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Short Sea Shipping: Barriers, Incentives and Feasibility of Truck Ferry

by

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B.S. Ocean Engineering, United States Naval Academy, 2001

Submitted to the Department of Mechanical Engineering
and
Department of Civil and Environmental Engineering
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Abstract

Many problems plague the United States' transportation infrastructure: congestion, poor roadway conditions, obsolescence, and maintenance cost not the least among these. In recent years, the Department of Transportation, through its Maritime Administration (MARAD), has begun a program for partial solution to this complex transportation issue. MARAD, acting on tasks assigned to it in the Energy Independence and Security Act of 2007, has established the Marine Highways Initiative to spur development of alternative and supplemental transportation modes that utilize inland waterways and coastlines of the United States. At the same time, the U.S. Department of Defense is investigating ways to fulfill its sealift requirements, while at the same time reducing its inventory of government owned vessels that do not trade.

This paper explores the issues surrounding the current state of transportation and transportation infrastructure. It also seeks to determine the feasibility of a truck ferry that would accomplish both MARAD's Marine Highway as well as the Department of Defense's sealift goals. The feasibility study examines the hypothetical business' profitability through different funding and operating scenarios. The analysis also sets a framework for other studies by using open-source data to determine freight flows, potential costs and market share.

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Part I

Background

Chapter 1

Introduction

In recent years, the transportation networks of the United States have become increasingly congested, leading many to conclude that additional infrastructure investments must be made to alleviate the congestion and provide cheaper and more reliable transportation of goods. The U.S. Department of Transportation is also concerned with the requirement of building and maintaining additional roads and rail to accommodate future cargo needs. Additional complexities have added urgency to the discussion, specifically: the paucity of U.S.–flagged vessels engaged in domestic and international trade as well as environmental impacts of the current shipping modes, most specifically, trucking. Spurred by the Energy Independence and Security act of 2007, the Department of Transportation (DOT) and the Maritime Administration (MARAD) have begun the Marine Highways Initiative (MHI) to research and promote Short Sea Shipping (SSS) as an alternative method of moving people and goods between major markets. The Department of Defense (DOD) also sees great benefit in the expansion of SSS in the United States since it would, in part, relieve the government from acquiring and maintaining transport ships for contingency operations.

For the purposes of this discussion, and found in nearly all SSS literature, Short Sea Shipping is defined as the movement of goods by sea and waterways that does not involve an ocean transit. To that end, SSS encompasses transit of goods among and between all the states and countries in the Western Hemisphere, however this discussion will be limited to

Canada — U.S. — Mexico trade as well as U.S. interstate commerce.

Short Sea Shipping has been a portion of the seagoing trade worldwide for decades. The most important increase in SSS was seen during the 1960's and 1970's when the upswing of containerized cargo required the necessity of feeder vessels to bring containers to shipping hubs for liner-ship consolidation.

MARAD, the DOT and the DOD believe that SSS can move large volumes of truck traffic from the roads, and can provide:

- a more efficient mode of transportation for goods shipped in the U.S.
- redundant capacity for transportation in case of acts of God or other transportation system failures
- surge capacity for the military in a time of regional or worldwide conflict

This paper seeks to discover whether these beliefs are justified, as well as set a framework for a hypothetical business.

Chapter 2

The Current Transport Problem

Transportation in the United States faces some significant challenges in the near future: congestion, issues surrounding infrastructure construction and maintenance, as well as the expected increase in global trade. Increased imports and budget shortfalls will seriously stress a system that is already in a critical state. This chapter explores some of these issues.

2.1 Congestion

The transportation system of the United States is at a serious crossroads. The congestion in major cities and other urban and suburban thoroughfares is at a concerning level so much so that those roads and railroads are near or exceeding their capacities. This congestion not only threatens the health of the transportation network, but also the health of the economy and the populace.

MARAD states that road and rail congestion costs approximately \$2B annually, an amount expected to grow year-over-year[31]. MARAD estimates that Americans lose 3.7 billion hours and use 2.3 billion gallons of fuel just sitting in traffic every year, amounting to approximately \$200B per year[55]. If projections for the increase in cargo shipments (65-70 percent) are anywhere close to accurate, road congestion will be extraordinarily difficult to overcome.

Figure 2.1 shows the relative densities of daily truck traffic. The majority of truck traffic lies in the most heavily settled areas of the United States.

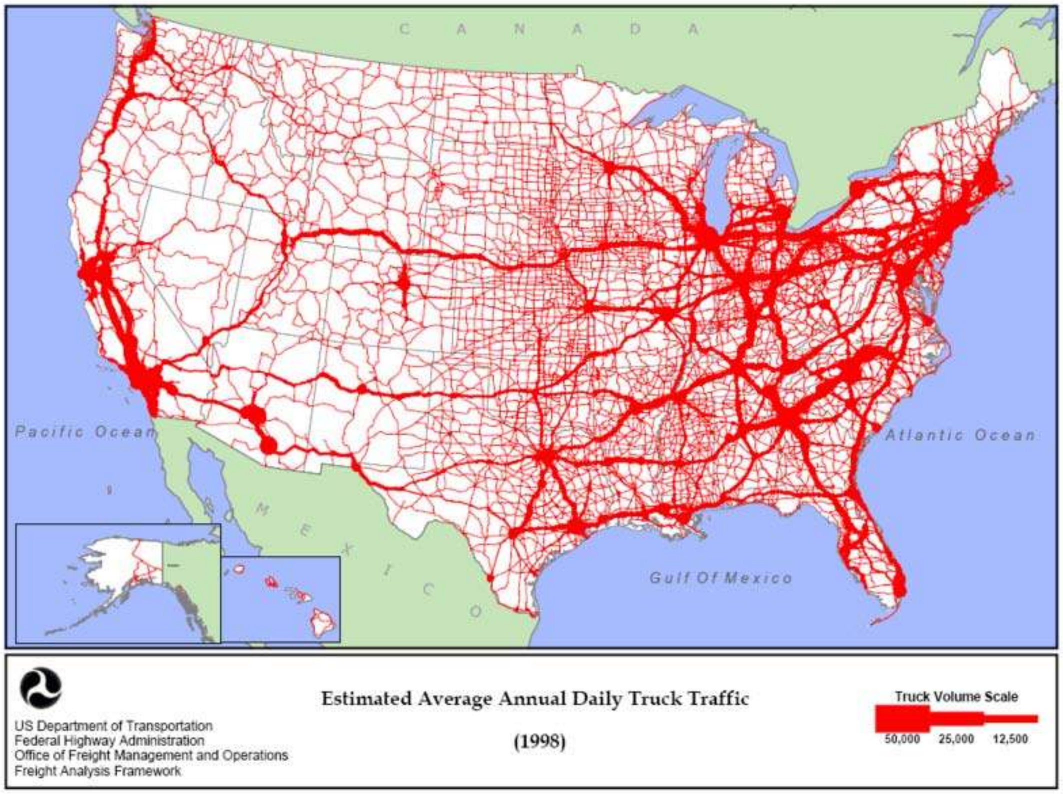


Figure 2.1: Estimated Average Annual Daily Truck Traffic

Major East Coast cities: Washington, D.C., Atlanta, New York, and Boston were all among *Forbes.com*'s ten most congested cities, and delays here would seriously degrade the reliability and predictability of shipments through and among these cities[6].

The rail system in the United States is likewise congested. Most of the major railroads are spending (and petitioning federal, state and local government for) millions of dollars on their own infrastructure increases.

As the Institute for Global Maritime Studies' report, *America's Deep Blue Highway*, states: "America must rebuild and reinvest in its transportation system. We have a 19^{th} century rail network, a 20^{th} century highway system and a 21^{st} century transportation gridlock looming on the near horizon[29]." Figures 2.2 and 2.3 plainly show that future congestion is almost a certainty, and as said many times, "we cannot pave our way out of this challenge[56]."

Figure 2.4 lends credence to the point illustrated in Figures 2.2 and 2.3. As the plot

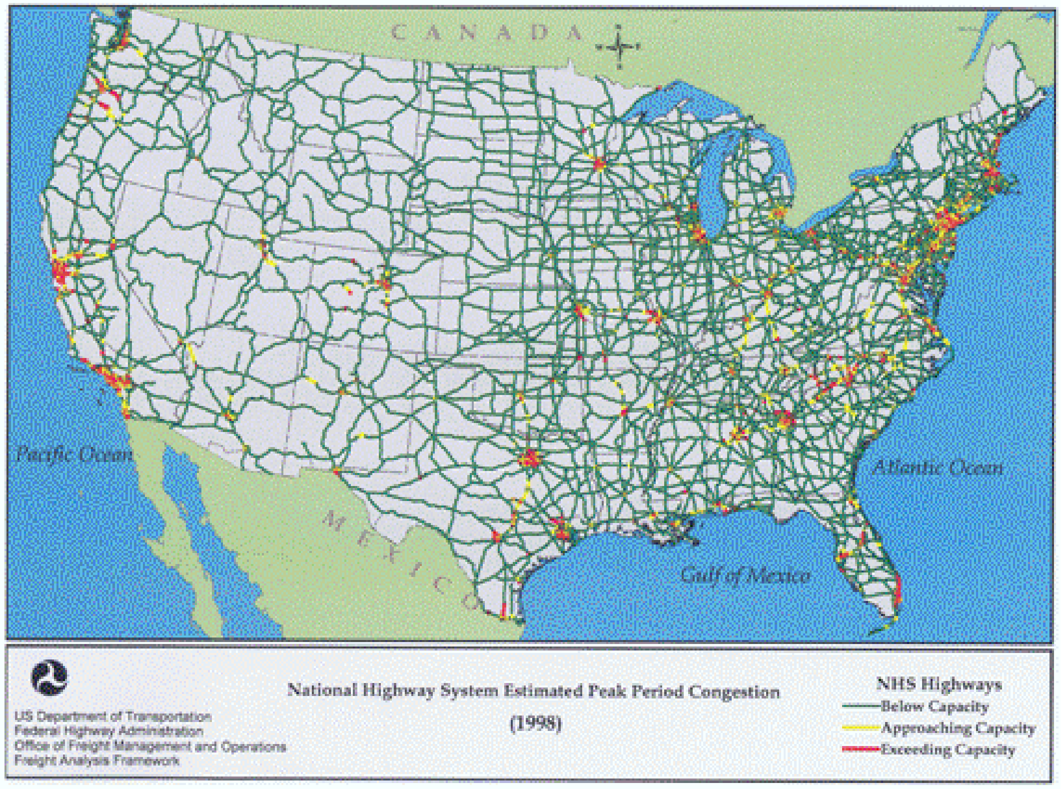


Figure 2.2: Peak Period Congestion 1998

shows, peak-period travel time is not likely to decrease over the next years. If global trade and imports follow an upward trend (even a modest upward trend) then these travel times may grow beyond control.

2.2 Failing Transport Infrastructure

The state of the U.S. Highway system is also not keeping up with the explosive growth of travel. Since 1970, total vehicle miles traveled (VMT) has increased 140%, while the amounts of lane-miles to accommodate that traffic has remained relatively the same. Figure 2.5 illustrates the discrepancy in the growth of public road lane-miles with respect to growth in vehicle miles of travel, licensed drivers, population and interstate freight.

In addition to the congestion, the large numbers of heavy trucks do significant damage to the existing roads, damage that is not usually offset by the charges imposed on the shippers.

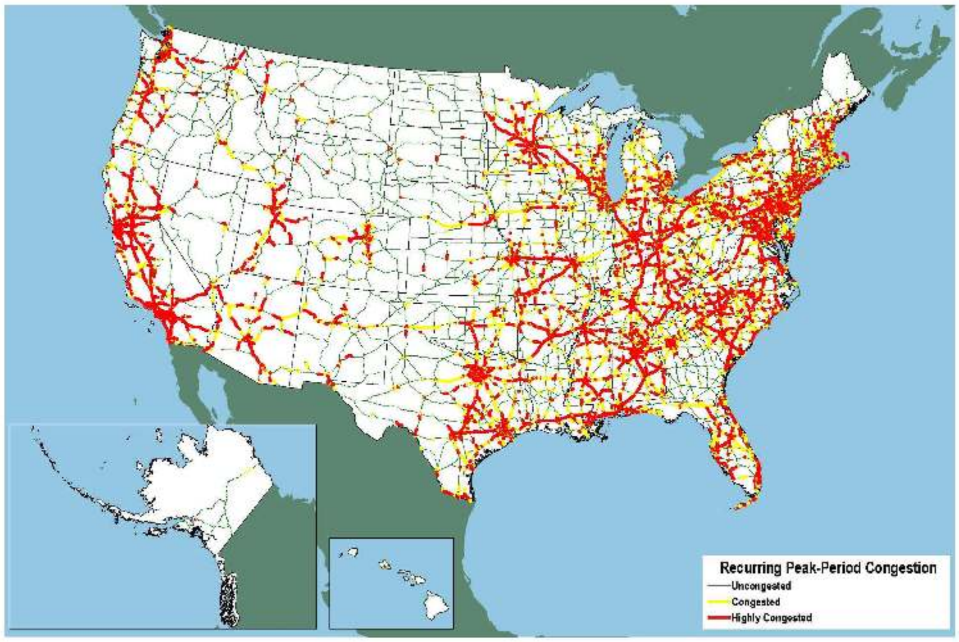


Figure 2.3: Peak Period Congestion 2035 est.

For comparison, one truck axle-pass is equivalent to 10,000 car axle-passes.

To counter the funding shortfalls and help maintain roads, the report of the National Surface Transportation Policy and Revenue Commission recommended a hike in the motor fuel tax to replenish the Highway Trust Fund, and to consolidate the funding programs to a super few to allow greater scope and flexibility in the way the government money is spent[16]. The status of the highway trust fund may be seen in Figure 2.6. Of note is the rapid decline of funds. Other concerning factors could be Congressional “repurposing” of these funds in light of recent 2009 economic stimulus funding.

As evidenced by the tragedy in Minneapolis in 2007, the landside infrastructure in the United States is in very poor shape. Many references encountered during research cited the same fact. The American Society of Civil Engineers estimates that 26% of the the nation’s nearly 600,000 major road bridges are either structurally deficient or functionally obsolete.

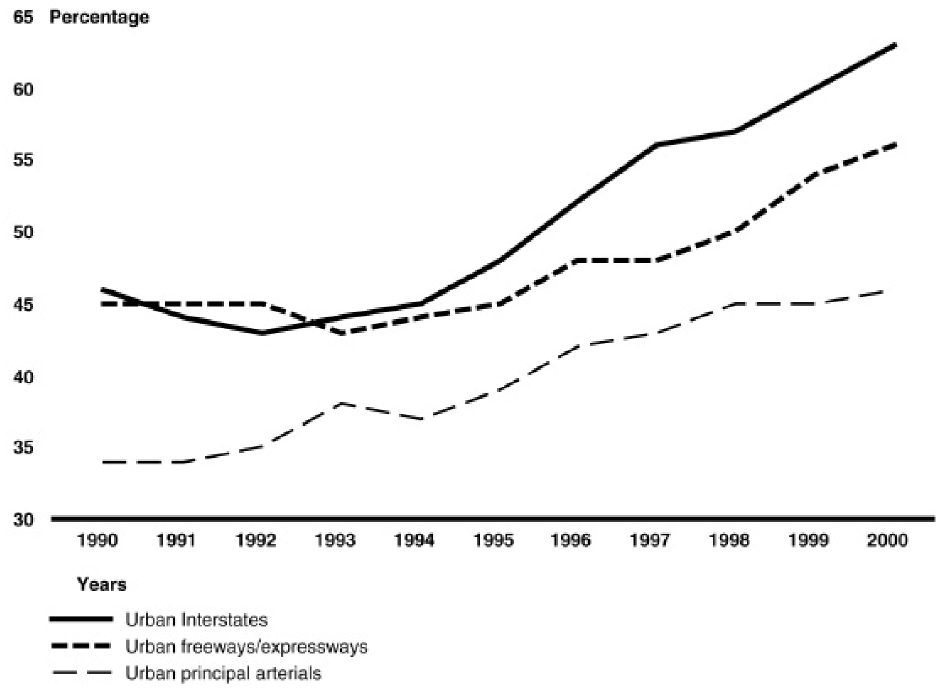
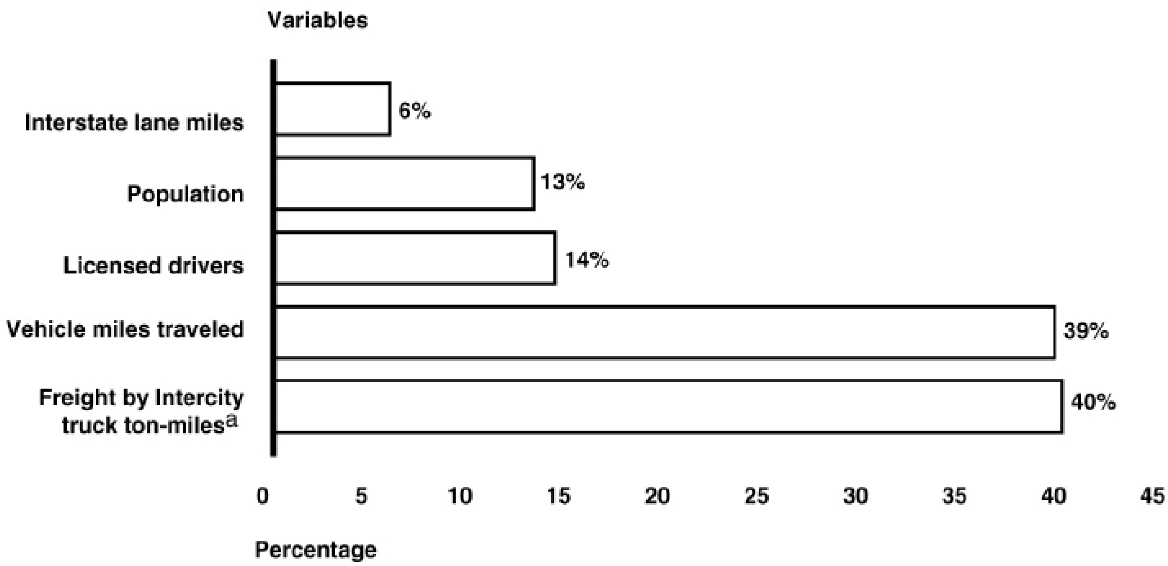


Figure 2.4: Urban Peak Period Travel Time Percent Increase by Road Class, 1990-2000[48]

This estimate can be misleading; however it does effectively point to the major fact that the system is in a serious state. Figure 2.7 shows a histogram of the nation's bridges by age. This graph shows a non-insignificant number of bridges greater than 50 years old. These bridges require constant maintenance, some of which may have been overlooked in lean-budget years.

Building more roads and bridges, is not an answer that makes sense when governments have difficulty maintaining those roads and bridges they currently own. In a GAO report published in 2002, an estimate of the annual cost of maintaining the current interstate infrastructure at the status-quo was given at approximately \$16.4B (in 2000 dollars); contrasted with approximately \$14.1B of capital investment expenditures in 2000[48]. The infrastructure budgets in 2000 fell \$2.3B short of modest estimates, and that was nearly 9 years ago. Many are concerned about how to make up for this shortfall. This situation has prompted some to wonder if most interstates become privatized tollroads to pay for upkeep and maintenance.



[a]Freight data were available only for 1990 to 1998.

Source: Prepared by GAO using data from FHWA *Highway Statistics*, U.S. Census Bureau Census *2000 Brief*, and Bureau of Transportation Statistics *National Transportation Statistics 2000*.

Figure 2.5: Percent Change of Variables Related to Congestion[48]

2.3 Increase in Global Trade

Before the fallout of the financial crisis of '08-'09, many industry experts as well as the Federal Highway Administration were expecting a 75-100% increase in freight by the year 2020. Gloomy financial outlooks for the next few years, and the impact that it may have on global manufacture, shipping and trade, should not be allowed to affect infrastructure improvements that may have been contemplated.

The present climate of financial instability may not seem the best time to prepare for increased freight and traffic; however, a report recently released by the Maritime Administration suggests the opposite. The global economic "meltdown" may provide the opportunity the country needs to revamp its transportation infrastructure and prepare for more prosperous time[32].

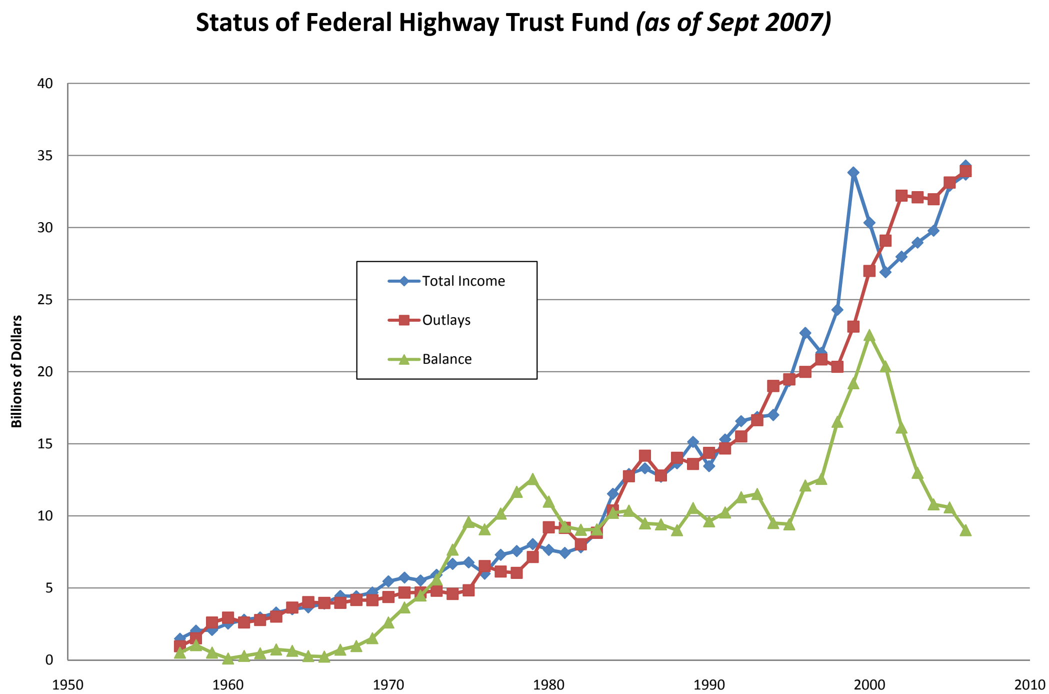


Figure 2.6: Status of the Highway Trust Fund[53]

2.4 Security

Congested roadways also have a security impact. The roadways, bridges and viaducts themselves can become a possible security concern. In the United Kingdom in early 2008, the truckers went on strike to protest fuel prices. These truckers lined up their vehicles on the roads and effectively blocked all transit. While this is not a terrorist action per-se, it shows the vulnerability of the infrastructure systems of the industrialized world.

Figure 2.8, major interchange bottlenecks, shows just how vulnerable the transit system of the U.S. could be. This figure, though, only shows interchanges by truck volume, not critical system points (river crossings, roadway stretches with no effective alternate routes, etc.) Shutdown at just a few major bottlenecks can seriously disrupt or incapacitate freight flows. A redundant and reliable alternative needs to be in place in order to adequately handle a "force majeure" situation.

