious candidates for mega-containership deployment. This is not simply a question of draught depth at various Gulf ports. Currently, the North Atlantic liner schedules have Gulf ports that are either last or first in the string and are therefore rarely fully loaded. Because they are not fully loaded, their draught requirements are less; it would thus be theoretically possible to operate mega-containership liner schedules to ports with draughts under 50 ft. However, the more important constraint in the Gulf is container demand and, as noted in the summary of this chapter, the numbers do not appear to support the implementation of very large containerships on Gulf routes.

The continuing globalization in shipping, together with consolidation in liner shipping and the opportunities for larger vessels exhibiting economies of scale, will impact the Gulf in the next 20 years. This potential can be described in three areas.

1. There is likely to be continued strong growth in container movements between the U.S. Gulf and Latin American and Caribbean markets. In some of the latter, these will be relayed or transshipped from other markets, which implies that the links between the Caribbean and Texas ports will be better served by feeder ships or conventional Panamax containerships than by very large containerships.
2. There is likely to be moderate-to-modest growth in container demand between Gulf ports and European, Mediterranean, and Middle East markets. This demand may be better served by faster regular containerships capable of maintaining 25 knots or more frequent service schedules of Panamax vessels, rather than bigger containerships.
3. Currently the rather slow large liner schedule with Houston could be replaced by a significantly faster vessel of similar size, which could either reduce the numbers of ships needed for each string or speed up the service between the Gulf origins with the foreign market destinations.

Despite the growth of container traffic with Texas Gulf ports, the research results to date suggest that Panamax vessels will adequately service this trade for at least the next decade. European, Mediterranean, and Middle East groups might eventually use mega-containerships on their liner schedules, although it should be remembered that it is perfectly feasible (and economical) to offer a Gulf-based service using faster 4,000 TEU Panamax vessels and improved liner schedules.

Appendix 1. A Note on International Trade

International trade is determined by both international patterns of production and consumption. From the traditional trade theory's point of view, international trade takes place because of the differences (including resources, wages, technologies, etc.) between countries. Countries trade in pursuit of maximizing comparative advantages. The new trade theory acknowledges the difference is one of the primary reasons of international trade, but it also addresses another reason: Driven by inherent advantages to specialization, countries trade. Especially between similar countries, trade represents specialization to take advantage of increasing returns rather than to capitalize on inherent differences between countries. In other words, countries produce goods that would have been relatively cheap in the absence of trade. Comparative advantage may arise from a variety of sources, but in any case the attributes of a country determine what it produces.

This was first established in 1817, when David Ricardo noted that with the existence of some patterns of comparative advantages, there would be gains from trade, regardless of whether one country has an absolute advantage[1] in all goods. Three major Ricardian propositions[2] are:

1. Except when labor input requirements are identical across countries, there exists gains from international trade.
2. The observed terms of trade are bounded between the comparative labor cost ratios of the two countries where international trade takes place.
3. A country exports the commodity in which it has a comparative labor cost advantage and imports the commodity in which it has a comparative advantage.

Gains from trade are mutual, but will not be shared equally by all citizens of a country. The gains by one country are not at the expense of other countries. The gains from trade can be broken down into gains from exchange and gains from specialization.

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[1] Absolute advantage: A country has an absolute advantage in good X if one unit of labor produces more X than is produced by one unit of labor in the other country.

[2] David Ricardo, The Principles of Political Economy and Taxation, London 1817.

The Heckscher-Ohlin model has served as the pre-eminent trade theory in the twentieth century. In this model, comparative advantage and trade are determined by national differences in factor endowments. The Heckscher-Ohlin Theorem is known as: given the assumption of this model, a country will export the commodity that intensively uses its relatively abundant factor. Among main results of the Heckscher-Ohlin theory, the Factor Price Equilibrium Theorem—factor prices will be equalized between countries—is one of the most powerful findings in trade theory, as it shows how trade affects the distribution of income[3].

The optimality of free trade rests on the need for area specialization in production, brought about by comparative advantages based on differences between nations' resource endowments, productions and transportation costs and institutional frameworks. Its benefits include expanded markets, minimal or no government restrictions, increased production, scale economies and temporary labor or trade imbalances. In practice, however, many economists come to believe that such benefits are hardly manifested given different trade regulations affecting producers of different nationalities, labor and capital immobilities, structural bottlenecks and varying degrees of competitiveness.

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[3] It is also the most fragile theorem, for it will not hold if any one of the eight assumptions is violated. Those assumptions are: No barriers to trade; No transportation cost; Perfect competition plus full employment; Factors are mobile in each country but are immobile between countries; No specialization; Production functions exhibit constant returns to scale and are different between industries; Identical technologies between countries; No factor intensity reversal. Another important neoclassical trade theory is Factor-Price Equalization Theorem, which states that trade will diminish the cross-national difference in factor prices.

Appendix 2. Containership Calls and Average TEU Ship Size per Call at U. S. Atlantic and U.S. Gulf Ports in 1999

In March 2000, researchers purchased data from Lloyd’s Maritime Information Services Ltd. on container arrivals at North Atlantic ports. The data, on a CD-ROM, contained full voyage history data tables for unitized vessels (full and part containers) that were reported as calling at any port on the U.S. Atlantic or U.S. Gulf Coast during the year 1999.

The vessels were first categorized by size into six classes of 1000 TEU units and for each class of vessel the numbers of TEUs handled, together with the number of arrivals, were read. From these data the average TEU per vessel call was calculated and represented as a percentage of the total TEUs handled in 1999. The following tables provide comparative information for those ports in the Lloyds database. They comprise New York, Charleston, Miami, Hampton Roads, Houston, New Orleans, and Savannah. Los Angeles is also given for comparative purposes.

It should be noted that although some calls by mega-containerships are reported for New York and Charleston, they are not part of a liner service. Maersk were demonstrating their flagship category to Port Authorities as part of their hub selection strategy.

Table A2.1. Average TEU per Vessel Call as a Percentage of TEU's Handled in 1999

NEW YORK				
Vessel Size (TEU)	Subtotal	Arrivals	Average TEUs	%
<1,000	78,316	183	428	1.36
1,000~1,999	735,239	509	1,444	12.73
2,000~2,999	2,118,828	848	2,499	36.68
3,000~3,999	1,848,250	541	3,416	32.00
4,000~4,999	957,177	224	4,273	16.57
>5,000	38,508	6	6,418	00.67
TOTAL	5,776,318	2,311	—	100.00

CHARLESTON				
Vessel Size (TEU)	Subtotal	Arrivals	Average TEUs	%
<1,000	35,559	77	462	00.84
1,000~1,999	545,698	366	1,491	12.90
2,000~2,999	1,436,617	578	2,485	33.97
3,000~3,999	1,098,042	306	3,588	25.96
4,000~4,999	1,075,245	246	4,371	25.42
>5,000	38,508	6	6,418	00.91
TOTAL	4,229,669	1,579	—	100.00

MIAMI				
Vessel Size (TEU)	Subtotal	Arrivals	Average TEUs	%
<1,000	362,012	722	501	26.96
1,000~1,999	461,804	309	1,495	34.39
2,000~2,999	518,871	221	2,348	38.64
3,000~3,999	0	0	0	00.00
4,000~4,999	0	0	0	00.00
>5,000	0	0	0	00.00
TOTAL	1,342,687	1,252	—	100.00

HAMPTON ROADS				
Vessel Size (TEU)	Subtotal	Arrivals	Average TEUs	%
<1,000	42,541	90	473	1.14
1,000~1,999	542,979	378	1,436	14.57
2,000~2,999	1,293,679	515	2,512	34.72
3,000~3,999	1,248,237	364	3,429	33.50
4,000~4,999	598,859	138	4,340	16.07
>5,000	0	0	0	00.00
TOTAL	3,726,295	1,485	—	100.00

Table A2.1. Average TEU per Vessel Call as a Percentage of TEUs Handled in 1999 (Cont.)

HOUSTON				
Vessel Size (TEU)	Subtotal	Arrivals	Average TEUs	%
<1,000	134,501	291	462	8.67
1,000~1,999	504,952	356	1,418	32.57
2,000~2,999	464,296	184	2,523	29.94
3,000~3,999	206,874	62	3,337	13.34
4,000~4,999	239,928	52	4,614	15.47
>5,000	0	0	0	0.00
TOTAL	1,550,551	945	—	100.00

NEW ORLEANS				
Vessel Size (TEU)	Subtotal	Arrivals	Average TEUs	%
<1,000	39,736	111	358	4.36
1,000~1,999	469,387	323	1,453	51.50
2,000~2,999	332,060	140	2,372	36.43
3,000~3,999	65,702	20	3,285	7.21
4,000~4,999	4,614	1	4,614	0.51
>5,000	0	0	0	0.00
TOTAL	911,499	595	—	100.00