These choke points increase the vulnerability of the region's infrastructure to possible terrorist action[6]. In military parlance, "choke points" are always a matter of concern. One

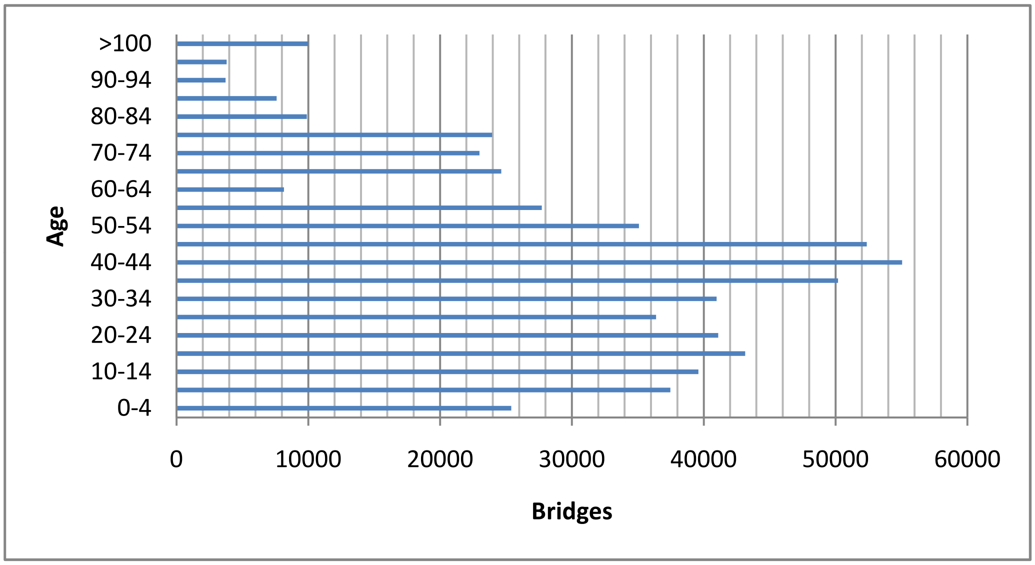


Figure 2.7: Bridges by Age[52]

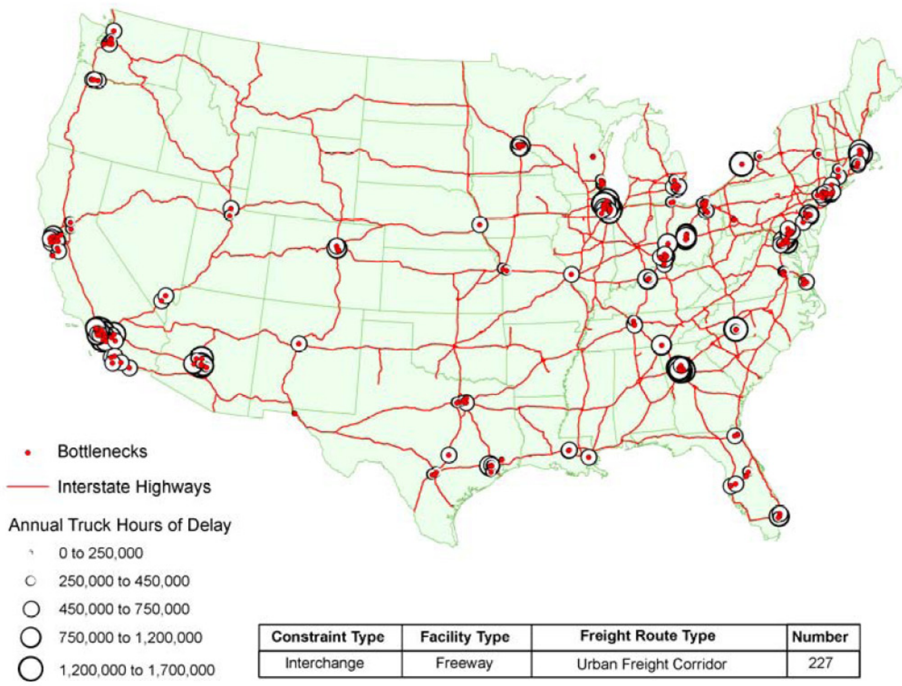
always wants to control the choke point so as to control who has access and ensure that it is available when needed. Choke points also are sources of vulnerability.

A vast majority of these bottlenecks occur in the Northeast's I-95 corridor, I-10 along the Gulf of Mexico as well as Southern California and the Pacific Northwest. All of these choke points are very close to available shipping centers. The traffic, mostly those derived from imports landing in those same ports can bypass the local roads (and the local traffic) and continue on domestic ships to ports closer to their destination.

2.5 Chapter 2 Conclusion

Judging by these facts, there needs to be a paradigm shift in the transportation thinking in the United States. The country needs to prepare for a future that includes larger amounts of import goods and larger numbers of transport system users. This network must also be had at a reasonable price. Transport planners must find a reasonably priced solution to national freight movement.

Perhaps the future of the transport system of the United States lies in her past: the sea. Many transportation experts agree that the Marine Highway can serve as an extension and



Source: Cambridge Systematics, Inc.

Figure 2.8: Major Highway Interchange Bottlenecks for Trucks

a complement to the existing infrastructure network and can provide the increased capacity, redundancy and reliability that the current system sorely needs. As former Secretary of Transportation Mary Peters said: “We need to transition away from status-quo solutions that produce status-quo results.”

Chapter 3

Analysis of Possible Solutions

The very real problems identified in the previous chapter have been recognized by many transportation planners and planning organizations. Some of the proposed solutions, their benefits and drawbacks are explored here.

3.1 Roads

3.1.1 Trucking

Whether one is measuring by weight or value, the larger share of the freight in the United States is traveling by truck [6]. However, trucking companies are feeling the financial pinch due to the aforementioned congestion. Trucking companies are changing their business models as evidenced by increasing emphasis on local markets as they struggle with rising fuel prices and driver shortages [8].

To make matters worse, there may be more complicating factors on the horizon for trucking companies. Former Secretary of Transportation, Mary Peters supported initiatives like congestion pricing (tolls charged based on the hour of travel in order to change driving habits, charged to both cars and trucks) and truck-only-toll (TOT) (schemes like HOV lanes where trucks would pay for faster travel through congested road segments) [12], a policy that will most likely be continued in the new Presidential administration.

A similar issue was the congestion into and out of the ports of Los Angeles/Long Beach. To combat the congestion the ports started "PierPass," a system in which truckers were charged $100 to leave the port during peak hours. In 2007, the port imposed an additional charge of $35 on 20' units and $70 on 40' containers [27].

This refrain seems to be taken up in the transportation academia. Kawamura claimed, and perhaps rightfully so, that commercial vehicles and freight carriers have a higher value of time, and as such should be able to bear *substantially* higher tolls (emphasis mine) [34].

Holguin, et al. analyzed truck-only-tolls as to their viability and found that on the Ohio turnpike, in 2003, trucks were charged approximately $0.38/mi ($0.24/km) and with fuel taxes (on the order of $0.16 -$0.21/mi ($0.10 -$0.13/km)) are already paying between $0.55 -$0.60/mi ($0.34 -$0.37/km) [28]. The tolls in the analysis ranged from $0.43/mi to $3.18/mi and that for the trip to be profitable for truckers to use the tollroads, they must be traveling in excess of 37 to 110 miles [28].

On top of congestion tolling and TOT, further restrictions may be put on truck operators with respect to the CO_2 that they emit. Perhaps they may be required to purchase carbon credits to offset the miles that they report. In London, reports the *Birmingham Post*, operators of heavy trucks that fail to meet low emissions standards will now be charged £200 to drive into greater London [4].

3.1.2 Trucker Shortage

Another issue that trucking companies are facing is the shortage of long-haul truckers as well as truckers in general. Labor supply issues plague nearly all industries, especially since that growth of the overall labor force will slow significantly from 1.4% currently to only 0.5% by 2012.

Studies indicate that the supply of new long-haul heavy-duty truck drivers will grow at an average rate of 1.6% over the next ten years; however, new jobs will grow at a faster pace. Anticipated economic growth will require an average increase of those same drivers of about 2.2% [21].

The age of the truck workforce, which mirrors the age of the national workforce, is getting older in the aggregate. This presents two problems. The first problem is that older drivers require higher pay for their experience as well as their general reluctance to run less-desirable routes and less-desirable cargoes. The second problem is that a large portion of the trucking workforce is closer to retirement, and their retirement will cause a glut of jobs to be filled in the next ten years. This is a serious obstacle when compared with the Federal Highway Administration's estimates of freight increases in the next 10 to 20 years. Figure 3.1 illustrates the anticipated growing gap in trucker supply and demand.

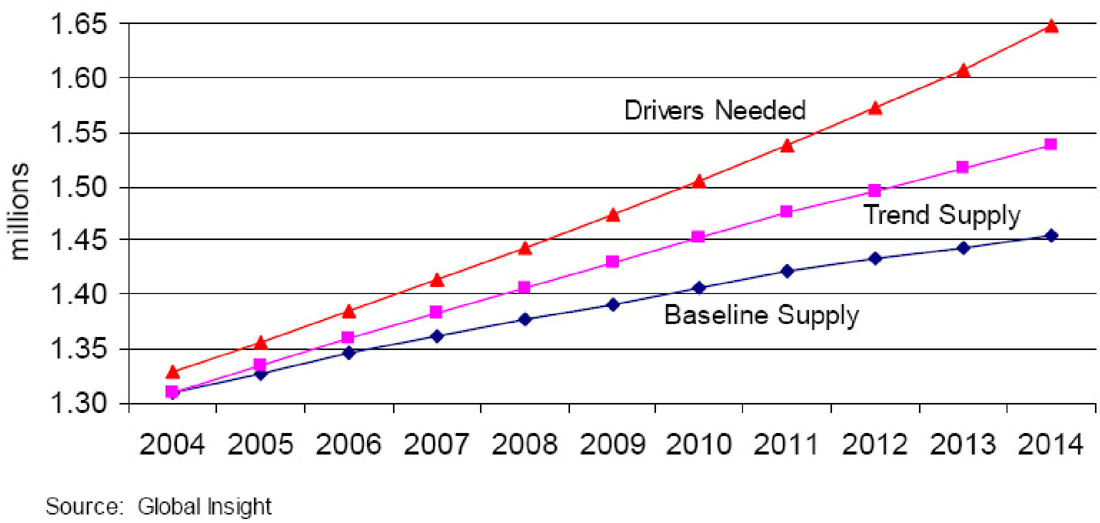


Figure 3.1: Potential Supply-Demand Imbalance for Heavy-Duty Truck Driver Jobs[21]

The demographics of the U.S. in the next 10 years will present another challenge to the trucking industry. White males 35-54, over 50% of all truck drivers, will decrease by 3 million between 2004 and 2014 [21]. There is already a shortage of long-haul heavy-duty truck drivers equal to perhaps 1.5% of the over-the-road driver workforce. Closing this gap implies attracting a higher share of the labor force into the truck driving occupation. And the primary means by which more workers are drawn into long-distance trucking is higher wages. If the trucking industry is to fill the impending driver gap anticipated over the next 10 years, earnings in the industry must be competitive with other sectors [21].

A critical element in the current truck driver shortage is the competitiveness of wages in the truck transportation industry. Average weekly earnings in long-distance trucking were above average earnings in construction throughout the 1990s but fell below construction earnings by 2001 and were still 1% lower in 2004. In a large portion of the industry literature, a large portion of the owner-operators of trucks cannot make enough on their current jobs to recapitalize once their vehicle reaches the end of its service life.

3.2 Railroads

3.2.1 Railroads and Congestion

Recently railroads have been getting more and more attention with respect to congestion and the looming increases with respect to worldwide trade and freight. The economic downturn of 2008 and 2009 may put a damper on the expected growth in the immediate future, but growth will happen nonetheless. Michael Ward, the CEO of CSX cited a DOT study that forecast the need for a $5 trillion investment over the next 15 years to improve and maintain the highways. He observed, quite obviously: “People are going to have a hard time coming up with that money.... That can be positive for our industry [8].” Indeed it can be positive for the railroad, but can they handle the demand?

The answer is most likely “no,” since the rail industry is suffering from serious congestion itself. One-rail lines and large volumes of freight are causing thousands of carloads to sit on sidings daily with nowhere to go. Rail industry analysts expect the problem to worsen over the next ten years. The slowdown on the rails will, in all likelihood, lead to higher shipping costs. The U.S. Chamber of Commerce, as optimistic as the Federal Highway Administration, expects at least a doubling of freight over the next 25 years [49].

Randy Mullett, an analyst for the nonprofit Transportation Research Board states: “Even if the estimates are half wrong, we can’t put even 25 percent more freight in the system right now without serious implications.”

3.2.2 Railroads and Public Money

The rail industry desires to invest in its own infrastructure, but only partially. Railroads are seeking a 25% tax credit to help them recoup the costs of their new infrastructure [44]. This may be good for the rail industry; however, the results of that kind of investment would only be accessible to the railroads. It also raises the issue of the good chance that the profits generated (even at modest levels) from that increase in capacity would cover the costs of construction (and if so, probably many times over).

To attempt to cope with the increased traffic, railroads are expanding at a rate not seen since the end of World War I. To fund this expansion, railroads are turning to federal and state governments to partially foot the bill [44]. For one Norfolk Southern project, estimated at $260M, the Federal government is paying $125M and the states involved are invested for another $38M. All told, the public is paying for 63% of a project that may not necessarily provide the infrastructure they need to reduce traffic and/or keep up with rising freight demand. Cambridge Systematics has produced a study for the Association of American Railroads. The study estimates that $148B (in 2007 dollars) will be needed in the next 28 years to keep pace with the growth of freight and international imports [7].

3.3 Seagoing Cargo

Coastal shipping could be a key part to an urgently needed national, comprehensive and strategic transportation vision [5]. The Congress has paved the way to using the seas as a portion of the solution to the transportation crisis. The Energy legislation referred to in Chapter 1 allows the Maritime Administration to designate water routes as Highways of the Sea, opening them up to other avenues of finance and support. As an example, the State of Alaska designated the water route known as the Inland Passage as the Alaskan Marine Highway and included it as part of the highway system [2].

Those concerned with the shipment of freight in the United States will need to reevaluate their positions in the near future. Larger ships with huge capacities and deeper drafts will dominate the container shipping markets (although as this document is being prepared, they are mostly entering layup due to tough economic times). The Panama Canal expansion project will bring new volumes to the East Coast of the United States as California and other West Coast ports (with price, environmental and labor issues dominating) allow competing ports to take an advantage. Over the next 20 years or so, most shipping industry analysts/aficionados expect a doubling, if not a tripling of container volumes. With this dramatic increase in shipping volumes, some studies show that current systems will be too congested to handle this jump in volume [30].

Even if the roads and railroads could handle today's traffic efficiently, there needs to be a concerted effort in the near future to find alternate ways to accommodate this anticipated freight in an economical, efficient and ecological way.

There is unsung transportation capacity in the United States. MARAD reminds shippers that there are tens of thousands of miles of navigable waterways and coastlines in the United States that represent "capacity" [32]. The only problem with this argument is that that capacity is undredged.

For other corridors where additional capacity is needed, small investments in parallel water routes can give shippers an alternative and let lawmakers and the populace recognize that redundancy is good with respect to failing infrastructure, rising freight volumes and terrorist threats [2]. Short Sea Shipping is good because it can be reliable due to its relative independence from traffic and other transit concerns.

Metropolitan Planning Organizations (MPO) are transportation policy making organizations that combine government, populace and industry in metro areas to plan expansion, propose projects and channel federal transportation funds to the transportation in their purview. These MPOs can use the Marine Highway to pool their money and efforts to reduce congestion on their roads and the impact that 12-15% of the traffic that is trucks that pass through their jurisdiction over which they would normally not have control [15].

LGEN Kenneth Wykle (ret) estimates that investing $2B in coastal shipping and ports could take 700,000 trucks from I-95 and I-81. By comparison, $8.5B to widen I-81 through Virginia would add a few hundred lane-miles and keep those same 700,000 trucks on the road

[12].

Congress, through the Energy Bill is beginning to see the economic, environmental and security benefits of Short Sea Shipping [24]. Former MARAD Chief, Connaughton, touts what may be the biggest impact of the Energy bill with respect to Short Sea Shipping:

> There are now regulations, via the Energy Act [Energy Independence and Security Act of 2007 (P.L. 110-140)] that allow for the set-up of programs and projects for short sea shipping similar to those for interstate highways and have access to additional Federal funds [15].

Erik Johnsen, director of International Shipholding Corp maintains that significant funds are expended just to maintain the interstate system while insufficient attention is given to the marine highways. He goes on to state that SSS only requires government incentives that cost less than highway maintenance and, when established, can remove trucks and trailers in large volume [30].

Table 3.1 shows the relative emissions of the different freight transportation modes in the United States. In all cases, waterborne freight is less polluting than either truck or rail transport.

Emissions (grams/ton-mile)				
	HC	CO	NO_x	PM
Inland Towing	0.01737	0.04621	0.46907	0.01164
Eastern Railroad	0.02419	0.06434	0.65312	0.01624
Western Railroad	0.02423	0.06445	0.65423	0.01621
Truck	0.020	0.136	0.732	0.018

Table 3.1: Summary of Emissions[9]

Interviewees in the I-95 Corridor Coalition Study indicated that SSS would be a great alternative and perhaps have great cost-benefits, however it needs to be proven to entice shippers to use it. More studies and demonstrations must be done [6].

Chapter 4

Short Sea Shipping Barriers

4.1 The Jones Act

The first issue, the Jones Act requires that ships engaged in intra-U.S. coastal trade be of U.S. manufacture as well as their ownership and crewing to be predominantly U.S. personnel. This act has been the most significant element of maritime policy that has kept the U.S. merchant marine alive. It ensures that the U.S. maintains a presence in the worldwide seagoing merchant trade. It also keeps U.S. shipyards in business, but at a huge penalty. This act, although it has many critics, will most likely not be repealed or be allowed to be circumvented except in dire need.

4.2 U.S. Shipbuilding

The second barrier is an offshoot of the Jones Act issue. The shipyards and the shipbuilding industry as a whole, as stated before, are smaller than once they were. Larger yards have been consolidated mostly between Northrop Grumman and General Dynamics, companies of military contracting fame. These shipyards exist primarily because of their role in military ship design and construction. Other yards capable of such construction have been closed and have become the trade terminals they once served.

As the industry shrinks, the yards lose their competitiveness with the loss of economies of scale. They also lose the skill sets that are essential to efficient and effective shipbuilding. There are scant few yards capable of building Jones Act ships in the United States that aren't already busy with military contracts. On the West Coast of the U.S. there is Todd Pacific Shipyards in Seattle, WA that once built the Oliver Hazard Perry class frigate, but has lost, in large part, the skilled laborers needed for shipbuilding. In San Diego, National Steel Shipbuilding Company or NASSCO has and continues to build large commercial ships as well as some of the sealift ships discussed earlier. On the East Coast, one of the only shipyards capable of building large commercial ships, other than those currently engaged in military contracts, is Aker yards, a subsidiary of a Norwegian shipbuilder, in the ex–Philadelphia Navy Yard. This yard, though once complete with its Jones Act replacement order book, will most likely shrink in scope. Smaller shipyards may, with some large capital investment, may be able to increase their production capabilities to serve a rapidly expanding Jones Act fleet, if needed.

An even more concerning problem is that a medium-to-long range Roll-On/ Roll-Off (RO/RO) service would require multiple ships, depending on the length of the journey, to ensure frequent and reliable service. The construction of these ships in an optimally efficient yard could take upwards of two years, not counting order book backlogs. Essentially, a SSS operation could be waiting two years without revenue to optimistically be only one-fifth of the way towards a fully functioning liner fleet.

In the opinion of Ernst Frankel, productivity in U.S. shipyards is lagging mostly due to management's inability to include new technologies into design and construction and a poorly trained workforce [46]. Another lesson on this tack can be the lesson of Toyota production and continuous improvement. The work of Deming in post WWII Japan has proven itself many times over with the extraordinary successes of Japanese manufacturers.

Shipbuilder problems stand in stark contrast to U.S. innovation in the shipping industry. The United States introduced containerization, Liquefied Natural Gas (LNG) ships, Oil/Bulk/Ore (OBO) ships and quality leaders embraced in post-WWII Japan manufacturing like Ludwig and Deming [25].

"Cheap foreign labor" was always cited as the reasons for the cost of U.S. built ships when that isn't necessarily the case. In recent years, foreign labor rates have begun to exceed U.S. labor rates. In the case of relatively the same ship built in Japan and the U.S., the U.S. version takes 5 times the engineers and double the production to build the ship at poorer quality [25]. In the U.S., serious cost, schedule and quality issues keep the U.S. shipbuilders from being competitive: 2 to 3 times as expensive as a Korean built ship [25].

Frankel echoes this sentiment when, in 1996, he stated "It is a basic finding of economics that government subsidies, aids, protection and regulation of an industry will cause its productivity to decline [26]." He goes on to indicate that the structure of the U.S. maritime industry and the shipbuilding industry is to blame for its decline, not costs related to construction and manning [46].

4.3 U.S. Merchant Marine

The numbers of U.S. merchant mariners have been steadily declining over the years as fewer people replace those retiring. This is a concern of nearly all shipping companies around the world who see a critical shortage of qualified "quality" personnel. The Chairman of the subcommittee reviewing the International Maritime Organization's (IMO) rules on crewing and training defined human resources as the most significant challenge to international shipping now, and in the future [35]. Additionally, security, particularly the Transportation Worker Identification Credential (TWIC), is thinning the ranks of qualified mariners.

The U.S. Merchant Marine Academy and the state maritime academies are attempting to keep up with the demand; however their graduates are usually concentrating on deepwater trades, leaving serious gaps in coastal and river shipping. To add to the difficulty, the training ships that the state schools use are aging and are in need of refurbishment or replacement [47].

4.4 Harbor Maintenance Tax and Dredging

4.4.1 Harbor Maintenance Tax

The Harbor Maintenance Tax (HMT) is a legislative issue that hinders the use of SSS in the United States. The HMT assesses goods landed at U.S. ports as to the value of the goods. The HMT was created to gather monies for the Army Corps of Engineers' dredging operations in U.S. ports. Currently, the HMT assesses 0.125% (or $125 per $100,000) of the value of the cargo once unloaded in the U.S. This tax not only affects the goods imported, but also impacts those import goods transshipped by sea from one U.S. port to another. According to a GAO estimate in 2007, the current surplus in the HMT account is approximately $4.7B, and expected to grow to $8B by fiscal year 2011.

An illustration of the HMT's impact is the Detroit-Windsor ferry. The ferry operates "international" service by ferrying trucks across the Detroit River to Windsor, Canada. Trucks wanting to avoid the traffic at the bridge border crossing may take the ferry (significantly reducing crossing time); however those entering the U.S. by this ferry are subject to the HMT, while trucks crossing the bridge are not. Similarly, goods entering the port of Long Beach, CA from overseas are assessed the HMT once landed, but if they are loaded on a ship to Seattle, WA, these same goods are assessed the HMT again once they land in Seattle.

Congressman Cummings has introduced a bill in Congress to amend the Harbor Maintenance Tax law [43]. This shows promise, however, as noted previously, measures like this have been on the Congressional calendar for the past 6-7 years with no result. Former Secretary of Transportation, Mary Peters stated that the "Harbor Maintenance Tax is the most significant impediment under current law to the initiation of [SSS] [17]."

4.4.2 Dredging

Many organizations believe that the condition of U.S. ports and waterways is reaching a crisis [19]. Low water levels in the Great Lakes and poor dredging hurts the shippers. Ships hauling ore on the lakes must leave port with an average of 6400 long tons of capacity unfilled due to reduced drafts in the ports they serve [31].

In fiscal 2007, the Harbor Maintenance Trust Fund (HMTF) collected approximately $1.4B while only $751M was appropriated by Congress to fund the U.S. Army Corps of Engineers' dredging efforts [19]. In fiscal 2000, the HMTF collected $760M and 83% was spent on dredging. By fiscal 2007, spending on dredging had fallen to 53%. Federal harbors and waterways cannot be adequately maintained at current U.S. Army Corps of Engineers funding levels [3].

Dredging costs have skyrocketed with environmental mitigation, crewing, barges, fuel, steel, what to do with the spoil and various other issues [3]. Congressman Jim Oberstar, in 2007, had heard the call and was advancing the agenda of increasing the dredging budget to $88M per annum [31].

Gulf and East Coast ports are expecting a spike in business when the Panama Canal Extension is completed in 2014, however measly dredging appropriations threaten to place a choke-hold on their competitiveness [3].

4.5 Funding

In the not too distant past, ship owners and companies desiring to enter the sea shipping trade were able to raise capital privately and be aided by the Federal Government with a mortgage guarantee known as Title XI mortgage insurance. Title XI is a part of the Merchant Marine Act of 1936 that established the Federal Ship Financing Guarantee Program to assist private companies in obtaining financing for the construction of ships and the modernization of U.S. shipyards [37]. Where these guarantees are available, interest rates encountered are invariably lower for the shipowners.

In the current political climate, however, the mortgage guarantees appear as none too subtle subsidies to the shipping industry. This is evidenced by the Maritime Administration's reluctance to issue Title XI guarantees. Between 1985 and 1987, 129 Title XI defaults cost the government nearly $2B [37]. The Federal Credit Reform Act of 1990 imposed stricter requirements on the issuance of these guarantees, improving their performance until between 1998 and 2002, nine Title XI loans defaulted. These defaults combined with the "credit crunch" and sub-prime loan failures, will most likely make lending requirements even more strict.

Shipping incentives in the United States have had a semi-sordid past. Most recently (and most importantly since it is fresh in the mind of the government and lawmakers) the failure of American Classic Voyages was a black eye for MARAD which was required to complete a $367M obligation when a Title XI loan guarantee had to be settled in 2001 [38].

U.K. government makes monies available to waterborne freight companies to assist with operating costs when trucking is the cheaper option [40]. The government, however, is having great difficulty in getting people to take these grants. The process associated with the grants and the requirements for receiving them are just too bureaucratic: ...[T]he rules associated with the grant just don't make them worth the effort [40]."