SAVANNAH				
Vessel Size (TEU)	Subtotal	Arrivals	Average TEUs	%
<1,000	23,749	56	424	1.19
1,000~1,999	342,378	228	1,502	17.09
2,000~2,999	554,594	223	2,487	27.69
3,000~3,999	949,549	294	3,230	47.40
4,000~4,999	132,792	33	4,024	6.63
>5,000	0	0	0	0.00
TOTAL	2,003,062	834	—	100.00

LOS ANGELES				
Vessel Size (TEU)	Subtotal	Arrivals	Average TEUs	%
<1,000	6,840	28	244	0.29
1,000~1,999	187,974	123	1,528	7.94
2,000~2,999	440,992	163	2,705	18.63
3,000~3,999	1,047,315	302	3,468	44.25
4,000~4,999	613,234	146	4,200	25.91
>5,000	70,598	11	6,418	2.98
TOTAL	2,366,953	773	—	100.00

Appendix 3. Forecasting TEU Volumes from North Atlantic, Gulf, and Texas Regions to Various Regions of the World

The PIERS data provided by the Port of Houston was used to determine base year TEU volumes from North Atlantic ports to various regions of the world. The North Atlantic ports were then reduced to a Gulf set and a further reduction to a Texas port set.

The complexity of forecasting over a 20 year period suggested that it would be more useful to devise a way of testing the sensitivity of different growth rates over the period. The real issue was the likelihood of any market reaching the volumes required for mega-containership liner schedules (currently estimated at around 3 to 4 million TEU per year).

Accordingly, three scenarios were adopted which equated to pessimistic, normal, and optimistic market conditions. Different growth rates were used within each scenario, based on historic performance. Pessimistic used two per cent and four per cent; normal used four per cent and seven per cent; and finally, optimistic used six per cent and nine per cent. Using these rates, a 20 year forecast was developed and these data related to the five main categories of routes used in the North Atlantic. These comprise routes from North Atlantic, Gulf, or Texas ports to: Northern Europe (NEU); Mediterranean, Middle East, Asia, Africa, Oceania (MED-ME-ASIA-AF-OC); U.S. West Coast, Asia, Oceania (USWC-ASIA-OC); Caribbean-Central America (CAR-CAM); West Coast South America (WCSA); East Cost South America (ECSA).

Table A 3.1. Forecasting Pessimistic, Normal, and Optimistic Growth Rates for South Atlantic and Gulf Ports over 20 Years

SOUTH ATLANTIC + GULF PESSIMISTIC	GROWTH RATE	PLANNING HORIZON			
		5 years	10 years	15 years	20 years
NORTH EUROPE	2.0%	906,382	1,000,719	1,104,874	1,219,871
CENTRAL AMERICA	4.0%	713,764	788,053	870,074	960,632
EAST COAST SOUTH AMERICA	4.0%	465,524	513,976	567,471	626,533
CARIBBEAN	4.0%	445,583	491,959	543,163	599,696
NORTHEAST ASIA	2.0%	277,183	306,032	337,884	373,052
WEST COAST SOUTH AMERICA	4.0%	267,190	294,999	325,703	359,602
MEDITERANNEAN	2.0%	257,675	284,494	314,104	346,796
SOUTHEAST ASIA	2.0%	112,204	123,883	136,777	151,012
AFRICA	4.0%	82,789	91,406	100,920	111,424
MIDDLE EAST	2.0%	76,969	84,980	93,825	103,590
OTHER ASIA	4.0%	62,281	68,763	75,920	83,822
OCEANIA	2.0%	25,940	28,640	31,621	34,912

	ROUTES	PLANNING HORIZON			
		5 years	10 years	15 years	20 years
1	NEU	906,382	1,000,719	1,104,874	1,219,871
2	MED-ME-ASIA-AF-OC	617,859	682,166	753,167	831,557
3	USWC-ASIA-OC	477,609	527,319	582,202	642,799
4	CAR-CAM	1,159,347	1,280,012	1,413,237	1,560,328
5	WCSA	267,190	294,999	325,703	359,602
6	ECSA	465,524	513,976	567,471	626,533