4.6 Public Awareness

The last barrier is the lack of public awareness of seagoing trade. The average American is woefully unaware of the fact that nearly everything they use on a daily basis was transported to them by sea. The near total transparency of the operation of the world markets to the U.S. consumer is astounding. Even more astounding is the lack of governmental support of local shipping.

States, municipalities and even the federal government see SSS as merely added congestion to their roads rather than the reduction of that congestion. They see increased pollution rather than a more efficient and less polluting transportation mode (on a ton-mile basis) than the modes they currently employ. Added to this is the relative reluctance of the shippers to use the sea, the Marine Highways. There clearly is a lack of public awareness of the benefits of SSS: economic, financial and environmental as well as its role in reducing congestion that needs to be addressed by the current and potential SSS industry.

Chapter 5

Short Sea Shipping Barrier Removal

5.1 The Jones Act

This barrier is one that will most likely never be removed even though it places a huge financial burden on companies desiring to be in the U.S. SSS trade. The Jones Act has caused some inventive people to find ways around building large ships. For instance, as discussed in Section 4.2, the U.S. shipyards, the majority of which are small, have moved to the construction of smaller ships for the Gulf of Mexico oil-rig service industry and oceangoing tugboats. These tugboats are the predominant traders in intra-U.S. trade. Tugboats and barges are cheaper to manufacture, certify and crew; and since the lion's share of seagoing cargo is non time-sensitive bulk materials, speed is not a concern. Tugs and barges, however are a stopgap measure in the movement of cargo now and in the future.

5.2 U.S. Shipbuilding

The shipyard issue is probably the most difficult to overcome. The United States, despite the best efforts of the Jones Act, has allowed the U.S. Merchant fleet and the associated shipbuilding and ship repair to seriously atrophy almost to the point of its demise. As mentioned earlier, in 2002 approximately 70 percent of the monies spent on ship repair and ship construction in the U.S. were spent by the U.S. military. The shipbuilding industry, especially if it is going to build all the ships necessary to fill the anticipated transportation gap, needs to become more cost competitive (and by extension, more efficient) with the rest of the world.

As an intermediate measure, RO/RO SSS can be begun on small scale by using ships that the government has and maintains in reduced operating status (discussed in Chapter 8). These vessels may be leased to operators and operated and maintained by the lessee. The few vessels used in this way could establish sound cost comparisons for SSS to competing modes of transportation while the U.S. shipyards build vessels better suited to the commercial trade. Once the concept has been proven, and profitability can be demonstrated, investors can be drawn to the SSS operators and follow-on ships can be built, improving both the capacities of the existing yards as well as letting ship owners take advantage of economies of scale.

A short-term measure that will improve the public perception of SSS as well as clear the roads and rails of some cargo is using smaller container ships that are available now. This part of the solution does not really help the Military Sealift Command (MSC) maintain its worldwide logistics mission; however, it is a first step towards a successful, and thereby profitable, domestic SSS market. Currently, Horizon Lines is working to develop a "Coastwise Container Feeder Network" to carry out this very solution [50]. The recent interest in short sea shipping could revive, or at least provide a foothold to an industry that was once proud and booming, and an aid to help the economy, ecology and the infrastructure of the United States [25].

Among the smaller shipyards in the U.S., few have dealt with the federal government (the U.S. Navy): change orders, cost-plus contracting and suffocating bureaucracy [26]. This is a positive development, since these yards could provide the revitalization that the industry needs. Many of these shipyards have, by necessity, become leaner: lean management, logistics and production. They have also devised builder-friendly designs that have proven themselves in the offshore oil and gas industry [26].

An overhaul needs to take place within the shipyards: production planning, worker training, shipyard management, design and process integration all need to be improved. Frankel estimated, in 1992, that a 35-40% increase in productivity could decrease cost by approximately 15-20%. Additional decreases in construction times could decrease costs by another 50% [46].

Government incentives for shipyards, although they may be desirable on paper, may prove to be disastrous. The shipyards should be able to compete on their own merit in the global shipbuilding business. Initially, the shipyards may need propping-up, however, they should actually be given *dis*-incentives to keep accepting government grants and subsidies. Shipbuilders should abandon the protectionism that undermines their competitiveness and embrace the opportunity to reinvent and reestablish themselves by building a new fleet [5].

5.3 U.S. Merchant Marine

Some steps in helping to revitalize the U.S. merchant marine workforce have already been taken. Plans are in place to expose high-school students to jobs at sea. MARAD is working with a maritime high school in Baltimore to upgrade its curriculum [47].

This is a very small start, and filling the need for mariners will take a concerted effort, not to mention a lot of money. Higher wages is a sure way to entice young people to go to sea.

5.4 Harbor Maintenance Tax Mitigation

There are planned remedies for the HMT and its applicability to domestic trade, specifically (*2009 proposed legislation*): S. 551, "A bill to amend the IRS code of 1986..."; H.R. 528, Short Sea Shipping Act of 2009; H.R. 638, Short Sea Shipping Promotion Act of 2009. These pieces of legislation attempt to remove the HMT for domestic transshipment of cargo.

There is small hope, however for these amendments to the HMT. Bills have been introduced in past sessions of congress going back to the 107th Congress (2001-2) to address this concern; however none had been scheduled for debate, much less become law.

The U.S. Congress may have failed to act on the resolutions entered in the Congressional Record due in large part to a U.S. Government Accountability Office (GAO) report issued in 2005. This report characterizes MARAD's Marine Highways Initiative, and its push to employ public funding to the issue, as premature [54]. It expresses concern by the use of two examples of SSS currently available in the U.S.

The GAO believes that the issue, especially federal involvement, requires greater research in whether the benefits touted by the industry and MARAD would, in fact, be realized. Additionally, GAO believes that federal involvement without adequate estimates of the ramifications, may artificially distort the marketplace, and prop-up an industry that may not be able to support itself [54].

The Government Accountability Office is correct in its assertion that more research needs to be done. The marine highway is a sound enough concept, however whether it is a viable alternative to other transportation modes, and whether the industry can sustain itself without excess government support is yet to be determined. The Harbor Maintenance Tax reduction or elimination where domestic shipping is concerned should not be considered a federal investment, but rather a removal of a barrier placed in the way of a freely operating market.

The Harbor Maintenance Tax however may not be long for this world. Challenges to the HMT may be raised on the bases of the North American Free Trade Agreement (NAFTA) and by the World Trade Organization (WTO). In 1998, the HMT applied to exports was declared unconstitutional and similar arguments may be entered to nullify it. A compounding problem with the HMT fund is that its income grows from taxes and earmarks, but its expenditure must be appropriated [54]. This, combined with environmental issues of dredging and waterside work as well as the inability of dredging companies to do the work in a timely manner, places the Army Corps of Engineers in a difficult situation with deteriorating navigational waterways and deteriorating ports.

5.5 Funding

5.5.1 Title VI

MARAD's other funding program, the Capital Construction Fund (CCF) or Title VI, enabled qualified U.S. citizen operators to accumulate equity for fleet replacement on a tax deferred basis and to access private sector commercial vessel financing through a program of financing guarantees.

The Title VI program is currently limited to vessels for operation in the U.S. foreign, Great Lakes or non-contiguous domestic trade. Thus, it currently excludes SSS ships, but MARAD is proposing the expansion of the CCF program to include contiguous trades as well as mobile offshore drilling units.

H. Clayton Cook, a Washington attorney and former General Counsel of the U.S. Maritime Administration from 1970 to 1973, suggests that using both the Title VI and the Title XI program could provide dramatic benefits to the shipowners. [11] MARAD suggests that companies can use funds already on deposit in a CCF to fund the construction of the Marine Highway system.

Usually, the CCF was meant to be used for a company to recapitalize its fleet, but this is not the case in this scenario. Alternatively, the CCF funds can be used by a company that isn't planning on using the funds before the tax deferral period expires. This company can contract to build a new vessel for long-term charter or sale at shipyard delivery. This structure can save the company with CCF funds on deposit from penalties, and a portion of the savings can be used to reduce the cost of the ship to the "resale" purchaser. [11]

5.5.2 Title XI

The Maritime Industry could figure a boon in the 2009 Stimulus Package with already $47M in Title XI guaranty program. There also is new tax legislation that will allow U.S. Shipowners to repatriate earnings tax-free to invest in new ship construction [33]. House Transportation and Infrastructure Committee Chairman, James Oberstar, is credited for including this money for MARAD Title XI shipbuilding loan guarantee program and the American Shipbuilding Association is lobbying to secure it [45].

More care must and will be taken with the issuance of these guarantees. With recent failures noted earlier, the Title XI program will be under serious scrutiny.

5.5.3 Other Funding

Paul Bea, a government relations advisor specializing in transportation and the chair of the Coastwise Coalition, spoke at a Marine Highways roundtable in 2008. He suggested that the government open the Transportation Infrastructure Finance and Innovation Act (TIFIA) and the Railroad Rehabilitation and Improvement Financing (RRIF) program to water transportation infrastructure. This could be a good source of funding for the SSS industry [2].

While many may think that a particular industry would benefit from governmental funding, local port authorities (and the people and local economies they serve) would benefit should they be given money to improve the portions of infrastructure in their charge (piers, viaducts, collector roads, etc.) [30].

Trucking companies could also be given incentives to use SSS as perhaps a link in a coordinated logistics plan [30]. This would alleviate some of the concern that these companies are having with finding long-haul drivers. These companies can, in accordance with their increasingly local business models, send cargo without having to commit drivers to long trips.

5.6 Public Awareness

This issue is somewhat complex since it really does not concern the ultimate consumer of transported goods, but rather the shippers and freight forwarders. Most of these customers are currently in long-term shipping arrangements that have proven adequate to their needs. The difficulty lies in convincing shippers that changing these arrangements and using SSS is beneficial to their business. Education though, should not be limited to the shippers, but it should also extend to the education of government officials (federal, state and local) so as to gain advocates at all levels [36].

Lastly, efforts to bring the SSS discussion to the fore should extend to the people as a whole. The shipping industry can improve its image and tout the environmental and efficiency benefits of waterborne transportation much like the railroad currently does.

5.7 The Way Forward

The suggestions contained above are broad in scope and require more research to gain enough granularity on the subject to be able to make informed and adequate decisions. That said, the obvious barriers preventing SSS from becoming the norm are not insurmountable, however some will require much work and even more money.

As discussed, the most difficult portion of the SSS problem is collecting, converting or constructing enough qualified vessels to make a RO/RO service a reality and a financial success. If SSS becomes the avenue for growth in the next decade and a half, the United States shipbuilding industry could see a rebirth to profitability and a stake in the worldwide shipbuilding industry.

Financing is the second most difficult arena. Once investors realize that the transportation infrastructure is too outdated for the volumes of traffic and the efficiency of seagoing commerce is understood, financing will follow the profitability of such a venture. The difficulty remains, however, of finding the first dollar ventured.

The last issue, categorized by legislation and specifically the Jones Act and the Harbor Maintenance Tax, are the least worries of potential operators in this type of venture. The Jones Act will most likely not be repealed, however the HMT may be mitigated, eliminated or take some other form so that tax can still be collected appropriately. If the legislature fails to act, and the operators can prove profitability, both pieces of legislation will not be so much of a “barrier” but a hindrance.

Chapter 6

Business Structure

Many people have voiced their concerns with respect to the qualities and attributes of a Short Sea Shipping Service. This chapter addresses these concerns and attempts to provide a bounding framework for such a service.

6.1 Characteristics

The Jones Act, as stated before is a major hurdle for a SSS service. All ships that conduct this service must be Jones Act qualified and employ American mariners. This requirement, in place since 1920 and credited with keeping U.S. shipping alive, will most likely not be circumvented. The Jones Act will prove a difficult challenge, however, it will give the shippers a selling point for raising public capital. By starting a service like this, the companies can claim that they are creating hundreds of American jobs (if not thousands, when one counts the shipbuilders and longshoremen).

A SSS service could also prove a blessing to the Merchant Marine Academies, since they can serve as training vessels for the cadets at these schools. As mentioned in Section 4.3, the training ships for these schools are aging and in need of repair or replacement.

A second characteristic of this service must be its frequency. Cambridge Systematics, in its report for the I-95 Corridor Coalition, agrees that this is one of the most important aspects of the service [6]. In order to meet goals of congestion reduction and pollution reduction, service needs to be such that it can make an impact on these issues. Initially, service needs to be daily, such that the operators can prove reliability and schedule adherence. Once profitability and can be shown and a demand for such a service can be determined, a second sailing per day can be introduced on the heaviest days.

Next, SSS must have effective and efficient access to intermodal transportation. New terminals constructed, or those that could be used for this service, must have unfettered access to major roadways and trackways and be located so as not to exacerbate the congestion that the planners are trying to eliminate. These intermodal connections would also provide the service's potential customers. If the service is difficult to use or difficult to get to, transporters will not choose it.

There must also be guaranteed berth availability where the SSS desires to serve. Some of the larger ports have priority arrangements with regards to berthing availability. In order to keep a consistent schedule, the SSS service must not be turned away from a port-of-call. To solve this, the ferry must choose smaller ports where berthing can be guaranteed, or purchase or lease berth and laydown space.

Along with port issues, there must also be access to a large enough pool of stevedores. The plan for loading and unloading the ships needs to be determined so as to be able to estimate the longshoremen required, but they must be available in order to efficiently load and unload the ferry. This issue can also prove to be valuable political capital, in that it brings more jobs to smaller ports.

Lastly, there needs to be adequate access to capital. The Title VI and Title XI programs can help with lowering the final cost and interest rate respectively; however, the company needs to find private or corporate entities willing to invest in this transportation project. If governmental programs exist to allow for tax benefits for investors, perhaps more can be enticed to invest. An effort also needs to be made to make sure that there are no impediments; local, state or federal regulations, that would make SSS more expensive than land transport [30].

To be successful, SSS must have reliability, price competitiveness, frequency of service and cargo/passenger safety and equal or faster delivery times against existing transit modes as well as cooperative port authorities [30].

6.2 Recent Developments

In the area of short-sea shipping there has been some positive developments in the area of Short Sea Shipping. Although some companies have been doing it for years, other shippers are just discovering the benefits of such a service.

Some U.S. companies are attempting pilot programs in the U.S. short sea shipping market. Horizon Lines, an American Shipping line, is attempting to use some of its spare vessels to break into coastwise shipping and attempt to take trucks off the road. Horizon's CEO, Charles Raymond states:

> Gateway ports with deepwater will serve the large containerships and primary metropolitan consumer markets. Regional ports will provide the intermodal safety valve served by a network of smaller container vessels and RO/RO ships, offering fast connections to local markets [41].

Horizon Lines has five unemployed vessels in the 1200 to 1500 TEU (twenty-foot equivalent unit[1])range as well as some newer 2800 TEU ships that can be committed to the company's goals SSS [42].

Other entrepreneurs see short sea shipping as a great opportunity. One waterfront developer in the Port of New York/New Jersey indicated, "...Many industry observers view short sea shipping as the key to transportation growth in the coming years." The same developer went on to state "...I expect most of the traffic to come from goods being moved between East Coast ports on smaller vessels in order to avoid land-based congestion." He plans to rehabilitate a dock and add 2000ft to a pier on the Raritan River near Port Elizabeth, NJ. The facility was expected to be in operation in late 2008, however current economics may have put a damper on the construction [14].

[1] A shipping container with dimensions:20'x8'x8.5'

The James River Barge is another example, a pilot program for the Marine Highways. It takes containers from Hampton Roads, VA to Richmond, VA bypassing truck transport via I-64. The maiden voyage for this service was December 1st, 2008[15] and since then has enjoyed a faster-than-expected growth, so much so that break-even is expected in the first year. The James River Barge was helped with a $2.3M grant from the federal Congestion Mitigation and Air Quality program[1], perhaps another source for funding support.

As another recent example, International Shipholding Company (ISC) has begun a U.S.–Mexico rail car ferry. To accomplish this, ISC constructed railways and other mode-specific gear at the ports they serve. Their success was due to pairing with cooperative port authorities [30].

In its Marine Highways program, MARAD desires to incentivize startup companies that measurably reduce congestion/pollution; to quantify benefits of increased waterway use. MARAD also desires to spur investment in new vessel technology and to remove/reduce impediments. Lastly, it desires to revise legislation like the Harbor Maintenance Tax and the Inland Waterway User fund in order to efficiently and equitably collect funds to modernize waterways and port facilities [32].

6.3 Further Studies

This paper makes use of open-source data to make first approximations on the feasibility of a Short Sea Shipping service. There are, of course, some shortfalls in the methods and data used. Some of the data are not specific enough to have high confidence in the results, but rather are used to extrapolate the costs and revenues of such a service.

The following section highlights some of the issues that shipping executives and government appointees have raised with regards to further studies and other information-based issues with Short Sea shipping.

The Department of Transportation provides a large amount of data related to freight and its movement in and among the states. A vast amount of information was found at the Department of Transportation, Freight Management and Operations' Freight Analysis

Framework (FAF) system. The FAF site, `http://ops.fhwa.dot.gov/freight/freight_analysis/faf/#faf2trk` provides commodity origin-destination data as well as highway and truck data. This data is an excellent starting point, although it may not provide the specific data on which ship owners would base multi-million businesses.

Erik Johnsen, in a speech he gave on 16 April 2008, covered topics of concern to Short Sea Shipping. He pointed out, in light of the same studies his company ISC, had conducted prior to beginning its rail ferry service that an analysis of freight volumes can aid in ship size decisions and terminal requirements [30].

Trade patterns need to be developed; ports & facilities need to be located or built. These trade patterns will show markets for exploitation as well as premiums charged for differences in origin – destination [30]. This can also be extended to price discrimination with regards to shipper's willingness to pay, but not so much as to price. As trading patterns and freight volumes continue to increase; as regional distribution of trailers and containers rise, a review must be conducted to help fuel savings and take pressure from existing infrastructure [30].

To ensure a certain level of business or cost coverage, contractual agreements between the Short Sea Shipper and rail/trucking companies should be arranged from the outset. Fenimore, president of Columbia Coastal Transport, doesn't envision growth in the SSS segment "... until carriers, shippers and consignees have some kind of financial incentive or tax credit to make them want to change the way they do business."[18]

The goals of the operator with respect to the truck ferry should be to show:

1. on-time performance
2. measurable congestion reduction or congestion status-quo with rising shipping volumes
3. measurable infrastructure benefits
4. if possible, measurable environmental benefits
5. profitability in order to raise capital for new ships

Ship and port design needs to be considered in order to maximize flow through ports, minimum loading and unloading times as well as minimum manning so as to keep costs low.

Some ideas for port and ship configurations were presented in a paper from Louisiana State University (LSU) and are discussed in Appendix D[39].

6.4 Chapter 6 Conclusion

Many hurdles have been presented, however there are many opportunities as well. To start a SSS truck-ferry service, the considerations are legion: level of service, frequency, volume, costs, cost-competitiveness in pricing, the list is endless. However, with a solid framework and business model as well as a method to reduce the financial impact of failure, the benefits of the Marine Highway could be tested.

The first concern with a seagoing shipping service must be, of course, ships. The pages of the shipping and naval architecture related scholarly journals are filled with every flavor of RO/RO ship. Unfortunately, these ships are manufactured mainly in shipyards outside the United States. Thanks to the Jones Act, the construction of these ships must be in the U.S., most likely increasing their cost by 150%-200%.

This is an unavoidable consequence, but may provide the beginning of a resurgence of U.S. shipbuilding. The operation of European shipbuilding companies in the U.S. is not without precedent. Aker shipyards, a foreign ship manufacturer, has started operations in the United States in order to build Jones Act vessels. This could possibly open the door to other manufacturers as well as provide a model for existing U.S. shipbuilders or other "brownfield" projects.

New ships are preferable to using older ships. The maintenance on newer ships is understandably less, the configuration can be tailored to the industry using the ship, and new technology can be more effectively applied to new-construction rather than retro-fitting old ships. However nice and preferable new ships are to old ships, they take time and money to build.

As was discussed earlier, frequency of service is paramount in a truck-ferry or most other coastwise cargo trades. At least a daily service is needed to provide the desirable effect. Most ships take about 18 months from keel-laying to delivery; if ships could be started every 9 months, it would take 7.5 years to accumulate a fleet large enough to serve the U.S. East coast on a daily basis!

There needs to be a way to jump-start this service and prove its profitability and usefulness without such a risky outlay of capital and investment in ship construction time. Fortunately, the U.S. Department of Defense owns and operates a large fleet of RO/RO (as well as other cargo ships) for military sealift. The vast majority of these ships are in layup or reduced operating status, that is to say, *unused*. Unfortunately, the majority of these ships are not Jones Act qualified ships inasmuch as they were not of U.S. manufacture. They were acquired by the Military Sealift Command from U.S. operators when those operators were going to retire the ships or the companies were going out of business. These ships were then and are still critical to MSC's mission, so they were purchased by the government and placed in layup. To address this, perhaps waivers can be granted with respect to these ships only, since they are owned by the U.S. government and must remain within 4 days of their loading ports.

The government has offered the use of some of these ships for such a service, but as of yet, no companies have accepted the offer. Using a few of the more efficient and more capacious of these RO/RO ships could provide an immediate start to the service. It could also save the government some of its Title XI funding and the shipbuilder large amounts of shipbuilding capital on an unproven business.

Chapter 7

Existing Sealift Ships

Figure 7.1: MSC Sealift Ships unload Operation *Iraqi Freedom* equipment in Kuwait *www.msc.navy.mil*

7.1 Sealift Ships

The United States, after World War II, decided to keep a large portion of its military forward deployed overseas in order to maintain global stability and to contain Communism. Since the fall of the Berlin Wall and the collapse of the Soviet Union, the United States has adjusted its strategy and repositioned all but a very small number of forward-deployed forces, while at the same time decreased the size of the force. The military now is mainly based in the continental United States with a mission to deploy rapidly overseas to counter any threats to the United States or her allies.

This post Cold-War strategy relies on one main aspect, transportation. Rapid, dependable, reliable and strategic transportation is a critical element in global power projection [57]. The U.S. Military maintains this capability by keeping large numbers of ships (already loaded with war materiel) stationed around the world. It also keeps larger amounts of ships in "reduced operating status" in places around the country. These ships must be manufactured, manned, maintained and scrapped when they are no longer needed or obsolete. This is a huge drain on the government's defense budget. There needs to be another way to provide this vital transportation capacity without spending such large amounts of money for under-utilized or non-utilized ships.

In August 2002, Military Sealift Command awarded Maersk Line, Limited, of Norfolk, Virginia, a five-year contract that could total $400M to operate and maintain eight large, medium-speed, roll-on/roll-off ships [23]. The ships concerned were forward deployed prepositioning ships. The award of that contract shows that they could cost approximately $10M per ship per year. Bob Hope class ships maintained in lay berth in the United States could be assumed to cost somewhat less. *GlobalSecurity.org* also reports that the Fast Sealift Ships of the Algol class are maintained in lay berth at approximately $4M per ship per year [22]. A safe assumption could be that the inactive sealift ships are maintained at approximately $6M per ship per year. This assumption, spread over 51 ships must be, conservatively, in excess of $360M per year. The 2009 DOD budget shows a line-item for "Navy Operation and Maintenance, Naval Reserve and Prepositioning Force" more than $650M. Judging by other

Figure 7.2: USNS Gordon (T-AKR 296) *Note sideport/aft ramps & cargo cranes www.msc.navy.mil*

“operation” budget lines, where maintenance accounts for at least half of the operational cost, $360M is an appropriate estimate

The cost of maintaining these ships that are not actively useful to the military or the economy, but rather a drain on resources may be mitigated somewhat by their use in everyday commerce.

7.2 Military Sealift Command Overview

This section is paraphrased from `http://www.msc.navy.mil`.

Military Sealift Command’s Prepositioning Program is an essential element in the U.S.

military's readiness strategy. Prepositioning of war materiel strategically places equipment and supplies aboard ships located overseas to ensure rapid availability during a major theater war, a humanitarian operation or other contingency.

Prepositioning ships provide movement of military gear between operating areas without reliance on other nations' transportation networks. These ships give U.S. war fighters what they need to respond in a crisis.

Military Sealift Command's Sealift Program provides ocean transportation for the Department of Defense and other federal agencies during peacetime and war. More than 90 percent of U.S. war fighters' equipment and supplies travels by sea. The program manages a mix of government-owned and long-term-chartered dry cargo ships and tankers, as well as additional short-term or voyage-chartered ships. By DOD policy, MSC must first look to the U.S - flagged market to meet its sealift requirements. Government-owned ships are used only when suitable U.S.-flagged commercial ships are unavailable. In some cases, this means that the government owned vessels are not used at all.

7.2.1 Large, Medium-Speed, Roll-On/Roll-Off Ships *(LMSR)*

A key part of MSC's surge sealift fleet includes 11 government-owned, contractor-operated LMSRs that support the U.S. military in times of peace or war. Each LMSR is capable of lifting more than 300,000 square feet of cargo and can travel at up to 24 knots.

LMSRs are ideal for carrying heavy armored vehicles and equipment used by the U.S. military. Each LMSR has a slewing stern ramp and a movable ramp that services two side ports, making it easy to drive vehicles on and off the ship. Interior ramps between the decks ease the traffic flow once rolling cargo is loaded aboard ship. Cargo can also be loaded onto LMSRs by shipboard cranes. This could allow for some deck space topside to be used for feeder-type operation of standard containers.

The LMSRs are ordinarily kept pierside in reduced operating status, with small crews aboard to maintain the ships, so they are capable of being activated, crewed and ready to depart their U.S. layberths in four days. A great statistic showing that these ships are ready to begin service immediately.

7.2.2 Fast Sealift Ships

MSC's surge sealift assets also include eight fast sealift ships, which were converted from what were formerly the largest and fastest container ships in the U.S.-flagged commercial fleet. All of the FSS, like LMSRs, are government-owned, and are operated by private companies under contract to MSC. Throughout their tenure with MSC, the FSS, like LMSRs, have ordinarily been kept pierside in reduced operating status with only small crews aboard. When needed, the FSS, each with a cargo-carrying capacity of 150,000 square feet, could be fully activated and crewed within four days.

7.2.3 The Ready Reserve Force

With a shrinking U.S. merchant fleet, the importance of ready and available surge vessels increases each year. 51 Ready Reserve Force ships owned and maintained by the Maritime Administration provide a resource to offset the shortage of militarily useful U.S.-flagged ships.

The RRF consists of fast sealift ships, roll-on/roll-off ships and other specialized ships. Maintained in four-, five-, 10- or 20-day readiness status, these ships are activated when needed for wartime, humanitarian and disaster-relief operations.

Most of the RRF's roll-on/ roll-off ships are maintained in a five-day readiness status, each with a nine-person crew aboard. RRF ships are maintained by MARAD at ports around the U.S. East, Gulf and West Coasts in close proximity to potential military loading sites.

Part II

Feasibility Study

Chapter 8

MSC Ships: Cost and Revenue

8.1 Analysis of Sealift Ships

8.1.1 Existing Sealift RO/RO Ships

The U.S. Navy and the Military Sealift Command, as stated in Section 7.1, owns and operates a large number of Roll-On/Roll-Off ships for contingency operations. The easiest way for a business like the truck ferry to begin (and test feasibility without an extended amount of capital investment in new ships) is to lease some of these ships from the U.S. Government for use as the first ferries. Military Sealift Command has offered the lease of these ships for this very purpose.

The lease of the ships is a good idea for both the lessor and lessee. The lessor, MSC, could allow these ships to be used rather than let them sit at layberths unused. MSC also gains from the upkeep provided by the lessee: classing inspections, propulsion plant maintenance, etc. The lessee benefits because he need not have an initial outlay of capital to build ships that may not prove to be profitable. These ships (although not perfect for the job) could provide a demonstration project for the system and allow investors and clients to see the benefits of such a service.

Service can bring the current sealift ships to the ends of their useful life and replace them with new construction ships that would, with new technology, fulfill the sealift goals of the military.

8.1.2 Availability of Useful Ships

The first step in deciding whether this ferry service is possible, let alone a good idea, was to identify RO/RO ships that are owned by the U.S. Government. All these ships could potentially be used for a truck ferry. Second, the ships that were in the "Prepositioning" program were then ruled out, since they are currently in use and deployed around the world with war material. A list of the remaining ships and their particulars are contained in Appendix B.

No other issues related to the current use or "deployability" of these ships were considered, since the number of "acceptable" ships (at least at first glance) is relatively large, and the large amount of ships allows them to be interchanged. Next, the material condition of the ships (working equipment: ramps, deck gear, ground tackle, main and auxiliary machinery, watertight closures) was also assumed to be acceptable, since these ships are purported to be able to sail in 4-10 days from activation. This may be a poor assumption due to past activation performance during Operation *Desert Storm*. Again, the large number of ships from which to choose allowed for the interchange of ships deemed unserviceable.

8.1.3 Propulsion Analysis

The propulsion plants of these ships were then compared. The horsepower and speed of these ships were obtained from multiple sources, though mainly from the Naval Institute Press' *Combat Fleets of the World* 88-89 and *Jane's Fighting Ships* 2002-2003.

These MSC ships are also beneficial since their main and auxiliary machinery is constructed to utilize the military's Diesel Fuel, Marine (DFM). This is important, since regulations are being contemplated or in place for at-sea emissions. Recently, the United States and Canada have proposed the implementation of Emission Control Areas (ECA) to coincide with the Exclusive Economic Zone (EEZ), 200 NM from the coast.

Since these coastal traders will operate almost exclusively in these new ECAs, they will need to utilize low sulfur fuels (a difficult issue if one were using traditional bunker fuels). A different matter, however, would be the control of particulates and nitrogen that they emit. There will, however, be compliance periods for these regulations allowing these ships to be operated for a period before they are subject to limits.

8.1.4 Fuel Consumption

Fuel consumption per round-trip voyage was calculated from horsepower, speed, as well as nominal specific diesel fuel consumption rates combined with a typical voyage distance (discussed in Section 8.4 below). The specific diesel fuel consumption rates used were: 0.475 lb/hp-hr for a steam plant, 0.305 lb/hp-hr for diesel plants, and 0.410 lb/hp-hr for gas turbine plants (these rates were averaged from open-source available estimates). These consumption rates are most likely for the engine's design points, and were used assuming that the ships under consideration were operated at or near this design point.

A simplifying assumption used to estimate horsepower at lower-than-maximum speeds was the cubic relationship of horsepower to speed. The maximum speed and maximum horsepower were used as a single data-point and slower speed horsepowers were extrapolated backwards:

$$HP_{calc} = \left[\frac{HP_{Max}}{Speed_{Max}^3} \right] Speed_{calc}^3$$

Where: HP_{calc} = the estimated horsepower at $Speed_{calc}$, HP_{Max} = the rated maximum horsepower of the available ships, $Speed_{Max}$ = the listed maximum speed of the available ships. This assumption is a little simplistic; however in the operating ranges of these ships and at cruising speeds, it is a reasonable assumption.

The fuel consumption values proved to be another characteristic that allowed for the elimination of some ships from consideration. The steam plants burned anywhere between 2.5 to 4 times as much fuel as medium-speed diesel or gas turbine ships for the same distances. The sophisticated steam plants were also, according to *Combat Fleets of the World*, expensive to operate and not very reliable [13].

8.1.5 Cargo Capacities

The remaining ships were then prioritized by cargo capacities and fuel consumption. Various sources were used for the cargo capacities: the sources mentioned above and other online sources. The cargo capacities in square meters, square feet and lane-meters are included in the list of ships in Appendix B.

The cargo capacities of the "acceptable" ships (the LMSRs and the RO/ROs) are, on average, 20,554 m^2 (221,244 ft^2). This capacity will be used as the basis for calculations requiring loading quantities and capacities for the available ships.

Some of the ships considered indicated very small cargo values. These were most likely due to estimation error made by the author, but were based on the only available information and were included for completeness. They were not used in the average cargo calculations, and these ships are assumed to have, on average, similar capacities to the others under consideration.

8.1.6 Ship for Analysis

For the remainder of the analysis, a hypothetical ship representative of the MSC ships under consideration will be used. The ship has approximately 220,000 ft^2 of cargo space, will be able to transit at at least 16 knots, and consumes fuel (at 16knots) at an average of 0.1311 LT per NM.

8.2 Operation Costs

8.2.1 Fuel Costs

Historic Costs and Simulations

When examining the feasibility of a transportation mode, the fuel consumption must be a major concern. For this study, fuel prices (both on-road and spot diesel) from March 1994 through February 2009 were compared (see Figure 8.1). Past prices were inflation adjusted and then analyzed.

Using the time plot of fuel prices from about April 2002 to November 2007, as seen in Figure 8.1, an estimate (albeit rough) can be made as to the percent increase in price of fuel over time. Calculations yield a 0.45 percent per month increase or approximately 5.4% per annum increase.

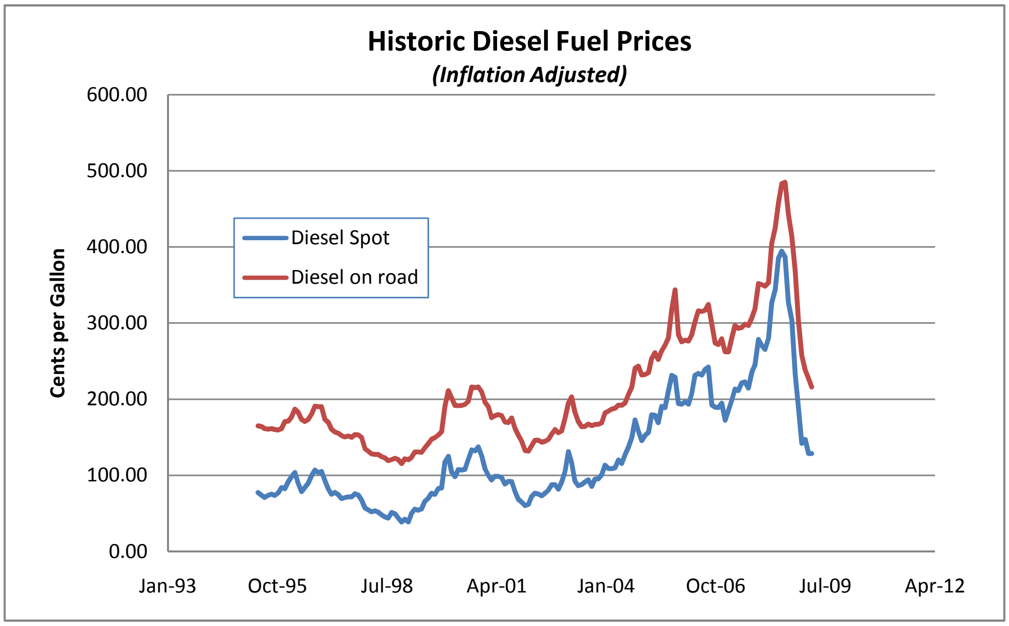


Figure 8.1: Diesel Prices Adjusted for Inflation *USDOT*

The next analysis was a statistical analysis to determine the cumulative distribution function in order to provide confidence intervals for future cost of fuel. The data from 1994 to 2009 was analyzed, however, data between 2004 and 2009 was deemed to be most applicable.

A statistical software package, JMP, was used to plot a histogram and to provide the distribution fit parameters. R-squared values of different distributions were used as the criterion for applicability. Figure 8.2 shows the histogram of the data analyzed.

From these data, analysis indicated that the diesel prices can be best approximated by a log-normal distribution. The parameters of this distribution were:

$$f(x, \mu, \sigma) = \frac{1}{x\sigma\sqrt{2\pi}} e^{\frac{-(ln(x)-\mu)^2}{2\sigma^2}}$$

Where $\mu = 4.5412$ and $\sigma = 0.600$.

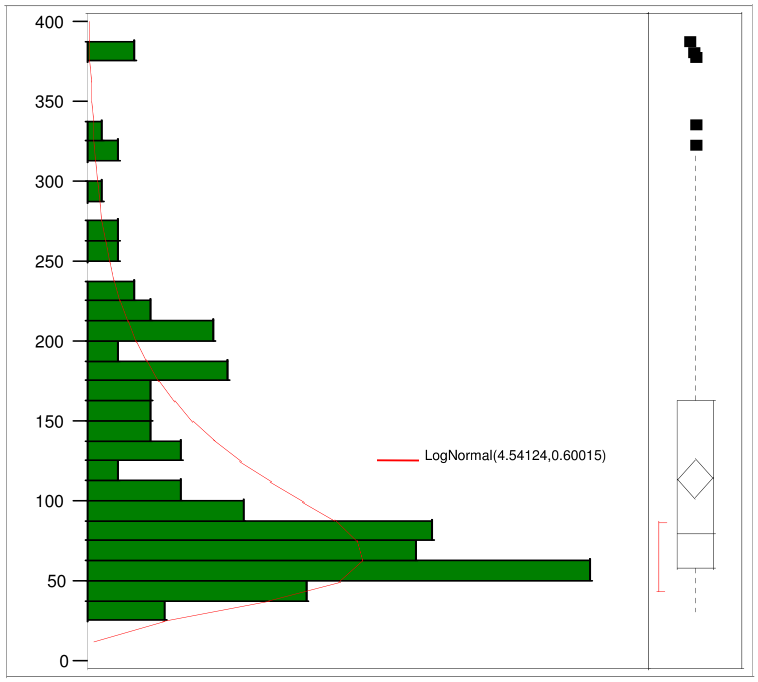


Figure 8.2: Histogram of Diesel Prices 2004-2009 *($0.01/gal)*

For cost-of-fuel calculations, five different situations were used. The first, **A**, kept the cost of fuel constant from the present (April 2009) for 20 years (in 2009 dollars). The second calculation, **B**, was done assuming the price of fuel increased at 5% per year.

The next two calculations, **C** and **D**, were simulations using the log-normal distribution described above. The first was with the average price of fuel, μ, steady; but prices were determined by random number simulations. The second assumed the average the price of fuel, μ, increased 5% per year and the price of fuel per gallon was determined by simulation.

The last simulation, **E**, used the variability of the week-to-week price change. The same statistical software was used to analyze the variability of price change. A histogram of this difference can be found in Figure 8.3. This analysis shows that the difference in price can be most accurately represented by a normal distribution with parameters: $\mu = 0.4619$ and $\sigma = 13.601$. In this model, an artificiality needed to be included that prevented the spot price from falling below $0.50 per gallon.

Simulations were prepared using these models and were used to determine the impact

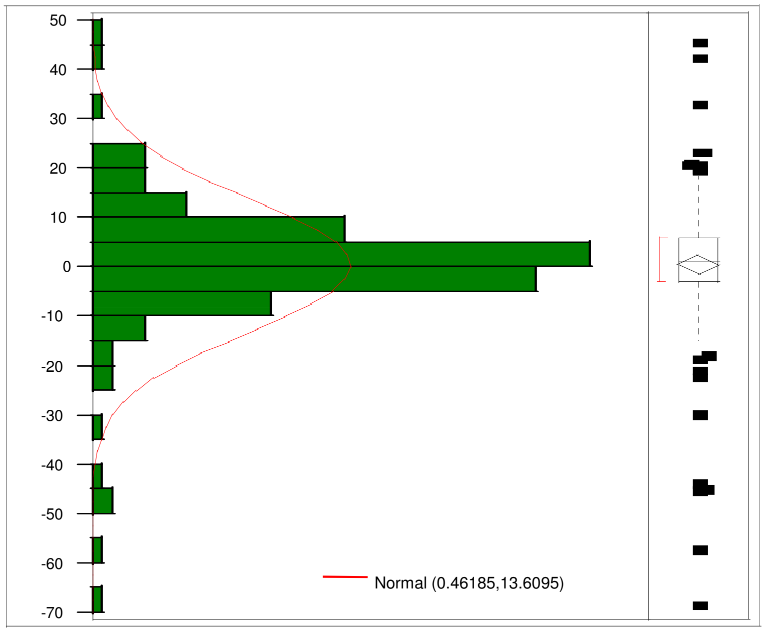


Figure 8.3: Histogram of Changes in Fuel Price 2004-2009 *($0.01/gal)*

of the variability of fuel prices on the operation of the ferry service. Figure 8.4 shows one particular time-based scenario and the forecast prices based on the methods outlined above.

Fuel Use Estimate

Once the simulations were prepared, the fuel consumption of the available ships on a "typical" voyage (outlined in Section 8.4) were compared. The average fuel consumption was 290 LT with a standard deviation of 60 LT. This fuel estimate was then multiplied by the price of fuel generated by simulation.

8.2.2 Ports and Facilities

An assumption for this analysis was that there is adequate berthing in the ports-of-call, although some (if not substantial) improvements would be necessary to make the facility fully functional as a ferry terminal. An estimate of $1.5M per port-of-call was assumed.

If work or land purchases in these ports were necessary above the $1.5M estimate, municipalities would be engaged to invest in the improvement of the port.

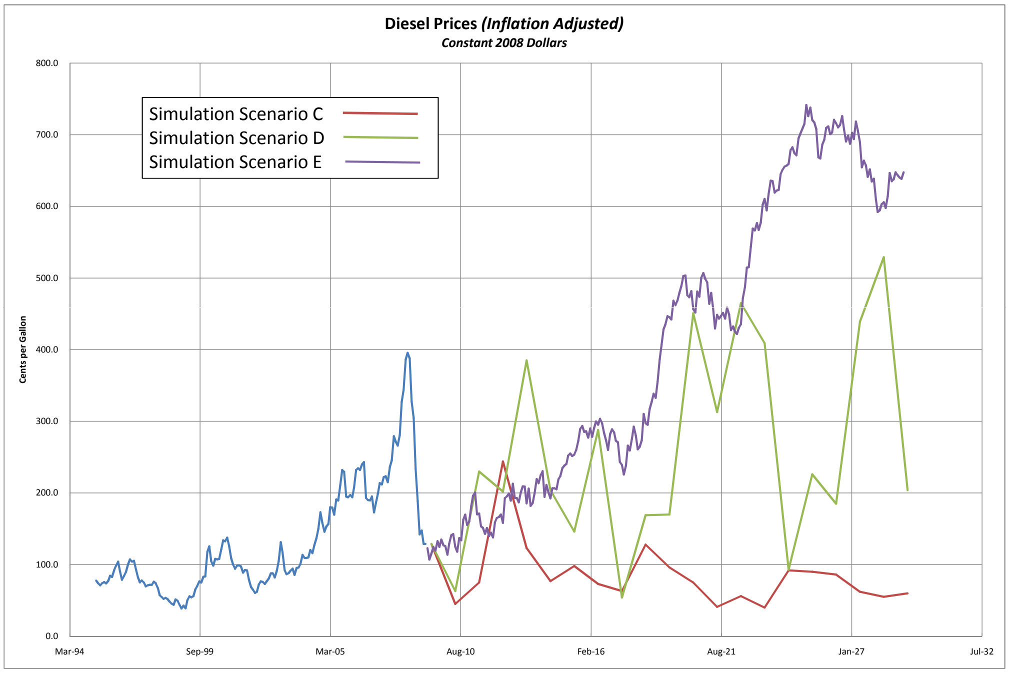


Figure 8.4: Historic and Probabilistic Simulations (**A** *and* **B** *not included*)

8.2.3 Crewing

As discussed earlier, crewing in the United States may prove difficult due to the lack of mariners available to man the ship. That discussion aside, the following table is an estimate of a ship crew's yearly salaries.

	Qty	Sal *(USD)*	Tot *(USD)*
Master	1	148,000	148,000
Chief Engineer	1	118,000	118,000
First Mate	2	118,000	236,000
Second Engineer	3	81,000	243,000
Able Seaman	8	62,000	496,000
Wipers	8	62,000	496,000
Cooks	2	66,000	132,000
Total *(USD)*			1,869,000
plus 20% overhead			2,242,800

Table 8.1: Crew Yearly Salaries *(Adapted from [20] and [39] and accelerated 3% per year from 2002)*

An estimate of 20% overhead was inserted in the yearly cost of crewing in order to account for the use of a crewing service as well as crew subsistence and other incidental expenses related to crewing (transportation, lodging, etc.).

8.2.4 Maintenance

For maintenance costs, an estimate of 3% of the value of a new construction ship was used. In order to acommodate the increased maintenance of an aging ship, a higher value was assumed. This value is similar to other papers estimating shipping costs. [20]

8.2.5 Insurance

The estimate used for insurance premium is 3% of the value of the ship. In the case of leasing MSC ships, this may be difficult to assess. In the case of leasing MSC ships, premiums were calculate assuming the ship was a new construction delivery.

Other papers estimating shipping costs have used a spread of 1% to 3%. The higher estimate was used the estimate used to include the added risk due to the ages of the ships under consideration (and their material condition). Since these considerations increase the risk of loss, the premiums should be raised to be comparable to the risk.

8.2.6 Other Assumptions

Other assumptions made with regards to the mathematical model can be found in Table 8.2.

8.3 Ports

8.3.1 Location

A relatively simple criterion was used for the locations of ports-of-call for the truck ferry. The ports needed to be very close to interstate highways, not in a major metropolitan center, but within a 30 minute to 1 hour drive. Additionally, the ports selected for this analysis were the nearest lower-tier ports to the congested roadways and trucking bottlenecks described in Sections 2.1 and 2.4. For this study, only East Coast congestion, freight flows and ports were considered.

Variable	Value	Unit	Comment
Discount Rate	10	%/yr	
Interest Rate	7	%/yr	
Fuel Infl	5	%/yr	
Periods	20	yr	Life of loan
Ship Value	$132,000,000		New construction value used in insurance and maintenance calcs
Scrap Val	$6,600,000		
Fuel Use	233.3	LT/wk	Average of fuel consumption based on routing in Section 8.4
Diesel ρ	3.17E-03	LT/gal	
Diesel Price	$1.290	/gal	Spot Price
Port Cost	$7.25	/m/Day	Tug/port costs
Length	190	m	Length for port cost estimate
LoadFact	0.8		
Handling Cost	$70	/trailer	
Days/Yr	343		Operational days
HMT			Harbor Maintenance Tax NOT PRESENT
Storage			Truck storage at origin/ destination minimal (1-2 days)

Table 8.2: Assumptions

The locations chosen must have ample laydown areas to allow for the delivery, staging, movement and loading/unloading of trailers. Initially, the ramps of the leased government ships will serve as the loading and unloading fixtures for the ferry, however as the newer ships come online, in order to carry more cargo, the loading and unloading fixtures may be best suited to be on the piers in the port.

Aerial photographs of the ports under consideration may be found in Appendix D. Possible locations are circled in red, and are chosen for their existing quay, extensive laydown area and proximity to major thoroughfares. A large amount of rehabilitation work may need to be done to start service in these areas.

8.3.2 Operation

The operation of the loading facilities can be very similar to those used in other short-sea or ferry operations. The facility can be modeled after the B.C. Ferries terminal in Tsawwassen, B.C., Canada, Vancouver's ferry terminal. Trailers to be loaded are queued according to their destination and low-slung tractors, similar to those used to move aircraft, Figure 8.5 can be used by stevedores to load and unload the trailers in each port.

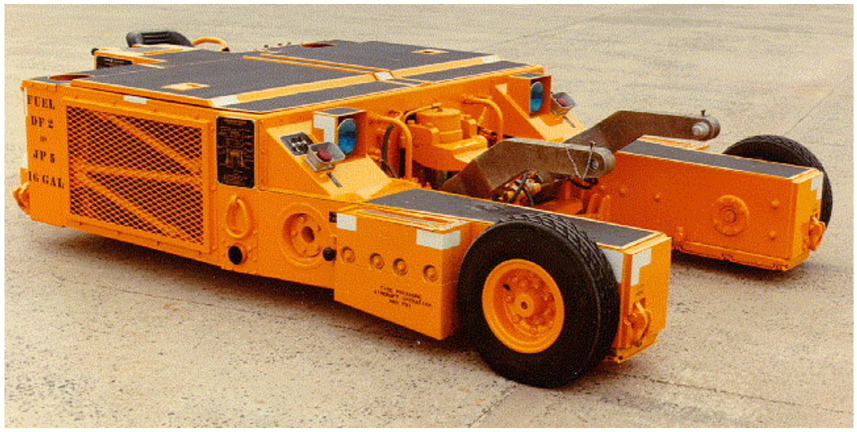


Figure 8.5: Aircraft Tractor `http://www.navair.navy.mil/lakehurst/nlweb/dolly.gif`

8.4 Sailing Schedule

The following tables show schedules at varying speeds with a layover time of 4 hours. These schedules allow for preliminary estimates on numbers of ships required and the fuel consumption rates.

One round-trip on this schedule is approximately 2209 NM or 2510 statute miles on the sea. An equivalent road journey would be 2465 statute miles via interstate.