SOUTH ATLANTIC + GULF NORMAL	GROWTH RATE	PLANNING HORIZON			
		5 years	10 years	15 years	20 years
NORTH EUROPE	4.0%	998,797	1,215,189	1,478,463	1,798,776
CENTRAL AMERICA	7.0%	786,539	956,945	1,164,270	1,416,513
EAST COAST SOUTH AMERICA	7.0%	512,988	624,129	759,348	923,863
CARIBBEAN	7.0%	491,014	597,394	726,821	884,289
NORTHEAST ASIA	4.0%	305,444	371,620	452,132	550,088
WEST COAST SOUTH AMERICA	7.0%	294,432	358,222	435,832	530,256
MEDITERANNEAN	4.0%	283,947	345,465	420,311	511,373
SOUTHEAST ASIA	4.0%	123,645	150,433	183,024	222,677
AFRICA	7.0%	91,231	110,996	135,044	164,301
MIDDLE EAST	4.0%	84,817	103,192	125,549	152,750
OTHER ASIA	7.0%	68,631	83,501	101,591	123,601
OCEANIA	4.0%	28,585	34,778	42,313	51,480

	ROUTES	PLANNING HORIZON			
		5 years	10 years	15 years	20 years
1	NEU	998,797	1,215,189	1,478,463	1,798,776
2	MED-ME-ASIA-AF-OC	680,856	828,365	1,007,833	1,226,183
3	USWC-ASIA-OC	526,306	640,331	779,061	947,847
4	CAR-CAM	1,277,554	1,554,339	1,891,092	2,300,802
5	WCSA	294,432	358,222	435,832	530,256
6	ECSA	512,988	624,129	759,348	923,863

SOUTH ATLANTIC + GULF OPTIMISTIC	GROWTH RATE	PLANNING HORIZON			
		5 years	10 years	15 years	20 years
NORTH EUROPE	6.0%	1,098,600	1,470,175	1,967,426	2,632,859
CENTRAL AMERICA	9.0%	865,133	1,157,744	1,549,322	2,073,343
EAST COAST SOUTH AMERICA	9.0%	564,248	755,091	1,010,482	1,352,253
CARIBBEAN	9.0%	540,078	722,747	967,198	1,294,329
NORTHEAST ASIA	6.0%	335,966	449,598	601,663	805,161
WEST COAST SOUTH AMERICA	9.0%	323,853	433,389	579,972	776,133
MEDITERANNEAN	6.0%	312,320	417,955	559,318	748,494
SOUTHEAST ASIA	6.0%	136,000	181,998	243,555	325,932
AFRICA	9.0%	100,347	134,287	179,706	240,487
MIDDLE EAST	6.0%	93,292	124,845	167,071	223,579
OTHER ASIA	9.0%	75,489	101,022	135,190	180,915
OCEANIA	6.0%	31,442	42,076	56,307	75,352

	ROUTES	PLANNING HORIZON			
		5 years	10 years	15 years	20 years
1	NEU	1,098,600	1,470,175	1,967,426	2,632,859
2	MED-ME-ASIA-AF-OC	748,890	1,002,183	1,341,148	1,794,758
3	USWC-ASIA-OC	578,896	774,694	1,036,715	1,387,359
4	CAR-CAM	1,405,212	1,880,490	2,516,520	3,367,672
5	WCSA	323,853	433,389	579,972	776,133
6	ECSA	564,248	756,091	1,010,482	1,352,253

Table A.3.2. Forecasting Pessimistic, Normal, and Optimistic Growth Rates for Gulf Ports over 20 Years

GULF PESSIMISTIC	GROWTH RATE	PLANNING HORIZON			
		5 years	10 years	15 years	20 years
NORTH EUROPE	2.0%	400,188	441,840	487,827	538,601
CENTRAL AMERICA	4.0%	318,576	351,734	388,342	428,761
EAST COAST SOUTH AMERICA	4.0%	117,599	129,839	143,352	158,273
CARIBBEAN	4.0%	43,695	48,243	53,264	58,808
NORTHEAST ASIA	4.0%	8,103	8,946	9,877	10,905
WEST COAST SOUTH AMERICA	4.0%	72,526	80,075	88,409	97,610
MEDITERANNEAN	2.0%	102,485	113,152	124,929	137,932
SOUTHEAST ASIA	4.0%	6,416	7,084	7,821	8,635
AFRICA	4.0%	35,777	39,500	43,612	48,151
MIDDLE EAST	2.0%	38,546	42,558	46,987	51,877
OTHER ASIA	4.0%	10,744	11,862	13,097	14,460
OCEANIA	4.0%	14,692	16,221	17,909	19,774