Departure from:								
	8kt	10kt	12kt	15kt	18kt	20kt	25kt	30kt
Boston, MA	0	0	0	0	0	0	0	0
New Hav, CT	1.12	0.93	0.80	0.67	0.59	0.55	0.47	0.42
Newark, DE	2.96	2.43	2.08	1.73	1.50	1.38	1.17	1.03
Charleston, SC	5.35	4.38	3.73	3.09	2.65	2.44	2.05	1.79
Miami, FL	7.18	5.88	5.01	4.14	3.56	3.27	2.75	2.40
Charleston, SC	9.01	7.38	6.29	5.20	4.47	4.10	3.45	3.01
Newark, DE	11.40	9.32	7.93	6.55	5.62	5.16	4.33	3.77
New Hav, CT	13.24	10.83	9.22	7.61	6.53	6.00	5.03	4.39
ARR Boston,MA	14.36	11.75	10.02	8.28	7.12	6.54	5.50	4.81

Table 8.3: Potential Schedule Assuming 4 Hour Layover *(days)*

The LSU paper proposed counter-rotating loops as well as interlocking loops. This would be an idea worth consideration, and perhaps some efficiencies could be gained by this strategy[39]. There are, however, some complicating matters. On the scale of the journeys where SSS is viable, the lay-time in ports plus the additional miles traveled to arrive at some of the more "inland" ports does not add significantly to the total schedule. Stopping at each port on both northbound and southbound journeys adds on the order of 1.5 days to the round-trip length.

One-direction loops, as the LSU paper suggests, would need 9 ships for daily service, and, consequently, 18 ships to complete the counter-rotating daily schedule. Two-direction, i.e. stopping at the same ports southbound and northbound, would require 10 ships for daily service to compensate for the added day-and-a-half.

8.4.1 Optimization

A multi-dimensional linear program (LP) can be developed to better locate ports, eliminate unprofitable legs, determine sailing speeds between ports, effectively implement price-discrimination through limitations of space for lower-paying customers, as well as determine near-optimal combinations of other variables. The objective function of the LP should be to maximize profit.

The underlying problem is a multi-commodity flow problem differentiated by origin-destination pairs. In follow-on studies, linear programming can be used to determine the best combinations of variables.

8.5 Potential Customers and Anticipated Market Share

As discussed in Section 6.3, the Federal Highway Administration's FAF database was invaluable in analyzing the general interstate freight flows.

Once the ports-of-call were chosen, the states that they served were grouped and an origin-destination matrix was generated. Some license was taken to reduce (in some cases significantly) the amount of commodity flowing between adjacent (or nearly adjacent) states or states with small seacoasts. In particular, the volumes of freight moving between and among the New England states, New York/New Jersey and the Middle Atlantic states due to the extensiveness of shared borders, relatively short road trips, and the connecting interstate system. Table 8.4 shows the modified FAF data from truck and train freight.

		Origin				
		MA,ME, NH	RI,CT, NY	MD,DE, PA,NJ	SC,GA	FL
Destination	MA,ME,NH	X	661	6,652	1,357	379
	RI,CT,NY	1,580	X	3,292	3,613	1,164
	MD,DE,PA,NJ	6,792	2,343	X	9,381	2,614
	SC,GA	878	335	6,338	X	4,051
	FL	1,911	339	4,156	4,849	X

Table 8.4: State-to-State Domestic Truck Commodity Flows *(in KTon)* [FAF2 Data 2010 est.]

The numbers in Table 8.4 are a little difficult to visualize, so Table 8.5 divides the cargo freight into fully laden 80,000 lb trucks for comparison. This matrix does not account for less-than-truckload trips.

The far right column of Table 8.5 attempts to estimate empty backhaul by calculating the truck arrivals minus the truck departures. South Carolina and Georgia appear to have a deficit of trucks, while Rhode Island, Connecticut and New York have a surplus. The relocation of empty trailers is estimated from these calculations at 9-12% of the total truck shipments.

		Origin					
		MA,ME, NH	RI,CT, NY	MD,DE, PA,NJ	SC,GA	FL	*Arriv - Dep*
Destination	MA,ME, NH	X	16,528	166,293	33,919	9,468	*-52,817*
	RI,CT,NY	39,508	X	82,310	90,332	29,090	*149,288*
	MD,DE,PA,NJ	169,812	58,577	X	234,514	65,347	*17,308*
	SC,GA	21,940	8,378	158,440	X	101,279	*-189,951*
	FL	47,765	8,469	103,899	121,224	X	*76,172*
Sum of trailers in matrix: 1,567,092							

Table 8.5: Trucks For Cargo

A standard on-road trailer is nominally 53 feet in length, 8.5 feet in width and 13.5 feet in height. Assuming that the trailer, for loading equipment, securing and personnel purposes, needs 3 feet between it and the next trailer on all sides, the dimensions become 56' x 11.5' x

13.5' *(l* x *w* x *h)*.

Ten ships, each with an average of 220,000 ft^2 cargo space can hold at most 340 trailers. Accounting for loading equipment requirements and dead-space, this number is reduced by 10%, so each ship can nominally hold 300 trailers. At steady-state, at most 3050 trailers per day could be at sea, and over the course of a year (343 days) and operating at full capacity, 1,046,150 trailers could been moved by sea. For comparison, the sum of the trailers in the matrix in Table 8.5 is 1,567,092 * 1.1 = 1,723,800 trailers (including 10% backhaul).

The previous calculation is simplistic, and does not account for less-than-truckload cargoes, however the fact that the volume of cargo that the ship operation is capable of carrying is the same order of magnitude as that calculated between the origin and destination states is very encouraging.

8.6 Pricing and Revenue

To calculate revenue, break-even pricing was determined by offsetting all the cash outflows in two different scenarios. The main purpose was to create a criterion for comparison with other modes by determining the unit cost of moving a trailer.

The following calculations were made using the assumptions stated above and snapshot values found in Appendix C. The first calculation bases the per-trailer rate on the full voyage from Boston to Miami and a ship at a load factor of 1.0 and uses the following formula.

$$Price_{\text{PerTrailer-NM}} = \frac{TotCost_{year} \cdot \ Days_{voyage}}{OpDays \cdot Trailers \cdot Miles_{voyage}}$$

Where: $TotCost_{year}$ = total operating cost per ship per year, $OpDays$ = the operational days per year (343), and $Trailers$ = trailers per ship.

Beginning with data in Appendix C, Table C.2, Fuel Scenario **A**, the total cost for a single ship in Year 1 is $15,905,413. To determine a carriage rate, this cost was averaged using the longest voyage, from Boston to Miami, 4.33 Days and 1552 NM (on the road: 24hr, 1,499 mi). The operational cost spread over the sailing days was $195,334. That cost was then spread over 300 trailers ($651 per trailer) and 1552 NM. This calculation resulted in a carriage rate of $0.420 per trailer-NM or $0.434 per equivalent road mile (the length of the same trip by road only).

The second calculation uses a much shorter and more representative voyage for comparison. This voyage, which comprises 28% of the northbound freight, is from South Carolina to Delaware. The voyage is 1.5 days and 543 NM (on the road: 10hr, 625 mi). On average, 75% of all freight in the analysis travels this distance or longer. Using this voyage for pricing purposes, and mirroring the calculation above, the price is $0.427 per trailer-NM or $0.371 per equivalent road mile.

Using the data in Appendix C, Table C.2 as the yearly cash outflow, break-even rates for trailer carriage were determined. A snapshot of these rates is included in Appendix C, Table C.3. The values in Table C.3 were determined by the method outlined above but used a load factor of 0.8 instead of 1.0.

From these calculations, a price schedule for carriage between ports can be determined, and is presented in Table 8.6. This schedule is based on a load factor of 0.8 and uses break-even rates.

	MA	CT	DE	SC
FL	$828.37	$680.52	$512.93	$223.10
SC	$605.26	$457.42	$289.82	
DE	$315.44	$167.59		
CT	$147.85			

Table 8.6: Inter-Port Rate Schedule Per Trailer (All MSC Ships)

Actual revenue can be determined once the trailer ferry system is compared with other modes of transportation. Once prices for similar carriage by truck and train are determined, the per-trailer rate can be increased. The ferry-rate can be increased to match the truck and train rates when in-delivery times are comparable. When the ferry in-delivery time is longer, the rate can be lowered from the competing mode's rate by an amount equal to the shipper's value of time. Conversely, when the ferry is faster, a premium, also based on the shipper's value of time, can be charged.

Figure 8.6: Map of Potential East Coast Route *Google Earth*

Chapter 9

New Ships: Cost and Revenue

Ultimately, new construction ships will be desired for the operation of such a ferry service, since the operator will want to have a ship tailored to the specific needs of the market. Emerging technologies such as the pentamaran ferries (in varying configurations) could provide even better fuel efficiencies and more economical service for the operators and users of the truck ferry. These new ships will not only serve as the workhorse for the truck ferry, but also can be the backbone of the Department of Defense's military sealift program.

New ships are also required due to the age of the MSC ships suggested for use. The MSC ships may need extensive maintenance that, after a few years, may become financially burdensome. The benefit of these ships, however, is that they can be used in the short-run to test the business model, to determine profitability and engage shippers and freight forwarders in a new aspect of interstate shipping.

9.1 Available Ship Designs

For conventional designs of RO/RO ferries (passenger and freight only) one needs to look no further than Europe. As stated earlier, Europe moves nearly 50% of its freight by sea. Some examples of suitable ships can be found and are compared in Appendix B.2.

9.2 Costs

The following analysis mirrors the previous chapter. All costs used in the MSC scenario are the same; however the cost of new-construction ships and their depreciation is included in the yearly costs.

9.2.1 New Construction Costs

Prices of new construction ships were based on estimates for contract prices of RO/RO Cargo ships under construction. The cost of the ships under construction varied widely with displacement, and were all of foreign (non-U.S.) manufacture. As stated in Sections 4.2 and 5.2, the costs of ships built in the United States is nearly double that of ships built overseas.

A regression analysis was conducted to determine a simple relationship between displacement of a RO/RO cargo ship and its cost. For comparison, the cost of the Bob Hope class ships was included. The regression indicated that the cost (in millions of U.S. dollars) of a ship could be estimated using the ship's displacement (in long tons)[1]:

$$Cost = 0.003 * Displacement + 13.70$$

For the purposes of this analysis, the hypothetical ship with space for approximately 300 trailers was used, and the contract values were approximately doubled. The cost of some elements on the ship can be defrayed by the application of government funds for "National Defense Features." These militarily-useful features allow the use of the ship as a national asset in time of war. Reinforced decks, cranes, roll-on/roll-off ramps and refueling-at-sea stations are a few of the defense features covered under the program, as well as maintenance costs directly attributable to these features.

The estimated cost of the new-construction ship used was $132M (2009 dollars). Corresponding to a displacement of 35,000 LT, and a cargo capacity of 220,000 ft^2 (300 Trailers).

A table of the amortization schedule is based on a ship value of $132M, an interest rate of 6%, a loan period of 20 years, and 12.5% of the value of the ship in equity, and can be found

[1]The regression used ships in the displacement range 5000dwt $\leq \Delta \leq$62,000dwt.

in Table C.4. The “debt service” column indicates level payments of $10.25M per year.

9.2.2 Depreciation

For depreciation, both straight-line depreciation as well as the Internal Revenue Service’s MACRS (explained below) arrangement were applied over the life of the vessel or the depreciation life, as appropriate. These two schemes are typically employed to reduce the tax burden of the company, and are counted here as negative cash flows.

Straight Line Depreciation

For a new construction ship, valued at approximately $132M and having a 5% scrap value at the end of the loan term (20 years), straight-line depreciation is approximately $6.3M per year.

Accelerated Depreciation Method

In reviewing the U.S. Internal Revenue Service (IRS) rules and tax law with regard to depreciation, “vessels and water transportation equipment” fall under the IRS’s Modified Accelerated Cost Recovery System (MACRS), General Depreciation System (GDS) class life of 10 years.

A table was used to depreciate the new construction ship over the GDS life of the ship (10 years). The benefit of the accelerated depreciation is taking tax benefits in the early years of operation. By depreciating an asset in this manner, it lowers the taxable income and allows the shipping company to recapitalize its fleet faster than it normally would. This depreciation was included in the analysis for comparison purposes.

In the MACRS arrangement, the value of the depreciation varies, but reaches a maximum in year 2 of about $24M, declines to $4M in year 10 and averages nearly $12M per year for 10 years.

9.3 Pricing and Revenue

A break-even analysis identical to that conducted in Section 9.3 was done for the new construction ships as well. Specific values can be found in Appendix C, but for comparison, the carriage rate averages about \$0.827 per trailer-NM for a load factor of 1.0 and \$1.030 for a load factor of 0.8.

From these calculations, a price schedule for carriage between ports can be determined, Table 9.1. This schedule is based on a load factor of 0.8 and uses break-even rates.

	MA	CT	DE	SC
FL	\$1,688.70	\$1,387.30	\$1,045.65	\$454.82
SC	\$1,233.88	\$932.49	\$590.83	
DE	\$643.06	\$341.66		
CT	\$301.40			

Table 9.1: Inter-Port Rate Schedule Per Trailer (All New Ships)

Again, actual revenue can be determined once the trailer ferry system is compared with other modes of transportation. Once prices for similar carriage by truck and train are determined, the per-trailer rate can be increased to be comparable.

9.4 Implementation Schedule

The first two years of operation are envisioned as the proof-of-concept period. Once profitability and customer base are established, new ships should be placed on order in the beginning of the third year. Assuming that construction will take 2 years from order to delivery (18 months may be more realistic, but 2 years simplifies calculations), the first new ship should come online in year 5. Assuming one ship is on order each year, half the fleet can be replaced by year 9. For calculation purposes, the shipyard is paid half of the contract value of the ship at time of order, and the remaining half at delivery.

MSC ships should be kept on the schedule since they keep costs low, despite their age and imperfect suitability. This is particularly evident when one compares the break-even carriage price. For a fleet of 10 MSC ships, the break-even carriage price is \$0.43 per trailer-NM (from

Section8.6), while the break-even for 10 new ships is closer to \$0.83 per trailer-NM.

A good time to reassess the business model is the point where half of the ships in operation are new. It is also a time to consider whether to order a new ship in year 9. At this point, there are enough MSC ships to support an increase in the scope of operation. Changes can be made like including other ports, expanding operations into the Gulf of Mexico, repeating the business model on the U.S. West Coast or to include border crossings.

9.5 Combined New & Old Ship Service

This section, and indeed the very business model, is based on the use of old ships while new ships are being built and an eventual phase-out of the least desirable old ships. It provides the link between the "only new" and "only old" service described in this chapter and Chapter 8 respectively. Appendix C includes projections for all scenarios.

Operation Year (OpYear) 1 and 2 costs are the "MSC" only columns multiplied by the number of ships, 10. OpYear 3 contains the order of the first ship and the operation of the 10 older ships; similarly, OpYear 4 has both the order and delivery of a new ship. The new ship enters service in OpYear 5, and the operational costs contained in the "New Construction" portion of Appendix C begin to be added. The following equation for OpYear i is representative of the calculations.

$$OpCost_i = MSC_i \cdot OpCost_{MSC_i} + [OpCost_{New_{i-4}} + OpCost_{New_{i-5}} + \ldots] + \ldots$$

$$\ldots + \frac{ShipVal}{2} \cdot [Order_i + Deliver_i]$$

Where: MSC_i, $Order_i$ and $Deliver_i$ = numbers of ships operating, ordered and delivered in year i respectively; and the terms in brackets are only present when their subscripts are greater than zero.

Table 9.2 shows the operational scheme, the yearly costs associated with Fuel Scenario **A** and straight line depreciation as well as break-even carriage rates per trailer-NM.

This scheme may not be optimal, and follow-on studies can apply techniques like linear

Year	MSC	New	Order	OpCost	Break Even *LF 1.0*	Break Even *LF 0.8*
1	10	0	0	$159,054,129	$0.427	$0.534
2	10	0	0	$157,173,129	$0.422	$0.527
3	10	0	1	$221,292,129	$0.594	$0.743
4	10	0	2	$219,411,129	$0.589	$0.736
5	9	1	1	$300,801,763	$0.808	$1.009
6	8	2	1	$316,380,498	$0.849	$1.062
7	7	3	1	$332,147,332	$0.892	$1.115
8	6	4	1	$348,102,267	$0.935	$1.168
9	6	5	1	$378,645,914	$1.017	$1.271
10	5	6	1	$394,788,948	$1.060	$1.325
11	4	7	1	$411,120,083	$1.104	$1.380
12	3	8	0	$295,639,317	$0.794	$0.992
13	2	9	0	$378,346,652	$1.016	$1.270
14	1	10	0	$329,242,086	$0.884	$1.105
15	0	10	0	$313,900,973	$0.843	$1.053
16	0	10	0	$312,019,973	$0.838	$1.047
17	0	10	0	$310,138,973	$0.833	$1.041
18	0	10	0	$308,257,973	$0.828	$1.034
19	0	10	0	$306,376,973	$0.822	$1.028
20	0	10	0	$304,495,973	$0.817	$1.022

Table 9.2: Combined Operation Scheme

programming and more sophisticated financial models. The purpose of this analysis is not to optimize, but rather to provide a framework for the operation and provide rough orders of magnitude for costs and revenues and determine feasibility from that point.

As in the previous two chapters, actual revenues for this operation can be conducted once the pricing is compared with that of competing modes.

Chapter 10

Comparison to Other Modes

Other competing modes of transportation are, as stated in Chapter 3, trucks and trains. For a general comparison, the author sought carriage quotes from freely available (online) sources. The CSX website and a website that provided automated trucking quotes [`http://www.freightcenter.com/QuickQuote.aspx`].

10.1 Trucks

Clearly, the major competing mode for the truck ferry is the tractor-trailer. The ferry's whole business model is to take trucks off the road. The ferry must do so in a more effective way by having better characteristics of cost, time, energy, emissions, or combinations of these.

The following section analyzes the tractor-trailer and compares it to the trailer ferry to determine which improvements, if any can be made to the transportation of goods by implementing the ferry.

10.1.1 Fuel

The average aerodynamic tractor-trailer combination operating at 60 miles per hour with 80,000 pounds gross vehicle weight manages approximately 6 miles per gallon [51]. Using this estimate in a simple case, we can calculate that one truck moving from Boston, Massachusetts

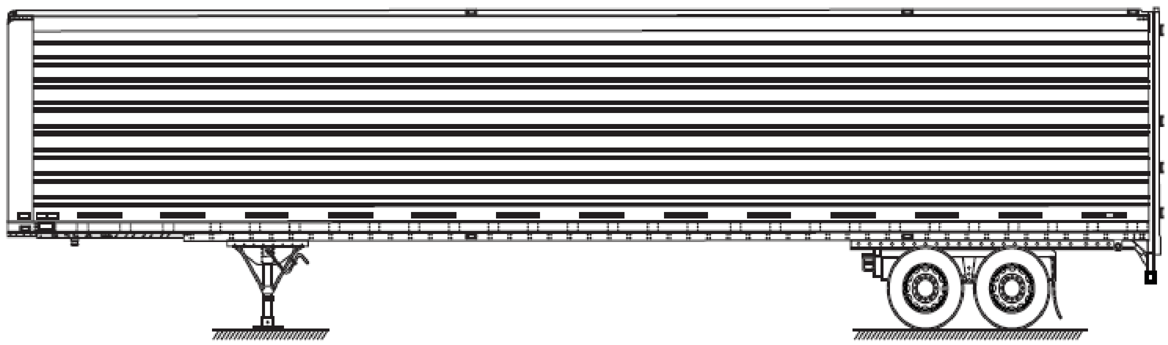


Figure 10.1: 53 Foot Box Trailer

to Miami, Florida (or vice-versa) will require approximately 0.788 LT of diesel for the journey, not counting idle time. That 0.788LT of *on-road* diesel would cost $535.

For a ship averaging 200 LT for the same journey, the break-even on a fuel basis would be 258 trailers from Boston to Miami. A standard on-road trailer is nominally 53 feet in length, 8.5 feet in width and 13.5 feet in height. Assuming that the trailer, for loading equipment and personnel purposes, needs 3 feet between it and the next trailer on all sides, the dimensions become 56' x 11.5' x 13.5' *(l* x *w* x *h).* For 258 trailers like this one, the ship would need 166,536 ft^2 of cargo space with adequate headroom.

Assume that the ships available from government have, on average, approximately 20,500 m^2 or 220,000 ft^2 of cargo space available. Using the 53 foot trailer example from above, this ship could fit approximately 340 trailers, reduced by 10% to 300. This shows that the current ships are competitive on a fuel-only basis.

10.1.2 Truck Drivers

The next step would be to estimate the costs associated with the drivers of these trucks. In the LSU paper, the fixed trucking costs are estimated to be $325, while the driver and truck cost approximately $50 per hour [39]. It is unclear whether this estimate considers lodging, differentials associated with overnight journeys, or other incidentals. The analysis that follows assumes that this rate is all-inclusive.

Average rates per-mile around the country are in the range of $1.6 per mile for solo drivers and \$2.5 per mile for teams. Rates on congested roadways, however, are more than 2 times the national average. On I-95, for instance, the rates are approximately \$2.5 to \$3.3 per mile. [39]

To determine how this compares with the \$50/hour estimate, the driving time must be calculated:

$$\frac{1499mi}{60mi/hr} = 24.98hours$$

Truckers, by law, must not drive more than 11 consecutive hours in a 14 hour period followed by no less than 10 consecutive hours of rest. So, that 25 hours becomes 2 11-hour and one three-hour drive periods punctuated by two 10-hour rest periods, a total of 45 hours. Assuming the trucker is not paid for time not in motion, 25 hours at \$50/hour yields \$1,250, \$0.83/mile.

In Section 3.1.2, the lack of truckers was discussed, and shows the vulnerability of this mode. Trucking prices do not appear as if they can be lowered without further impacting the drivers. One of the issues covered was that the trucking industry needed to improve its wage structure if it were to fill the driver ranks.

10.1.3 Tolls

A listing of toll facilities in the United States can be found at the Federal Highway Administration's website `http://www.fhwa.dot.gov/ohim/tollpage.htm`. In estimating the toll cost for a truck traveling north or south, the numbers of toll facilities were counted between origin and destination as well as the numbers of major crossings (like the George Washington and Tappan-Zee Bridges on the Hudson River, or the Delaware Memorial Bridge at the end of the New Jersey Turnpike). Fees for these roads or crossings were averaged and \$60 per toll-road and \$25 per major crossing was applied. Table 10.1 shows both the numbers of facilities between origin and destination and toll estimate. On the comparison voyage, tolls charged would be approximately \$310.

Facilities					
TollRoads					
	FL	SC	VA	DE	CT
MA	4	3	2	2	1
CT	3	2	1	1	
DE	2	1	0		
VA	2	0			
SC	1				
Major Crossings					
	FL	SC	VA	DE	CT
MA	2	2	2	2	0
CT	2	2	2	2	
DE	0	0	0		
VA	0	0			
SC	0				

Toll Estimate ($)					
TollRoads					
	FL	SC	VA	DE	CT
MA	260	195	130	130	65
CT	195	130	65	65	
DE	130	65	0		
VA	130	0			
SC	65				
Major Crossings					
	FL	SC	VA	DE	CT
MA	50	50	50	50	0
CT	50	50	50	50	
DE	0	0	0		
VA	0	0			
SC	0				

Table 10.1: Toll Facilities and Estimates Based on Origin/Destination

10.1.4 Quoted Prices

For the comparison journey, adding up all the costs tabulated above:

$$\$325_{Fixed} + \$535_{Fuel} + \$1,250_{Driver} + \$310_{Toll} = \$2,420$$

This cost does not include overhead and profit for the shipper/forwarder. Table 10.2 shows average prices quoted for full truckloads.

FROM	TO	PRICE	TRANSIT *(bus-day)*
Boston	Miami, FL	$2,696	4
Boston	Charleston, SC	$1,078	3
Boston	Wilmington, DE	$696	1
Boston	New Haven, CT	$696	1

Table 10.2: Quoted Truck Prices

The value calculated is relatively close to that quoted in Table 10.2. The most flexible portion of the calculation is the amount paid to the truck driver. Beginning with the quote from Boston to Miami, $2696, we subtract $535 for fuel (80,0000lb@60mph with no stops or idling) and $310 for tolls. That leaves $1,851 for driver, overhead and profit.

If 10% overhead and 7%profit is estimated and removed, \$1,851 - \$185 - \$130 = \$1536 for driver. This is very close to the fixed cost plus driver costs (\$325+\$1,250=\$1,575) and almost exactly \$1/mile. This could not possibly be enough for insurance and maintenance, let alone enough to recapitalize the cost of the truck.

A regression analysis was conducted on the trucking costs with regards to both miles between origin and destination and travel days quoted. Both instances showed a quadratic relationship between cost and miles/days. Figure 10.2 illustrates these relationships.

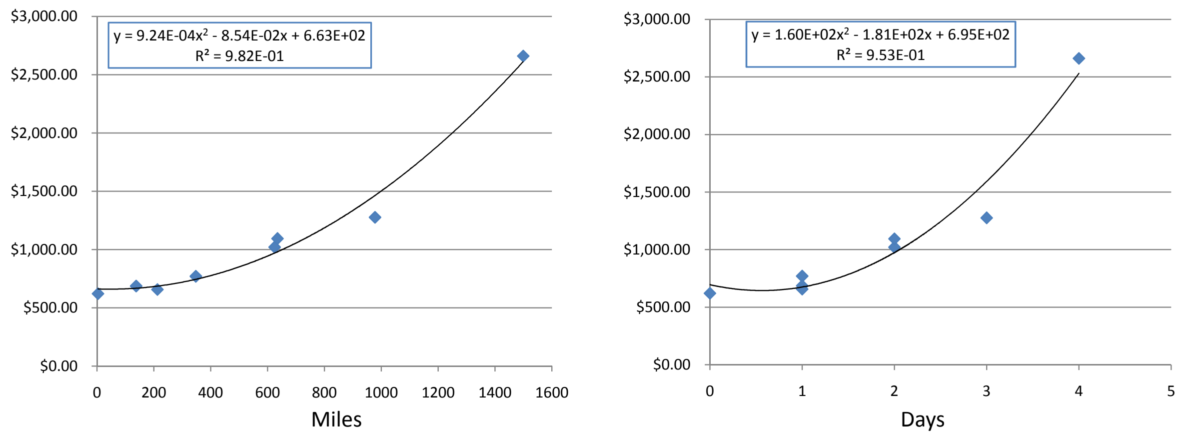


Figure 10.2: Regression of Truck Shipping Quotes *(full truckload)*

10.2 Trains

10.2.1 Fuel

Average fuel consumption across American Railroads is estimated at 412.9 ton-miles per gallon [9]. On the same trip from Boston to Miami (assuming that rail miles and road miles are equal), an 80,000lb (40 ton) truck-on-train traveling 1499mi would consume 145 gallons of fuel. Fuel costs would be (using \$1.28/gal, spot price) \$186. For comparison, the calculated fuel cost for a truck was \$535, and \$48 for the trailer ferry.

10.2.2 Quoted Prices

Carriage prices quoted from the CSX website, `http://shipcsx.com`, and averaged over different commodities in a box car (up to 53ft) yielded the regression in Figure 10.3. This regression indicated that the railroad freight rate is approximately \$2.90 per trailer-mile or \$562 per trailer-day. These rail quotes and time estimates are for moving a single trailer from origin to destination. Shipping in larger volume on a dedicated train would most likely significantly decrease both costs and shipping time, but it is difficult to determine why a freely available estimate for shipment would be inflated by as much as 166%.

FROM	TO	PRICE	TRANSIT *(bus-day)*
Boston	Miami, FL	\$3,448	8
Boston	Charleston, SC	\$2,587	6.5
Boston	Wilmington, DE	\$2,074	8
Boston	New Haven, CT	\$1,410	3

Table 10.3: Quoted Train Prices

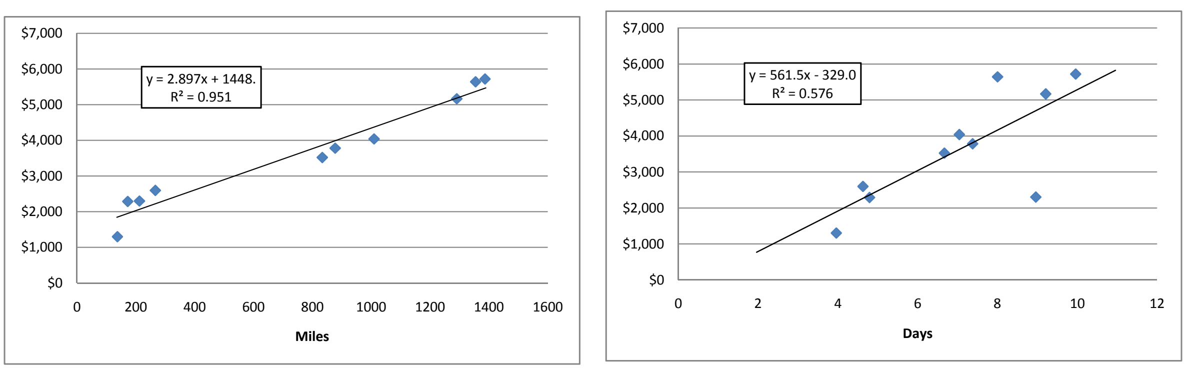


Figure 10.3: Regression of Rail Shipping Quotes

10.3 Potential Penalties

In recent years, environmental concerns and road congestion and maintenance problems have come to the fore. Many transportation analysts have indicated that there are a large amount of external costs to transportation for which neither the shippers nor their customers have been held accountable. Costs included are related to environmental cleanup of storm-water discharges, air quality impacts to health and agriculture. As the transportation industry looks forward, these costs must be contemplated as seriously affecting the bottom-line above and beyond "surplus charges."

10.3.1 Congestion Pricing

As a direct attack on road congestion, municipalities are installing toll facilities in the attempt to force changes in travel habits. The majority of these congestion tolling schemes use pricing schemes that constantly adjust based on the level of congestion and, by extension, the traveler's value of time. These schemes attempt to adjust or level-load the peak travel times, and in many cases, have had an impact on the congestion they were meant to address.

On-road freight moving through these cities, on the other hand, may not necessarily respond to the toll-scheme's attempts to adjust their driving behavior. When possible, trucks will most likely attempt to time their journeys through these locations when the toll is lowest, which is not always possible.

10.3.2 Emissions

As discussed in Chapter 3, seagoing ships have better air emissions per ton-mile than any of the competing modes. There are, however some issues. Ships operating near the coast of the United States will need to begin using low sulfur fuels, an issue that may add significantly to the fuel costs of ships. Additionally, there are increasing regulations on nitrogen, particulates and carbon dioxide emissions.

These issues are currently in flux and will most likely gain momentum in the coming decade, but the efficiency of ships with regards to fuel and emissions should place them in a positive position when the debate begins.

10.3.3 Carbon Credits

As an additional aspect of emissions, and a potential impact on operational costs, so-called "carbon credits" were entertained. The majority of literature available as well as those "selling" carbon credits price them at approximately $20 per metric ton of carbon dioxide. For a typical ship and train, that would add an almost negligible cost to the voyage. This penalty, however, may become a larger issue in the future.

Chapter 11

Revenue Forecasts and Sensitivity

11.1 Pricing Rates

The pricing rates from the previous chapter were used to serve as an upper limit for the per trailer-mile rate. The rate calculated for train carriage was $2.90 per trailer-mile, while the rate for truck-trailer carriage was approximately $1.75 per trailer-mile. Since the rate for trucks provide a tighter criterion, this will initially be the upper-bound for the ship's rates. The rate used for the ferry service will be $1.50 per trailer-mile ($1.70 per trailer-NM) to entice customers to switch modes.

The following calculation was used to estimate revenue in year i:

$$Revenue_i = CarriageRate \cdot Trailer \cdot LF \cdot Ships \cdot OpDays$$

Where *CarriageRate* = rate per trailer-NM ($1.75), *Trailer* = trailers per ship (300), *Ship* = number of ships operating (10), *LF* = load factor (0.8), *OpDays* = operational days (343). This simplified revenue calculation indicates that yearly revenue amounts to $518,517,216 per year. Table 11.1 shows the price schedule at this rate.

A break-even load factor was calculated for each year according to the operational scenario in Table 9.2, although the simulation was taken to 20 years with no procurement halt at year 9. The benefit of using the MSC ships is evident immediately.

	MA	CT	DE	SC
FL	$2,700.48	$2,218.50	$1,672.14	$727.32
SC	$1,973.16	$1,491.18	$944.82	
DE	$1,028.34	$546.36		
CT	$481.98			

Table 11.1: Inter-Port Rate Schedule Per Trailer (Mixed Operation)

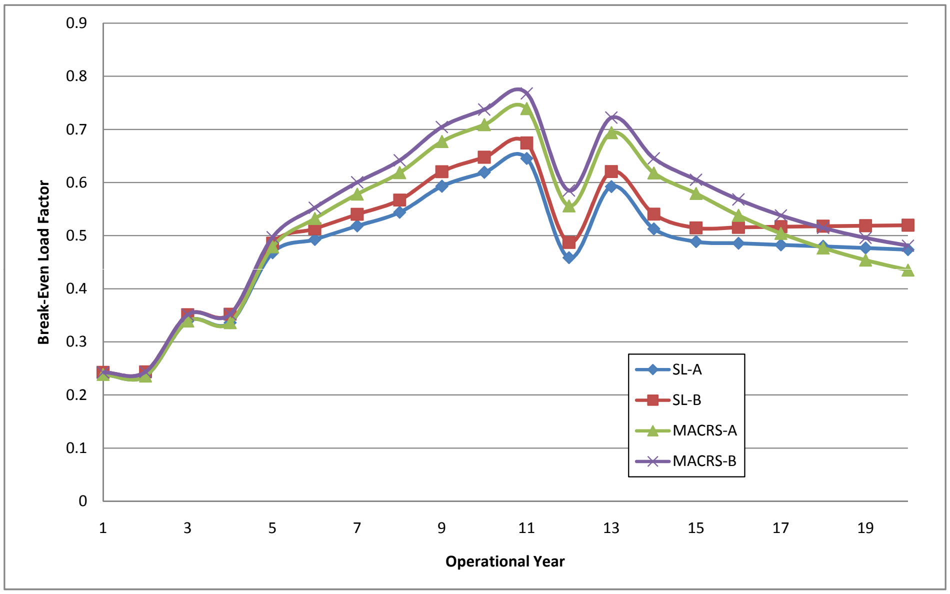


Figure 11.1: Break Even Load Factor at $1.70 /tr-NM

The graph shows that the ships can be between 25 and 50% full for the first 5 years and still break even. Operational year 11 will be the most challenging, since it includes the operation of 4 MSC ships, 7 new ships, the order of one ship and the delivery of another. Year 12 contains a dip since it is the year between the order of the last ship and its delivery. Steady-state for break-even appears to be between 48-55%.

11.2 Value of Time

An important concept in transportation pricing is the value of time, specifically, the value of freight travel time. This subject was explored by Zamparini and Reggiani who conducted an analysis of value of freight travel time. Analogous to consumer's willingness to pay, Value of Freight Travel Time Savings (VFTTS) can be defined as the marginal utility or benefit that derives from a unit reduction in the amount of time traveled from origin to destination [58].

Travel time savings allows for better spacial concentration, tighter scheduling and market expansion. Tighter scheduling allows for the reduction in driver's wages.. In the long run, freight travel time savings can cause logistical improvements that will lead to more efficient distribution [58].

In their analysis, Zamparini et al. discovered an average value of time of about $20 per hour [58]. Chu's study in Atlanta in 2008, showed an average value of time of about $31 per hour [10]. Lastly, Holguín estimates that approximately 25% of truck trips have travel time values exceeding $30 per hour [28].

Using a travel time penalty, the amount sea shipment carriage rates need to be reduced can be assessed. The quoted time for a truck from Boston to Miami was 4 business days and the ship voyage time was 4.5 days. The 12 hours are worth between $240 and $375, lowering the carriage rate to between $1.50 – $1.58 per trailer-NM. The travel time penalty lowers yearly revenue (using the same calculation as above) to between $447M and $471M, still well above break-even.

11.3 Sensitivity Analysis

The sensitivity of the present value of profit in Scenarios **A** to the following variables will be examined.

- Ship Cost
- Maintenance Percentage: the percentage of new ship value used as yearly maintenance cost
- Insurance Percentage: the percentage of new ship value used as yearly insurance cost
- Load Factor: a measure of used ship capacity per voyage
- Fuel Use: the amount of fuel used per ship per week
- Crew Cost: the estimate of yearly crew costs
- Cargo Cost
- Port Investment Per Port
- Carriage Rate

The plots in Figure 11.2 shows the sensitivity with respect to the variables above. The x-axis represents the change in the particular variable, while the y-axis represents the change in the Net Present Value of profits. The three variables in the plot on the left were the variables to which the model was most sensitive: load factor, carriage rate, and new construction ship value.

The plot on the right shows the sensitivity of the model to the other variables. Fuel use was only marginally significant, since a 20 percent increase in fuel per week per ship yielded only a 4 percent decline in Net Present Value. The model's sensitivity to fuel price was identical to its sensitivity to fuel use, since they are linearly related.

Since the responses are all linear, then they will combine linearly. For instance, a 5 percent decrease in the cost of new ship construction would likely offset a 20 percent increase in fuel use per ship per week.

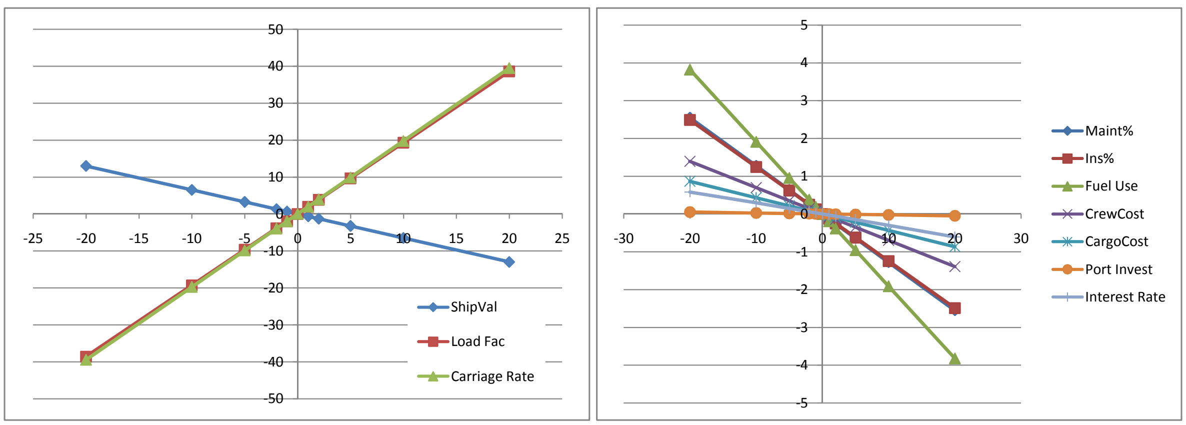


Figure 11.2: Sensitivity Analysis *(percent change)*

11.4 Fuel Simulation Results

A probabilistic simulation of fuel prices, described in Section 8.2.1 was conducted on the NPV of anticipated profits. This simulation was run in order to provide a measure of variability of the profits that the model presented here predicts.

The variability of fuel price was anticipated to have the most important effect on the profits of the truck ferry, however load factor and carriage rate appear to outstrip the impact of fuel. In follow-on analyses, the links between load factor, carriage rate and fuel price can be determined, and are most likely coupled in a significant way.

The simulations were conducted in Excel, and 500 samples were generated and analyzed. Figures C.1 and C.2 show the results of the simulations conducted. NPVs from fuel scenarios **C** and **E** were best described by Weibull distributions, while the NPVs from fuel scenario **D** were normally distributed.

These simulations discover confidence intervals on profit when considering the year-to-year variability of fuel. Follow-on analysis should determine the variability of the other constituting variables and include a multi-variable simulation. This type of simulation can gather the true variability of the model.

11.5 Chapter 11 Conclusion

After comparing established trucking and rail rates versus the truck ferry's break-even rates, SSS is proving to be more cost effective. Although there are time penalties associated with water freight, sea shipping still shows enormous potential.

Chapter 12

Conclusion

To address the transportation issues of the future, transportation planners need to entertain new and innovative solutions. The truck ferry has promise to reduce the volume of trucks on the roads, as well as provide a sorely needed source of transportation redundancy.

The current transportation modes, road and rail, are both showing signs of saturation and will not be as effective vis-a-vis cost and volume as they have been historically.

Barriers to Short Sea Shipping have been presented, despite these barriers, there are straightforward ways to remove or mitigate these barriers and make significant headway towards a cost effective and profitable business. The startup of such a business will be aided by the use of existing and suitable ships.

The business model presented illustrates that not only is the truck ferry more efficient and ecologically sound mode than current ones, but also less expensive. The transportation networks of the future will need many solutions, this is one to implement.

Appendix A

Congestion Data

Most Traveled Highway Sections

Average Annual Daily Traffic (AADT) > 250,000

State	Urban Area	Route	AADT
California	Los Angeles-Long Beach-Santa Ana	I-405	390,000
California	Los Angeles-Long Beach-Santa Ana	US-60	343,000
California	Los Angeles-Long Beach-Santa Ana	I-5	335,000
California	Los Angeles-Long Beach-Santa Ana	I-110	331,000
California	Mission Viejo	I-5	328,000
Texas	Houston	US-59	326,246
California	Los Angeles-Long Beach-Santa Ana	US-101	325,000
Georgia	Atlanta	I-75	322,440
Illinois	Chicago (IL-IN)	I-90	319,968
New Jersey	New York-Newark (NY-NJ-CT)	I-95	315,776
Florida	Miami	I-95	306,000
California	Los Angeles-Long Beach-Santa Ana	I-10	301,000
California	Los Angeles-Long Beach-Santa Ana	I-605	300,000
California	San Diego	I-15	300,000
California	Los Angeles-Long Beach-Santa Ana	I-210	299,000
California	Los Angeles-Long Beach-Santa Ana	US-91	298,000
New York	New York-Newark (NY-NJ-CT)	I-95	297,342
California	Concord	I-680	296,000
California	San Francisco-Oakland	I-80	294,000
California	Los Angeles-Long Beach-Santa Ana	US-57	293,000
Arizona	Phoenix	I-10	290,700
Puerto Rico	San Juan	I-18	288,000
Texas	Houston	I-45	284,211
Texas	Houston	I-610	284,010
California	Los Angeles-Long Beach-Santa Ana	US-110	282,000
Virginia	Washington (DC-VA-MD)	I-95	281,966
Texas	Dallas-Fort Worth-Arlington	I-35E	276,291
California	Riverside-San Bernardino	US-91	275,000
Georgia	Atlanta	I-285	268,840
California	San Francisco-Oakland	I-880	268,000
Georgia	Atlanta	I-85	267,900
New York	New York-Newark (NY-NJ-CT)	US-907M	264,795
Maryland	Washington (DC-VA-MD)	I-270	263,981
Nevada	Las Vegas	I-15	261,000
Puerto Rico	San Juan	I-22	258,100
Illinois	Chicago (IL-IN)	I-94	257,695
California	San Diego	I-8	254,000
California	Sacramento	I-50	253,000
California	San Francisco-Oakland	US-101	253,000
California	Los Angeles-Long Beach-Santa Ana	US-55	252,000

Office of Highway Policy Information February 5, 2008

Data Source: 2006 Highway Performance Monitoring System (HPMS)

Appendix B

Sealift Ships and Comparative Naval Architecture

B.1 Sealift Ships

B.2 Comparative Naval Architecture

This section looks at a cross-section of available ships for the truck ferry service. The majority of these ships were found in the pages of *Naval Architect*, the journal of the Royal Institute of Naval Architects (RINA) or *Marine Engineer Review*.

A comparison of the ships is found in Table B.2. The last column of this table shows the ratio of deadweight tons to lane-meters on the ship. The majority of commercial ships are on the order of 2. The exceptions are the INCAT, a high speed catamaran, and Wärtsilä's Proposed RO/RO cargo ship. The high speed catamaran is a light aluminum vessel meant for short journeys, and as such, even with a low displacement-to-cargo ratio, cannot carry a meaningful amount of trailers.

As seen in Table B.1, military sealift ships, in general have higher displacement to cargo ratios. These ships are usually more robust, have larger ranges, more fuel and larger machinery than their cost-conscious commercial counterparts.

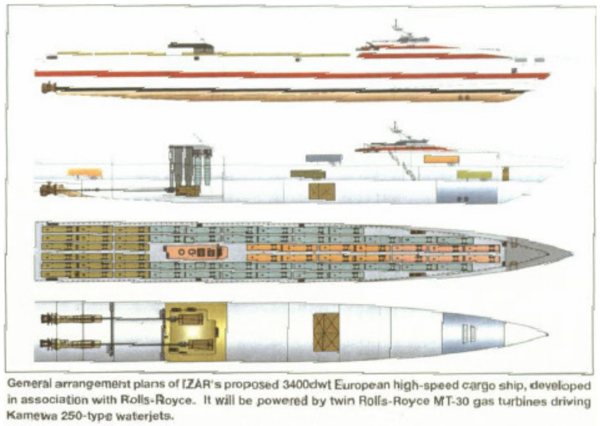
Type		Name	Length	Beam	Draft	Displ	Speed	Crew	Prog*	Loc**	Cargo			Cargo
											m^2	*ft^2*	*lane m*	Ratio
Fast Sealift Ships	SS	Algol	946	105	37	55350	27	42	RRF	LB	12170	130,997	4991.8	11.088
	SS	Altair	946	105	37	55350	27	42	SL		12170	130,997	4991.8	11.088
	SS	Antares	946	105	37	55350	27	42	RRF	LB	12170	130,997	4991.8	11.088
	SS	Bellatrix	946	105	37	55350	27	42	RRF		12170	130,997	4991.8	11.088
	SS	Capella	946	105	37	55350	27	42	RRF		12170	130,997	4991.8	11.088
	SS	Denebola	946	105	37	55350	27	42	RRF	LB	12170	130,997	4991.8	11.088
	SS	Pollux	946	105	37	55350	27	42	RRF	LB	12170	130,997	4991.8	11.088
	SS	Regulus	946	105	37	55350	27	42	RRF		12170	130,997	4991.8	11.088
LMSR	USNS	Benavidez	950	106	34	62069	24	30	SL		29498	317510	12099.1	5.130
	USNS	Brittin	950	106	34	62069	24	30	SL		29498	317510	12099.1	5.130
	USNS	Fisher	950	106	34	62069	24	30	SL		29498	317510	12099.1	5.130
	USNS	Gilliland	950	106	34	62069	24	30	SL		29498	317510	12099.1	5.130
	USNS	Gordon	950	106	34	62069	24	30	SL		29498	317510	12099.1	5.130
	USNS	Bob Hope	950	106	34	62069	24	30	SL		29498	317510	12099.1	5.130
	USNS	Mendonca	950	106	34	62069	24	30	SL		29498	317510	12099.1	5.130
	USNS	Pililaau	950	106	34	62069	24	30	SL		29498	317510	12099.1	5.130
	USNS	Seay	950	106	34	62069	24	30	SL		29498	317510	12099.1	5.130
	USNS	Shughart	950	106	34	62069	24	30	SL		29498	317510	12099.1	5.130
	USNS	Yano	950	106	34	62069	24	30	SL		29498	317510	12099.1	5.130
RORO	GTS	ADM W.M. Callaghan	694	92	29	26537	21.3	25	RRF	LB	15607	167,992	6401.6	4.145
	MV	Cape Decision	681	97	32	34790	16.2	27	RRF		19722	212,285	8089.4	4.301
	MV	Cape Diamond	681	97	32	34790	16.2	27	RRF	LB	19722	212,285	8089.4	4.301
	MV	Cape Domingo	681	97	32	34790	16.2	27	RRF	LB	19722	212,285	8089.4	4.301
	MV	Cape Douglas	681	97	32	34790	16.2	27	RRF	LB	19722	212,285	8089.4	4.301
	MV	Cape Ducato	681	97	32	34790	16.2	27	RRF	LB	19722	212,285	8089.4	4.301
	MV	Cape Edmont	652	94	31	32543	15.7	27	RRF	LB	10649	114,625	4367.9	7.450
	MV	Cape Henry	749	105	35	51007	17.4	28	RRF	LB	24166	260,117	9912.1	5.146
	MV	Cape Horn	749	105	35	51007	17.4	28	RRF	LB	24166	260,117	9912.1	5.146
	MV	Cape Hudson	749	105	35	51007	17.4	28	RRF	LB	24166	260,117	9912.1	5.146
	SS	Cape Inscription	684	102	32	33900	18.7	31	RRF	LB	16258	174,999	6668.6	5.084
	SS	Cape Intrepid	685	102	34	33900	18.7	31	RRF	LB	16258	174,999	6668.6	5.084
	SS	Cape Isabel	684	102	32	36355	18.7	31	RRF	LB	16258	174,999	6668.6	5.452
	SS	Cape Island	685	102	34	33900	18.7	31	RRF	LB	16258	174,999	6668.6	5.084
	MV	Cape Kennedy	695	105	35	29218	16.6	25	RRF	LB	N/A	N/A	N/A	
	MV	Cape Knox	695	105	35	29218	16.6	25	RRF	LB	N/A	N/A	N/A	
	MV	Cape Orlando	635	91	30	32799	16.2	25	RRF	LB	*10500*	*113,021*	*4306.8*	
	MV	Cape Race	647	105	32	32054	16.6	29	RRF	LB	19544	210,365	8016.2	3.999
	MV	Cape Ray	647	105	32	32054	16.6	29	RRF	LB	19544	210,365	8016.2	3.999
	MV	Cape Rise	647	105	32	32054	16.6	29	RRF	LB	19544	210,365	8016.2	3.999
	MV	Cape Taylor	634	89	28	24551	15.7	27	RRF	LB	*5053*	*54,391*	*2072.6*	
	MV	Cape Texas	634	89	28	24551	15.7	27	RRF	LB	*5053*	*54,391*	*2072.6*	
	MV	Cape Trinity	634	89	28	24551	15.7	27	RRF	LB	*5053*	*54,391*	*2072.6*	
	MV	Cape Victory	632	87	28	28215	14	25	RRF	LB	19410	208,926	7961.4	3.544
	MV	Cape Vincent	632	87	28	28215	14	25	RRF	LB	19410	208,926	7961.4	3.544
	MV	Cape Washington	697	106	38	53652	14.9	28	RRF	LB	17879	192,448	7333.5	7.316
	MV	Cape Wrath	697	106	38	53652	14.9	28	RRF	LB	17879	192,448	7333.5	7.316

* RRF: Ready Reserve Force; SL: Sealift Program

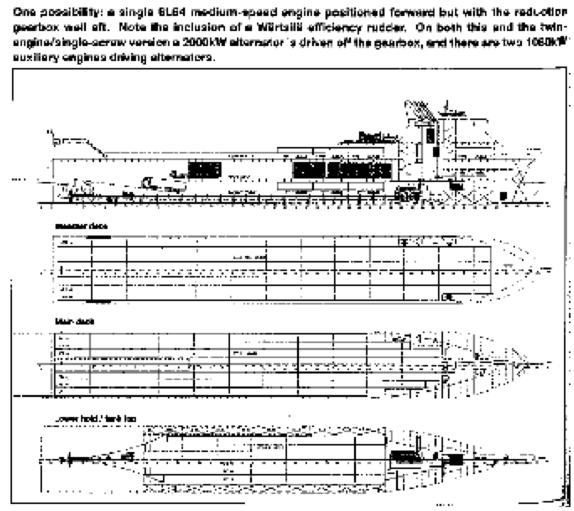
**LB: Layberth

Cargo Numbers in italics are most likely incorrect, but were based on freely available data

Table B.1: Potential Sealift Ships for Lease



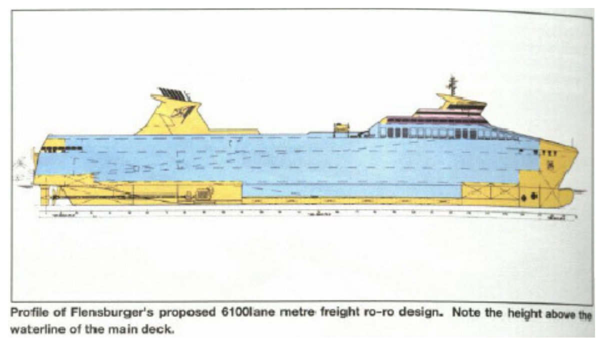
(a) IZAR's High Speed European Cargo Ship



(b) Wärtsilä's Proposed RO/RO

Figure B.1: Ships

(a) The Pride of Rotterdam



(b) Flensberger 6100 RO/RO

Figure B.2: Ships

The majority of these ships are also relatively short-range roll-on/roll-off and passenger vessels (RO/PAX). The Wärtsilä design as well as the Flensberger design are ones more focused on moving high volume and heavy cargoes for moderate distances. RO/RO ships with smaller displacement to lane-meter ratios are, in general, smaller, faster and meant for shorter journeys.