	ROUTES	PLANNING HORIZON			
		5 years	10 years	15 years	20 years
1	NEU	400,188	441,840	487,827	538,601
2	MED-ME-ASIA-AF-OC	208,659	230,377	254,354	280,828
3	USWC-ASIA-OC	39,954	44,113	48,704	53,773
4	CAR-CAM	362,271	399,976	441,606	487,569
5	WCSA	72,526	80,075	88,409	97,610
6	ECSA	117,599	129,839	143,352	158,273

GULF NORMAL	GROWTH RATE	PLANNING HORIZON			
		5 years	10 years	15 years	20 years
NORTH EUROPE	4.0%	440,992	536,534	652,775	794,201
CENTRAL AMERICA	7.0%	351,058	427,116	519,651	632,235
EAST COAST SOUTH AMERICA	7.0%	129,589	157,665	191,824	233,383
CARIBBEAN	7.0%	48,150	58,582	71,274	86,716
NORTHEAST ASIA	4.0%	8,929	10,864	13,217	16,081
WEST COAST SOUTH AMERICA	7.0%	79,921	97,236	118,302	143,933
MEDITERANNEAN	4.0%	112,935	137,402	167,171	203,389
SOUTHEAST ASIA	4.0%	7,070	8,602	10,465	12,733
AFRICA	7.0%	39,424	47,966	58,358	71,001
MIDDLE EAST	4.0%	42,476	51,678	62,875	76,496
OTHER ASIA	7.0%	11,839	14,404	17,525	21,322
OCEANIA	4.0%	16,190	19,698	23,965	29,157

	ROUTES	PLANNING HORIZON			
		5 years	10 years	15 years	20 years
1	NEU	440,992	536,534	652,775	794,201
2	MED-ME-ASIA-AF-OC	229,934	279,750	340,359	414,098
3	USWC-ASIA-OC	44,028	53,567	65,173	79,292
4	CAR-CAM	399,208	485,698	590,926	718,951
5	WCSA	79,921	97,236	118,302	143,933
6	ECSA	129,589	157,665	191,824	233,383

GULF OPTIMISTIC	GROWTH RATE	PLANNING HORIZON			
		5 years	10 years	15 years	20 years
NORTH EUROPE	6.0%	485,057	649,116	868,664	1,162,468
CENTRAL AMERICA	9.0%	386,137	516,738	691,512	925,400
EAST COAST SOUTH AMERICA	9.0%	142,538	190,749	255,265	341,602
CARIBBEAN	9.0%	52,962	70,875	94,846	126,926
NORTHEAST ASIA	6.0%	9,821	13,143	17,588	23,537
WEST COAST SOUTH AMERICA	9.0%	87,907	117,639	157,428	210,674
MEDITERANNEAN	6.0%	124,219	166,234	222,458	297,699
SOUTHEAST ASIA	6.0%	7,776	10,407	13,926	18,637
AFRICA	9.0%	43,364	58,031	77,658	103,924
MIDDLE EAST	6.0%	46,720	62,522	83,669	111,968
OTHER ASIA	9.0%	13,022	17,427	23,321	31,209
OCEANIA	6.0%	17,808	23,831	31,891	42,677

	ROUTES	PLANNING HORIZON			
		5 years	10 years	15 years	20 years
1	NEU	485,057	649,116	868,664	1,162,468
2	MED-ME-ASIA-AF-OC	252,910	338,451	452,923	606,113
3	USWC-ASIA-OC	48,428	64,807	86,727	116,060
4	CAR-CAM	439,099	587,613	786,359	1,052,325
5	WCSA	87,907	117,639	157,428	210,674
6	ECSA	142,538	190,749	255,265	341,602

Table A3.3. Forecasting Pessimistic, Normal, and Optimistic Growth Rates for South Atlantic and Gulf Ports over 20 Years