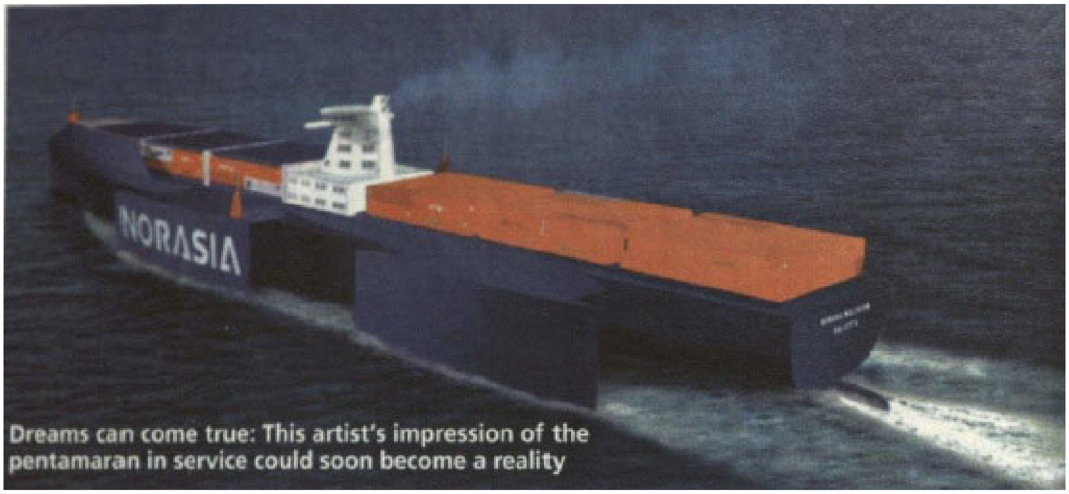
	Length m	Breadth m	Drft m	Disp dwt	RO/RO ln-m	Power	Output kw	Spd kt	Ln-m Ratio
Pride of Rotterdam	215	31.5	6.3	9250	3355	4xWartsila 9L46C	4x9450	22	2.757
European HS Cargo	212	27.7	6.75	3400	1700	2xRR MT-30	2x7800	37	2.000
Pentamaran FFerry	175	31.3	5	900	512	4xDiesel	4x12000	37	1.758
Flensberger RO/RO 6100	220	30.4	7.8	14100	6100	4xCAT MaK 7M43	4x6300	23	2.311
150m Auto Express Cat	150	22	4.5	1500	635	4xWartsila 16V32B	4x7360	28.5	2.362
122m Auto Express Cat	122	27	4.4	1000	650	4xdRuston 20V RK280	4x9000	40	1.538
Incat Evolution 112	112.6	30.2	3.3	1000	1170	4xRuston 20V RK280	4x9000	N/A	0.855
Mont St Michel	173.9	28.5	6.5	6300	2250	4xCAT MaK 6M43	4x5400	21	2.800
Pascal Paoli	175	30.5	7.3	6900	2305	4xWartsila 9L46	4x9450	24	2.993
IZAR/RR EHSCV	212	22	4.7	3400	1700	2xRR MT30	2x32MW	37	2.000
Proposed Wartsila	190	22	7.5	12000	2800	N/A	12000	18	4.286
Rolls Royce FNSLV	177	24	4.15	4000	1800	3xRR MT30	N/A	40	2.222
SeaFrance Rodin	185	27.7	6.75	6260	2000	2XWartsila 8L46B	2X7800	25	3.130
						2XWartsila 12VL46B	2X11700		

Table B.2: Table of Particulars for Selected RO/RO Ships

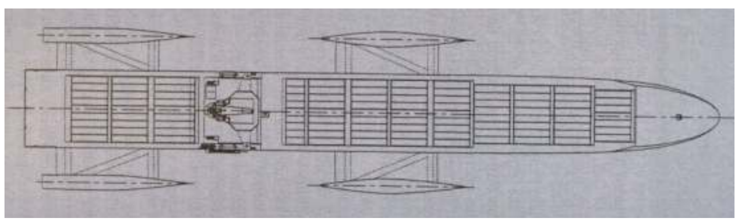
(a) Mont St Michel

(b) The SeaFrance Rodin

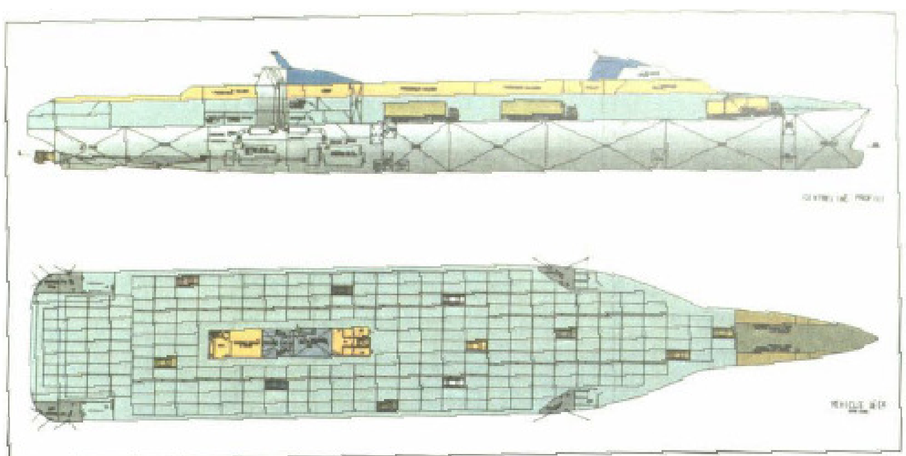
Figure B.3: Ships



(a) Pentamaran Containership Concept



(b) Plan View



General arrangement plans of the proposed Nigel Gee 900dwt Pentamaran fast ferry, for which IZAR holds an exclusive licence within Europe.

(c) Pentamaran Fast Ferry

Figure B.4: Pentamaran

General arrangement of Incat's new Evolution 112, which can be a ro-pax ferry, freight carrier, or a car carrier.

Figure B.5: INCAT Catamaran Design

Appendix C

Cost and Revenue Data

C.1 MSC Ships Only

year	FUEL COST SCENARIOS		Simulations			OTHER COSTS					
	Fuel (const)	Fuel (inc)	Fuel (const) LogNormal	Fuel (inc) LogNormal	Fuel (delta) Normal	Debt Service (Facilities)	Maint	Insurance	Crew	Port	Cargo
PV	$42,102,464	$57,907,887	$30,044,378	$48,200,114	$34,911,884	$5,566,885	$20,277,071	$21,690,271	$19,023,003	$3,987,328	$9,535,191
1	$4,945,340	$5,192,607	$4,523,644	$3,910,269	$3,588,763	$653,884	$3,300,000	$3,771,900	$2,234,435	$468,350	$1,120,000
2	$4,945,340	$5,439,874	$1,648,447	$4,638,652	$2,774,919	$653,884	$3,300,000	$3,583,800	$2,234,435	$468,350	$1,120,000
3	$4,945,340	$5,687,141	$4,446,972	$4,945,340	$3,024,378	$653,884	$3,300,000	$3,395,700	$2,234,435	$468,350	$1,120,000
4	$4,945,340	$5,934,408	$2,338,494	$7,245,498	$5,966,598	$653,884	$3,300,000	$3,207,600	$2,234,435	$468,350	$1,120,000
5	$4,945,340	$6,181,675	$1,533,439	$2,530,174	$5,630,998	$653,884	$3,300,000	$3,019,500	$2,234,435	$468,350	$1,120,000
6	$4,945,340	$6,428,942	$3,680,253	$1,571,775	$4,226,356	$653,884	$3,300,000	$2,831,400	$2,234,435	$468,350	$1,120,000
7	$4,945,340	$6,676,209	$2,031,806	$6,287,098	$4,551,886	$653,884	$3,300,000	$2,643,300	$2,234,435	$468,350	$1,120,000
8	$4,945,340	$6,923,476	$3,718,589	$11,654,134	$3,446,235	$653,884	$3,300,000	$2,455,200	$2,234,435	$468,350	$1,120,000
9	$4,945,340	$7,170,742	$1,073,407	$3,948,605	$2,685,559	$653,884	$3,300,000	$2,267,100	$2,234,435	$468,350	$1,120,000
10	$4,945,340	$7,418,009	$2,875,197	$3,756,925	$3,210,648	$653,884	$3,300,000	$2,079,000	$2,234,435	$468,350	$1,120,000
11	$4,945,340	$7,665,276	$6,057,083	$1,916,798	$3,550,351	$653,884	$3,300,000	$1,890,900	$2,234,435	$468,350	$1,120,000
12	$4,945,340	$7,912,543	$10,849,078	$10,734,071	$5,073,769	$653,884	$3,300,000	$1,702,800	$2,234,435	$468,350	$1,120,000
13	$4,945,340	$8,159,810	$4,255,292	$9,622,328	$5,594,677	$653,884	$3,300,000	$1,514,700	$2,234,435	$468,350	$1,120,000
14	$4,945,340	$8,407,077	$3,871,933	$5,903,739	$4,787,198	$653,884	$3,300,000	$1,326,600	$2,234,435	$468,350	$1,120,000
15	$4,945,340	$8,654,344	$2,031,806	$7,973,881	$5,420,828	$653,884	$3,300,000	$1,138,500	$2,234,435	$468,350	$1,120,000
16	$4,945,340	$8,901,611	$1,265,087	$3,335,229	$5,237,663	$653,884	$3,300,000	$950,400	$2,234,435	$468,350	$1,120,000
17	$4,945,340	$9,148,878	$2,146,814	$5,290,363	$3,997,183	$653,884	$3,300,000	$762,300	$2,234,435	$468,350	$1,120,000
18	$4,945,340	$9,396,145	$2,530,174	$6,095,419	$3,654,133	$653,884	$3,300,000	$574,200	$2,234,435	$468,350	$1,120,000
19	$4,945,340	$9,643,412	$4,255,292	$20,816,430	$2,751,523	$653,884	$3,300,000	$386,100	$2,234,435	$468,350	$1,120,000
20	$4,945,340	$9,890,679	$14,069,300	$8,663,928	$4,900,214	$653,884	$3,300,000	$198,000	$2,234,435	$468,350	$1,120,000
	A	**B**	**C**	**D**	**E**						

Table C.1: Snapshot of 20 year Cost Model

			MSC SHIPS TOTAL YEARLY COSTS BY SCENARIO		
		A	**B**	**C**	**D**	**E**
	PV	$124,989,706	$140,795,129	$117,571,294	$119,339,502	$130,191,954
Year	1	$15,905,413	$16,152,680	$13,758,599	$15,165,971	$13,681,927
	2	$15,717,313	$16,211,847	$20,470,973	$14,785,454	$12,803,779
	3	$15,529,213	$16,271,014	$15,644,221	$15,791,667	$14,532,478
	4	$15,341,113	$16,330,181	$12,274,236	$15,068,338	$12,887,611
	5	$15,153,013	$16,389,348	$11,281,080	$14,359,016	$17,798,195
	6	$14,964,913	$16,448,515	$12,281,395	$14,221,048	$11,821,364
	7	$14,776,813	$16,507,682	$13,473,390	$13,652,537	$12,668,335
	8	$14,588,713	$16,566,849	$11,138,476	$13,451,167	$15,892,136
	9	$14,400,613	$16,626,016	$11,908,775	$13,528,470	$18,809,249
	10	$14,212,513	$16,685,183	$12,487,394	$13,862,329	$12,832,418
	11	$14,024,413	$16,744,350	$18,279,705	$13,405,140	$11,609,247
	12	$13,836,313	$16,803,517	$10,424,412	$12,759,220	$15,791,447
	13	$13,648,213	$16,862,684	$18,478,545	$12,593,237	$15,871,699
	14	$13,460,113	$16,921,851	$11,351,635	$12,900,555	$10,124,884
	15	$13,272,013	$16,981,018	$9,668,432	$12,858,427	$37,538,680
	16	$13,083,913	$17,040,185	$16,150,790	$13,609,558	$19,294,339
	17	$12,895,813	$17,099,352	$11,822,406	$11,784,807	$21,444,733
	18	$12,707,713	$17,158,519	$11,787,650	$12,019,140	$18,764,796
	19	$12,519,613	$17,217,686	$14,398,075	$11,575,221	$18,270,008
	20	$12,331,513	$17,276,853	$9,302,972	$11,003,024	$18,388,596

Table C.2: Snapshot of Total Yearly Costs per Ship by Scenario

BREAK EVEN CARRIAGE RATES BY FUEL SCENARIO *($ per trailer-NM) based on 0.8 Load Factor*						
Year	1	$0.534	$0.542	$0.462	$0.509	$0.459
	2	$0.527	$0.544	$0.687	$0.496	$0.430
	3	$0.521	$0.546	$0.525	$0.530	$0.488
	4	$0.515	$0.548	$0.412	$0.506	$0.432
	5	$0.508	$0.550	$0.379	$0.482	$0.597
	6	$0.502	$0.552	$0.412	$0.477	$0.397
	7	$0.496	$0.554	$0.452	$0.458	$0.425
	8	$0.490	$0.556	$0.374	$0.451	$0.533
	9	$0.483	$0.558	$0.400	$0.454	$0.631
	10	$0.477	$0.560	$0.419	$0.465	$0.431
	11	$0.471	$0.562	$0.613	$0.450	$0.390
	12	$0.464	$0.564	$0.350	$0.428	$0.530
	13	$0.458	$0.566	$0.620	$0.423	$0.533
	14	$0.452	$0.568	$0.381	$0.433	$0.340
	15	$0.445	$0.570	$0.324	$0.431	$1.260
	16	$0.439	$0.572	$0.542	$0.457	$0.647
	17	$0.433	$0.574	$0.397	$0.395	$0.720
	18	$0.426	$0.576	$0.396	$0.403	$0.630
	19	$0.420	$0.578	$0.483	$0.388	$0.613
	20	$0.414	$0.580	$0.312	$0.369	$0.617
		A	**B**	**C**	**D**	**E**

Table C.3: Snapshot of Break-Even Pricing

C.2 New Construction Ships

The following tables include debt service for the new construction ship as well as their depreciation.

	FUEL COST SCENARIOS								OTHER COSTS					
			Simulations			Ship Costs			Operation Costs					
	Fuel (const)	Fuel (inc)	Fuel (const) LogNormal	Fuel (inc) LogNormal	Fuel (delta) Normal	Debt Serv	Depreciation *(Straight Line)*	Depreciation *(MACRS)*	Debt Service (Facilities)	Maint	Insurance	Crew	Port	Cargo
PV	$42,102,464	$57,907,887	$30,694,519	$58,683,039	$63,196,774	$87,257,510	$53,380,045	$86,339,662	$5,566,885	$20,277,071	$21,690,271	$19,023,003	$3,987,328	$9,535,191
1	$4,945,340	$5,192,607	$3,603,581	$3,258,557	$5,125,610	$10,249,234	$6,270,000	$13,200,000	$653,884	$3,300,000	$3,771,900	$2,234,435	$468,350	$1,120,000
2	$4,945,340	$5,439,874	$1,418,431	$3,526,909	$5,357,752	$10,249,234	$6,270,000	$23,760,000	$653,884	$3,300,000	$3,583,800	$2,234,435	$468,350	$1,120,000
3	$4,945,340	$5,687,141	$4,025,276	$7,935,545	$5,364,816	$10,249,234	$6,270,000	$19,008,000	$653,884	$3,300,000	$3,395,700	$2,234,435	$468,350	$1,120,000
4	$4,945,340	$5,934,408	$1,571,775	$21,046,445	$7,356,980	$10,249,234	$6,270,000	$15,206,400	$653,884	$3,300,000	$3,207,600	$2,234,435	$468,350	$1,120,000
5	$4,945,340	$6,181,675	$4,791,996	$4,561,980	$6,845,940	$10,249,234	$6,270,000	$12,170,400	$653,884	$3,300,000	$3,019,500	$2,234,435	$468,350	$1,120,000
6	$4,945,340	$6,428,942	$728,383	$2,568,510	$5,850,575	$10,249,234	$6,270,000	$9,728,400	$653,884	$3,300,000	$2,831,400	$2,234,435	$468,350	$1,120,000
7	$4,945,340	$6,676,209	$4,791,996	$10,695,735	$7,641,653	$10,249,234	$6,270,000	$8,646,000	$653,884	$3,300,000	$2,643,300	$2,234,435	$468,350	$1,120,000
8	$4,945,340	$6,923,476	$4,101,948	$10,350,711	$10,006,324	$10,249,234	$6,270,000	$8,646,000	$653,884	$3,300,000	$2,455,200	$2,234,435	$468,350	$1,120,000
9	$4,945,340	$7,170,742	$3,526,909	$3,220,221	$9,396,105	$10,249,234	$6,270,000	$8,646,000	$653,884	$3,300,000	$2,267,100	$2,234,435	$468,350	$1,120,000
10	$4,945,340	$7,418,009	$6,900,474	$2,146,814	$9,980,133	$10,249,234	$6,270,000	$8,646,000	$653,884	$3,300,000	$2,079,000	$2,234,435	$468,350	$1,120,000
11	$4,945,340	$7,665,276	$3,066,877	$4,408,636	$8,581,425	$10,249,234	$6,270,000	$4,329,600	$653,884	$3,300,000	$1,890,900	$2,234,435	$468,350	$1,120,000
12	$4,945,340	$7,912,543	$3,526,909	$1,495,103	$6,983,057	$10,249,234	$6,270,000		$653,884	$3,300,000	$1,702,800	$2,234,435	$468,350	$1,120,000
13	$4,945,340	$8,159,810	$3,450,237	$9,162,296	$7,020,565	$10,249,234	$6,270,000		$653,884	$3,300,000	$1,514,700	$2,234,435	$468,350	$1,120,000
14	$4,945,340	$8,407,077	$4,830,332	$7,322,170	$7,955,233	$10,249,234	$6,270,000		$653,884	$3,300,000	$1,326,600	$2,234,435	$468,350	$1,120,000
15	$4,945,340	$8,654,344	$4,293,628	$6,172,091	$9,728,693	$10,249,234	$6,270,000		$653,884	$3,300,000	$1,138,500	$2,234,435	$468,350	$1,120,000
16	$4,945,340	$8,901,611	$7,475,513	$7,513,849	$11,551,918	$10,249,234	$6,270,000		$653,884	$3,300,000	$950,400	$2,234,435	$468,350	$1,120,000
17	$4,945,340	$9,148,878	$1,686,783	$7,628,857	$11,585,552	$10,249,234	$6,270,000		$653,884	$3,300,000	$762,300	$2,234,435	$468,350	$1,120,000
18	$4,945,340	$9,396,145	$5,712,059	$11,462,454	$10,634,763	$10,249,234	$6,270,000		$653,884	$3,300,000	$574,200	$2,234,435	$468,350	$1,120,000
19	$4,945,340	$9,643,412	$3,680,253	$9,238,968	$7,971,271	$10,249,234	$6,270,000		$653,884	$3,300,000	$386,100	$2,234,435	$468,350	$1,120,000
20	$4,945,340	$9,890,679	$7,705,529	$5,903,739	$9,188,659	$10,249,234	$6,270,000		$653,884	$3,300,000	$198,000	$2,234,435	$468,350	$1,120,000
	A	**B**	**C**	**D**	**E**									

Table C.4: Snapshot of 20 Year Cost Model (New Construction)

NEW CONSTRUCTION
TOTAL YEARLY COSTS BY SCENARIO
Straight Line

PV	$265,627,261	$281,432,684	$254,219,316	$261,561,114	$282,207,836
1	$32,424,647	$32,671,914	$31,082,888	$31,842,973	$30,737,865
2	$32,236,547	$32,731,081	$28,709,638	$31,421,171	$30,818,117
3	$32,048,447	$32,790,248	$31,128,384	$31,544,919	$35,038,653
4	$31,860,347	$32,849,415	$28,486,782	$30,654,239	$47,961,453
5	$31,672,247	$32,908,582	$31,518,903	$31,514,480	$31,288,888
6	$31,484,147	$32,967,749	$27,267,191	$31,305,738	$29,107,317
7	$31,296,047	$33,026,916	$31,142,703	$31,787,780	$37,046,442
8	$31,107,947	$33,086,083	$30,264,556	$30,738,595	$36,513,319
9	$30,919,847	$33,145,250	$29,501,417	$30,936,804	$29,194,729
10	$30,731,747	$33,204,417	$32,686,882	$30,942,595	$27,933,222
11	$30,543,647	$33,263,584	$28,665,185	$29,767,344	$30,006,944
12	$30,355,547	$33,322,751	$28,937,117	$29,414,104	$26,905,310
13	$30,167,447	$33,381,918	$28,672,345	$29,739,854	$34,384,404
14	$29,979,347	$33,441,085	$29,864,339	$29,452,965	$32,356,177
15	$29,791,247	$33,500,252	$29,139,536	$29,521,421	$31,017,998
16	$29,603,147	$33,559,419	$32,133,321	$28,467,076	$32,171,657
17	$29,415,047	$33,618,586	$26,156,490	$28,508,991	$32,098,565
18	$29,226,947	$33,677,753	$29,993,667	$28,764,704	$35,744,062
19	$29,038,847	$33,736,920	$27,773,760	$28,278,763	$33,332,476
20	$28,850,747	$33,796,087	$31,610,937	$28,190,189	$29,809,146
	A	**B**	**C**	**D**	**E**