TEXAS PESSIMISTIC	GROWTH RATE	PLANNING HORIZON			
		5 years	10 years	15 years	20 years
NORTH EUROPE	2.0%	309,420	341,624	377,181	416,438
CENTRAL AMERICA	4.0%	58,144	64,196	70,877	78,254
EAST COAST SOUTH AMERICA	4.0%	90,292	99,689	110,065	121,521
CARIBBEAN	4.0%	23,483	25,927	28,625	31,605
NORTHEAST ASIA	2.0%	4,983	5,501	6,074	6,706
WEST COAST SOUTH AMERICA	4.0%	49,476	54,626	60,311	66,588
MEDITERANNEAN	2.0%	86,554	95,563	105,509	116,491
SOUTHEAST ASIA	2.0%	4,860	5,366	5,925	6,541
AFRICA	4.0%	29,674	32,763	36,173	39,938
MIDDLE EAST	2.0%	30,469	33,641	37,142	41,008
OTHER ASIA	4.0%	9,888	10,917	12,054	13,308
OCEANIA	2.0%	14,526	16,038	17,708	19,551

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	ROUTES	PLANNING HORIZON			
		5 years	10 years	15 years	20 years
1	NEU	309,420	341,624	377,181	416,438
2	MED-ME-ASIA-AF-OC	175,973	194,288	214,510	236,836
3	USWC-ASIA-OC	34,257	37,823	41,760	46,106
4	CAR-CAM	81,627	90,123	99,503	109,859
5	WCSA	49,476	54,626	60,311	66,588
6	ECSA	90,292	99,689	110,065	121,521

TEXAS NORMAL	GROWTH RATE	PLANNING HORIZON			
		5 years	10 years	15 years	20 years
NORTH EUROPE	4.0%	340,968	414,840	504,716	614,064
CENTRAL AMERICA	7.0%	64,073	77,954	94,843	115,391
EAST COAST SOUTH AMERICA	7.0%	99,498	121,054	147,281	179,190
CARIBBEAN	7.0%	25,877	31,483	38,304	46,603
NORTHEAST ASIA	4.0%	5,491	6,680	8,128	9,889
WEST COAST SOUTH AMERICA	7.0%	54,521	66,333	80,704	98,189
MEDITERANNEAN	4.0%	95,380	116,044	141,185	171,773
SOUTHEAST ASIA	4.0%	5,356	6,516	7,928	9,645
AFRICA	7.0%	32,700	39,785	48,404	58,891
MIDDLE EAST	4.0%	33,576	40,850	49,701	60,468
OTHER ASIA	7.0%	10,896	13,257	16,129	19,624
OCEANIA	4.0%	16,008	19,476	23,695	28,829

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	ROUTES	PLANNING HORIZON			
		5 years	10 years	15 years	20 years
1	NEU	340,968	414,840	504,716	614,064
2	MED-ME-ASIA-AF-OC	193,915	235,927	287,042	349,230
3	USWC-ASIA-OC	37,750	45,929	55,880	67,986
4	CAR-CAM	89,950	109,437	133,147	161,994
5	WCSA	54,521	66,333	80,704	98,189
6	ECSA	99,498	121,054	147,281	179,190

TEXAS OPTIMISTIC	GROWTH RATE	PLANNING HORIZON			
		5 years	10 years	15 years	20 years
NORTH EUROPE	6.0%	375,039	501,887	671,638	898,803
CENTRAL AMERICA	9.0%	70,475	94,311	126,210	168,897
EAST COAST SOUTH AMERICA	9.0%	109,440	146,456	195,991	262,280
CARIBBEAN	9.0%	28,463	38,090	50,972	68,213
NORTHEAST ASIA	6.0%	6,039	8,082	10,816	14,474
WEST COAST SOUTH AMERICA	9.0%	59,969	80,251	107,395	143,718
MEDITERANNEAN	6.0%	104,910	140,394	187,878	251,423
SOUTHEAST ASIA	6.0%	5,891	7,883	10,550	14,118
AFRICA	9.0%	35,967	48,133	64,412	86,198
MIDDLE EAST	6.0%	36,931	49,422	66,138	88,507
OTHER ASIA	9.0%	11,985	16,039	21,464	28,723
OCEANIA	6.0%	17,607	23,562	31,532	42,196

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	ROUTES	PLANNING HORIZON			
		5 years	10 years	15 years	20 years
1	NEU	375,039	501,887	671,638	898,803
2	MED-ME-ASIA-AF-OC	213,292	285,432	381,973	511,166
3	USWC-ASIA-OC	41,522	55,566	74,360	99,511
4	CAR-CAM	98,938	132,401	177,182	237,110
5	WCSA	59,969	80,251	107,395	143,718
6	ECSA	109,440	146,456	195,991	262,280

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