Table C.5: Total Yearly Cost, Straight Line

NEW CONSTRUCTION
TOTAL YEARLY COSTS BY SCENARIO
MACRS

	A	B	C	D	E
PV	$298,586,878	$314,392,301	$287,178,933	$294,520,731	$315,167,453
1	$39,354,647	$39,601,914	$38,012,888	$38,772,973	$37,667,865
2	$49,726,547	$50,221,081	$46,199,638	$48,911,171	$48,308,117
3	$44,786,447	$45,528,248	$43,866,384	$44,282,919	$47,776,653
4	$40,796,747	$41,785,815	$37,423,182	$39,590,639	$56,897,853
5	$37,572,647	$38,808,982	$37,419,303	$37,414,880	$37,189,288
6	$34,942,547	$36,426,149	$30,725,591	$34,764,138	$32,565,717
7	$33,672,047	$35,402,916	$33,518,703	$34,163,780	$39,422,442
8	$33,483,947	$35,462,083	$32,640,556	$33,114,595	$38,889,319
9	$33,295,847	$35,521,250	$31,877,417	$33,312,804	$31,570,729
10	$33,107,747	$35,580,417	$35,062,882	$33,318,595	$30,309,222
11	$28,603,247	$31,323,184	$26,724,785	$27,826,944	$28,066,544
12	$24,085,547	$27,052,751	$22,667,117	$23,144,104	$20,635,310
13	$23,897,447	$27,111,918	$22,402,345	$23,469,854	$28,114,404
14	$23,709,347	$27,171,085	$23,594,339	$23,182,965	$26,086,177
15	$23,521,247	$27,230,252	$22,869,536	$23,251,421	$24,747,998
16	$23,333,147	$27,289,419	$25,863,321	$22,197,076	$25,901,657
17	$23,145,047	$27,348,586	$19,886,490	$22,238,991	$25,828,565
18	$22,956,947	$27,407,753	$23,723,667	$22,494,704	$29,474,062
19	$22,768,847	$27,466,920	$21,503,760	$22,008,763	$27,062,476
20	$22,580,747	$27,526,087	$25,340,937	$21,920,189	$23,539,146
	A	**B**	**C**	**D**	**E**

Table C.6: Total Yearly Cost, MACRS

Break-Even Carriage Rates By Scenario										
	Straight Line					MACRS				
Yr	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
1	$0.870	$0.877	$0.834	$0.855	$0.825	$1.057	$1.063	$1.020	$1.041	$1.011
2	$0.865	$0.879	$0.771	$0.844	$0.827	$1.335	$1.348	$1.240	$1.313	$1.297
3	$0.860	$0.880	$0.836	$0.847	$0.941	$1.202	$1.222	$1.178	$1.189	$1.283
4	$0.855	$0.882	$0.765	$0.823	$1.288	$1.095	$1.122	$1.005	$1.063	$1.527
5	$0.850	$0.883	$0.846	$0.846	$0.840	$1.009	$1.042	$1.005	$1.004	$0.998
6	$0.845	$0.885	$0.732	$0.840	$0.781	$0.938	$0.978	$0.825	$0.933	$0.874
7	$0.840	$0.887	$0.836	$0.853	$0.995	$0.904	$0.950	$0.900	$0.917	$1.058
8	$0.835	$0.888	$0.812	$0.825	$0.980	$0.899	$0.952	$0.876	$0.889	$1.044
9	$0.830	$0.890	$0.792	$0.831	$0.784	$0.894	$0.954	$0.856	$0.894	$0.848
10	$0.825	$0.891	$0.878	$0.831	$0.750	$0.889	$0.955	$0.941	$0.894	$0.814
11	$0.820	$0.893	$0.770	$0.799	$0.806	$0.768	$0.841	$0.717	$0.747	$0.753
12	$0.815	$0.895	$0.777	$0.790	$0.722	$0.647	$0.726	$0.609	$0.621	$0.554
13	$0.810	$0.896	$0.770	$0.798	$0.923	$0.642	$0.728	$0.601	$0.630	$0.755
14	$0.805	$0.898	$0.802	$0.791	$0.869	$0.636	$0.729	$0.633	$0.622	$0.700
15	$0.800	$0.899	$0.782	$0.793	$0.833	$0.631	$0.731	$0.614	$0.624	$0.664
16	$0.795	$0.901	$0.863	$0.764	$0.864	$0.626	$0.733	$0.694	$0.596	$0.695
17	$0.790	$0.903	$0.702	$0.765	$0.862	$0.621	$0.734	$0.534	$0.597	$0.693
18	$0.785	$0.904	$0.805	$0.772	$0.960	$0.616	$0.736	$0.637	$0.604	$0.791
19	$0.780	$0.906	$0.746	$0.759	$0.895	$0.611	$0.737	$0.577	$0.591	$0.727
20	$0.775	$0.907	$0.849	$0.757	$0.800	$0.606	$0.739	$0.680	$0.588	$0.632

Table C.7: New Construction Break-Even Carriage Rates By Scenario and Depreciation Method *(LF=1.0)*

Break-Even Carriage Rates By Scenario										
	Straight Line					MACRS				
Yr	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
1	$1.088	$1.096	$1.043	$1.069	$1.031	$1.321	$1.329	$1.276	$1.301	$1.264
2	$1.082	$1.098	$0.963	$1.054	$1.034	$1.669	$1.685	$1.550	$1.641	$1.621
3	$1.075	$1.100	$1.045	$1.059	$1.176	$1.503	$1.528	$1.472	$1.486	$1.603
4	$1.069	$1.102	$0.956	$1.029	$1.609	$1.369	$1.402	$1.256	$1.329	$1.909
5	$1.063	$1.104	$1.058	$1.058	$1.050	$1.261	$1.302	$1.256	$1.256	$1.248
6	$1.057	$1.106	$0.915	$1.051	$0.977	$1.173	$1.222	$1.031	$1.167	$1.093
7	$1.050	$1.108	$1.045	$1.067	$1.243	$1.130	$1.188	$1.125	$1.146	$1.323
8	$1.044	$1.110	$1.016	$1.032	$1.225	$1.124	$1.190	$1.095	$1.111	$1.305
9	$1.038	$1.112	$0.990	$1.038	$0.980	$1.117	$1.192	$1.070	$1.118	$1.059
10	$1.031	$1.114	$1.097	$1.038	$0.937	$1.111	$1.194	$1.177	$1.118	$1.017
11	$1.025	$1.116	$0.962	$0.999	$1.007	$0.960	$1.051	$0.897	$0.934	$0.942
12	$1.019	$1.118	$0.971	$0.987	$0.903	$0.808	$0.908	$0.761	$0.777	$0.692
13	$1.012	$1.120	$0.962	$0.998	$1.154	$0.802	$0.910	$0.752	$0.788	$0.943
14	$1.006	$1.122	$1.002	$0.988	$1.086	$0.796	$0.912	$0.792	$0.778	$0.875
15	$1.000	$1.124	$0.978	$0.991	$1.041	$0.789	$0.914	$0.767	$0.780	$0.830
16	$0.993	$1.126	$1.078	$0.955	$1.080	$0.783	$0.916	$0.868	$0.745	$0.869
17	$0.987	$1.128	$0.878	$0.957	$1.077	$0.777	$0.918	$0.667	$0.746	$0.867
18	$0.981	$1.130	$1.007	$0.965	$1.199	$0.770	$0.920	$0.796	$0.755	$0.989
19	$0.974	$1.132	$0.932	$0.949	$1.119	$0.764	$0.922	$0.722	$0.739	$0.908
20	$0.968	$1.134	$1.061	$0.946	$1.000	$0.758	$0.924	$0.850	$0.736	$0.790

Table C.8: New Construction Break-Even Carriage Rates By Scenario and Depreciation Method *(LF=0.8)*

C.3 Combined Operation

COMBINED OPERATON *(10 Ships)* TOTAL YEARLY COSTS BY SCENARIO Straight Line					
1	$159,054,129	$161,526,799	$145,636,541	$153,237,383	$142,186,304
2	$157,173,129	$162,118,469	$121,904,040	$149,019,364	$142,988,822
3	$221,292,129	$228,710,139	$212,091,497	$216,256,847	$251,194,183
4	$219,411,129	$229,301,808	$185,675,479	$207,350,044	$380,422,188
5	$300,801,763	$312,176,045	$298,079,910	$298,800,184	$295,664,744
6	$316,380,498	$328,991,114	$277,776,180	$313,556,169	$294,260,645
7	$332,147,332	$345,747,016	$325,285,194	$333,688,880	$372,285,089
8	$348,102,267	$362,443,752	$333,879,623	$342,779,465	$396,520,592
9	$378,645,914	$395,707,336	$360,819,690	$375,483,197	$383,897,941
10	$394,788,948	$412,344,904	$391,032,024	$392,400,323	$394,022,229
11	$411,120,083	$428,923,306	$389,920,293	$405,063,737	$427,949,572
12	$295,639,317	$313,442,540	$276,854,694	$289,494,504	$309,670,281
13	$378,346,652	$395,902,607	$359,408,684	$374,187,937	$409,437,120
14	$329,242,086	$346,303,508	$315,134,450	$325,623,023	$351,476,947
15	$313,900,973	$329,973,327	$299,371,642	$310,613,664	$334,909,083
16	$312,019,973	$330,564,997	$299,599,120	$308,606,598	$330,996,276
17	$310,138,973	$331,156,667	$297,143,081	$306,801,532	$330,342,027
18	$308,257,973	$331,748,337	$298,520,638	$305,600,259	$314,736,751
19	$306,376,973	$332,340,006	$296,141,270	$303,607,200	$314,465,862
20	$304,495,973	$332,931,676	$301,007,400	$300,768,538	$317,530,202
	A	**B**	**C**	**D**	**E**

Table C.9: Total Operational Costs for Combined Operation

COMBINED OPERATON *(10 Ships)* TOTAL YEARLY COSTS BY SCENARIO MACRS					
1	$159,054,129	$161,526,799	$145,636,541	$153,237,383	$142,186,304
2	$157,173,129	$162,118,469	$121,904,040	$149,019,364	$142,988,822
3	$221,292,129	$228,710,139	$212,091,497	$216,256,847	$251,194,183
4	$219,411,129	$229,301,808	$185,675,479	$207,350,044	$380,422,188
5	$307,731,763	$319,106,045	$305,009,910	$305,730,184	$302,594,744
6	$340,800,498	$353,411,114	$302,196,180	$337,976,169	$318,680,645
7	$369,305,332	$382,905,016	$362,443,194	$370,846,880	$409,443,089
8	$394,196,667	$408,538,152	$379,974,023	$388,873,865	$442,614,992
9	$430,640,714	$447,702,136	$412,814,490	$427,477,997	$435,892,741
10	$450,242,148	$467,798,104	$446,485,224	$447,853,523	$449,475,429
11	$468,949,283	$486,752,506	$447,749,493	$462,892,937	$485,778,772
12	$355,844,517	$373,647,740	$337,059,894	$349,699,704	$369,875,481
13	$440,927,852	$458,483,807	$421,989,884	$436,769,137	$472,018,320
14	$394,199,286	$411,260,708	$380,091,650	$390,580,223	$416,434,147
15	$369,987,773	$386,060,127	$355,458,442	$366,700,464	$390,995,883
16	$344,346,773	$362,891,797	$331,925,920	$340,933,398	$363,323,076
17	$323,457,773	$344,475,467	$310,461,881	$320,120,332	$343,660,827
18	$306,370,373	$329,860,737	$296,633,038	$303,712,659	$312,849,151
19	$292,318,973	$318,282,006	$282,083,270	$289,549,200	$300,407,862
20	$280,709,573	$309,145,276	$277,221,000	$276,982,138	$293,743,802
	A	**B**	**C**	**D**	**E**

Table C.10: Total Operational Costs for Combined Operation

COMBINED OPERATON *(10 Ships)* TOTAL YEARLY PROFIT BY SCENARIO Straight Line ($1.70 per trailer-NM, LF=0.8)					
PV	$1,511,220,158	$1,450,702,107	$1,625,166,481	$1,542,059,093	$1,376,398,012
1	$347,543,151	$345,070,481	$360,960,739	$353,359,897	$364,410,976
2	$349,424,151	$344,478,811	$384,693,240	$357,577,916	$363,608,458
3	$285,305,151	$277,887,141	$294,505,783	$290,340,433	$255,403,097
4	$287,186,151	$277,295,472	$320,921,801	$299,247,236	$126,175,092
5	$205,795,517	$194,421,235	$208,517,370	$207,797,096	$210,932,536
6	$190,216,782	$177,606,166	$228,821,100	$193,041,111	$212,336,635
7	$174,449,948	$160,850,264	$181,312,086	$172,908,400	$134,312,191
8	$158,495,013	$144,153,528	$172,717,657	$163,817,815	$110,076,688
9	$127,951,366	$110,889,944	$145,777,590	$131,114,083	$122,699,339
10	$111,808,332	$94,252,376	$115,565,256	$114,196,957	$112,575,051
11	$95,477,197	$77,673,974	$116,676,987	$101,533,543	$78,647,708
12	$210,957,963	$193,154,740	$229,742,586	$217,102,776	$196,926,999
13	$128,250,628	$110,694,673	$147,188,596	$132,409,343	$97,160,160
14	$177,355,194	$160,293,772	$191,462,830	$180,974,257	$155,120,333
15	$192,696,307	$176,623,953	$207,225,638	$195,983,616	$171,688,197
16	$194,577,307	$176,032,283	$206,998,160	$197,990,682	$175,601,004
17	$196,458,307	$175,440,613	$209,454,199	$199,795,748	$176,255,253
18	$198,339,307	$174,848,943	$208,076,642	$200,997,021	$191,860,529
19	$200,220,307	$174,257,274	$210,456,010	$202,990,080	$192,131,418
20	$202,101,307	$173,665,604	$205,589,880	$205,828,742	$189,067,078
	A	**B**	**C**	**D**	**E**

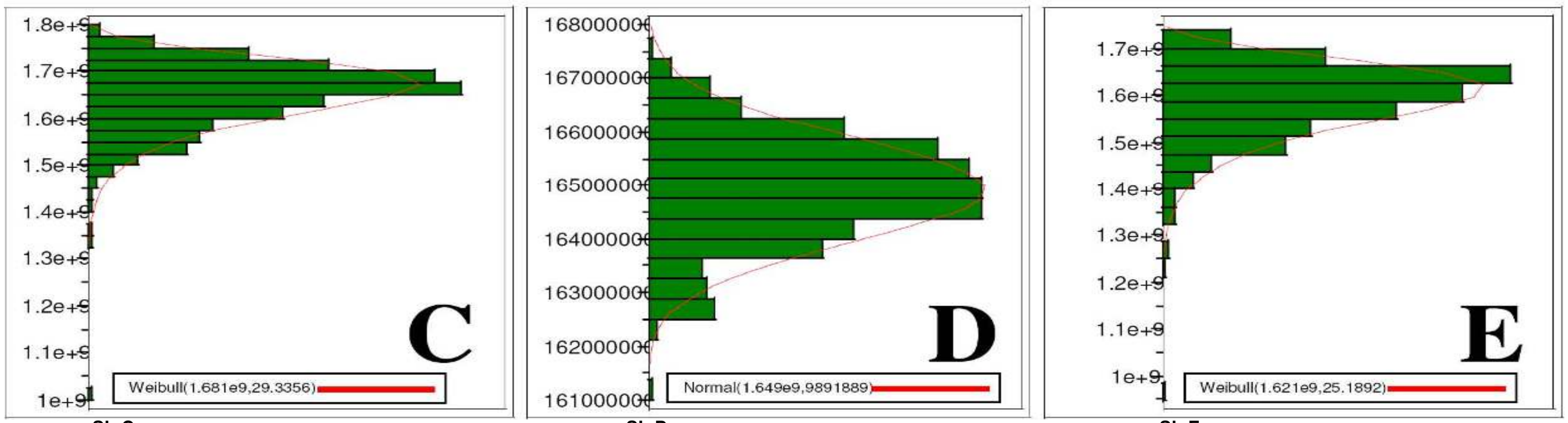
Table C.11: Total Operational Profit for Combined Operation

COMBINED OPERATON *(10 Ships)* TOTAL YEARLY PROFIT BY SCENARIO MACRS ($1.70 per trailer-NM, LF=0.8)					
PV	$1,409,130,932	$1,348,612,882	$1,523,077,256	$1,439,969,868	$1,274,308,787
1	$347,543,151	$345,070,481	$360,960,739	$353,359,897	$364,410,976
2	$349,424,151	$344,478,811	$384,693,240	$357,577,916	$363,608,458
3	$285,305,151	$277,887,141	$294,505,783	$290,340,433	$255,403,097
4	$287,186,151	$277,295,472	$320,921,801	$299,247,236	$126,175,092
5	$198,865,517	$187,491,235	$201,587,370	$200,867,096	$204,002,536
6	$165,796,782	$153,186,166	$204,401,100	$168,621,111	$187,916,635
7	$137,291,948	$123,692,264	$144,154,086	$135,750,400	$97,154,191
8	$112,400,613	$98,059,128	$126,623,257	$117,723,415	$63,982,288
9	$75,956,566	$58,895,144	$93,782,790	$79,119,283	$70,704,539
10	$56,355,132	$38,799,176	$60,112,056	$58,743,757	$57,121,851
11	$37,647,997	$19,844,774	$58,847,787	$43,704,343	$20,818,508
12	$150,752,763	$132,949,540	$169,537,386	$156,897,576	$136,721,799
13	$65,669,428	$48,113,473	$84,607,396	$69,828,143	$34,578,960
14	$112,397,994	$95,336,572	$126,505,630	$116,017,057	$90,163,133
15	$136,609,507	$120,537,153	$151,138,838	$139,896,816	$115,601,397
16	$162,250,507	$143,705,483	$174,671,360	$165,663,882	$143,274,204
17	$183,139,507	$162,121,813	$196,135,399	$186,476,948	$162,936,453
18	$200,226,907	$176,736,543	$209,964,242	$202,884,621	$193,748,129
19	$214,278,307	$188,315,274	$224,514,010	$217,048,080	$206,189,418
20	$225,887,707	$197,452,004	$229,376,280	$229,615,142	$212,853,478
	A	**B**	**C**	**D**	**E**

Table C.12: Total Operational Profit for Combined Operation

C.4 Fuel Simulation Results

Distribution of Anticipated Profits By Fuel Scenario (Straight Line)



SL-C

Quantiles

100.00%	maximum	1.79E+09
99.50%		1.79E+09
97.50%		1.76E+09
90.00%		1.73E+09
75.00%	quartile	1.70E+09
50.00%	median	1.66E+09
25.00%	quartile	1.61E+09
10.00%		1.55E+09
2.50%		1.49E+09
0.50%		1.35E+09
0.00%	minimum	1.01E+09

Moments

Mean	1.65E+09
Std Dev	74142072
Std Err Mean	3315734.3
upper 95%	1.66E+09
lower 95%	1.64E+09
N	500

Fitted 2 parameter Weibull

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Shape	Alpha	1.68E+09	1.68E+09	1.69E+09
Scale	Beta	29.335649	27.36184	31.375898

SL-D

Quantiles

100.00%	maximum	1.68E+09
99.50%		1.67E+09
97.50%		1.67E+09
90.00%		1.66E+09
75.00%	quartile	1.66E+09
50.00%	median	1.65E+09
25.00%	quartile	1.64E+09
10.00%		1.64E+09
2.50%		1.63E+09
0.50%		1.62E+09
0.00%	minimum	1.61E+09

Moments

Mean	1.65E+09
Std Dev	9891889.4
Std Err Mean	442378.74
upper 95%	1.65E+09
lower 95%	1.65E+09
N	500

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	1.65E+09	1.65E+09	1.65E+09
Dispersion	Sigma	9891889.4	9314435.4	10546254

SL-E

Quantiles

100.00%	maximum	1.73E+09
99.50%		1.72E+09
97.50%		1.71E+09
90.00%		1.68E+09
75.00%	quartile	1.64E+09
50.00%	median	1.60E+09
25.00%	quartile	1.54E+09
10.00%		1.48E+09
2.50%		1.39E+09
0.50%		1.11E+09
0.00%	minimum	914957172

Moments

Mean	1.59E+09
Std Dev	87614265
Std Err Mean	3918229.1
upper 95%	1.59E+09
lower 95%	1.58E+09
N	500

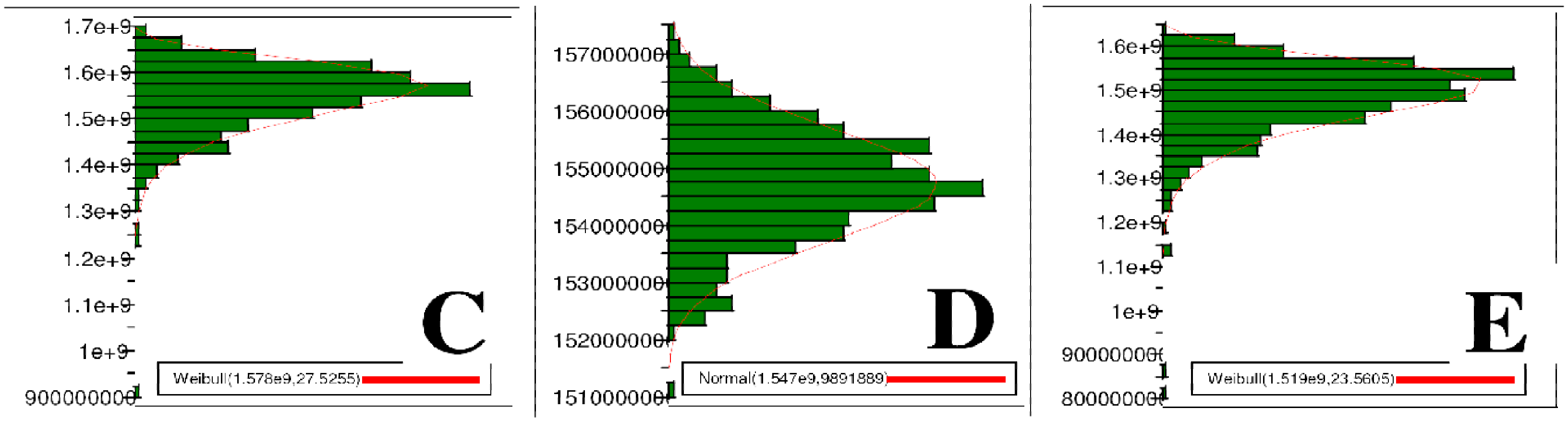
Fitted 2 parameter Weibull

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Shape	Alpha	1.62E+09	1.62E+09	1.63E+09
Scale	Beta	25.189154	23.466618	26.97368

Figure C.1: Straight Line Simulation

Distribution of Anticipated Profits By Fuel Scenario (MACRS)



MACRS-C

Quantiles

100.00%	maximum	1.69E+09
99.50%		1.69E+09
97.50%		1.65E+09
90.00%		1.62E+09
75.00%	quartile	1.59E+09
50.00%	median	1.56E+09
25.00%	quartile	1.51E+09
10.00%		1.45E+09
2.50%		1.38E+09
0.50%		1.25E+09
0.00%	minimum	904121177

Moments

Mean	1.55E+09
Std Dev	74142072
Std Err Mean	3315734.3
upper 95% Mean	1.55E+09
lower 95% Mean	1.54E+09
N	500

Fitted 2 parameter Weibull

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Shape	Alpha	1.58E+09	1.57E+09	1.58E+09
Scale	Beta	27.525543	25.672245	29.441267

MACRS-D

Quantiles

100.00%	maximum	1.57E+09
99.50%		1.57E+09
97.50%		1.57E+09
90.00%		1.56E+09
75.00%	quartile	1.55E+09
50.00%	median	1.55E+09
25.00%	quartile	1.54E+09
10.00%		1.53E+09
2.50%		1.53E+09
0.50%		1.52E+09
0.00%	minimum	1.51E+09

Moments

Mean	1.55E+09
Std Dev	9891889.4
Std Err Mean	442378.74
upper 95%	1.55E+09
lower 95%	1.55E+09
N	500

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	1.55E+09	1.55E+09	1.55E+09
Dispersion	Sigma	9891889.4	9314435.4	10546254

MACRS-E

Quantiles

100.00%	maximum	1.63E+09
99.50%		1.62E+09
97.50%		1.60E+09
90.00%		1.57E+09
75.00%	quartile	1.54E+09
50.00%	median	1.50E+09
25.00%	quartile	1.44E+09
10.00%		1.38E+09
2.50%		1.29E+09
0.50%		1.01E+09
0.00%	minimum	812867947

Moments

Mean	1.48E+09
Std Dev	87614265
Std Err Mean	3918229.1
upper 95%	1.49E+09
lower 95%	1.48E+09
N	500

Fitted 2 parameter Weibull

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Shape	Alpha	1.52E+09	1.51E+09	1.53E+09
Scale	Beta	23.560503	21.94809	25.231106

Figure C.2: MACRS Simulation

Appendix D

Port Locations

Images from Google Earth

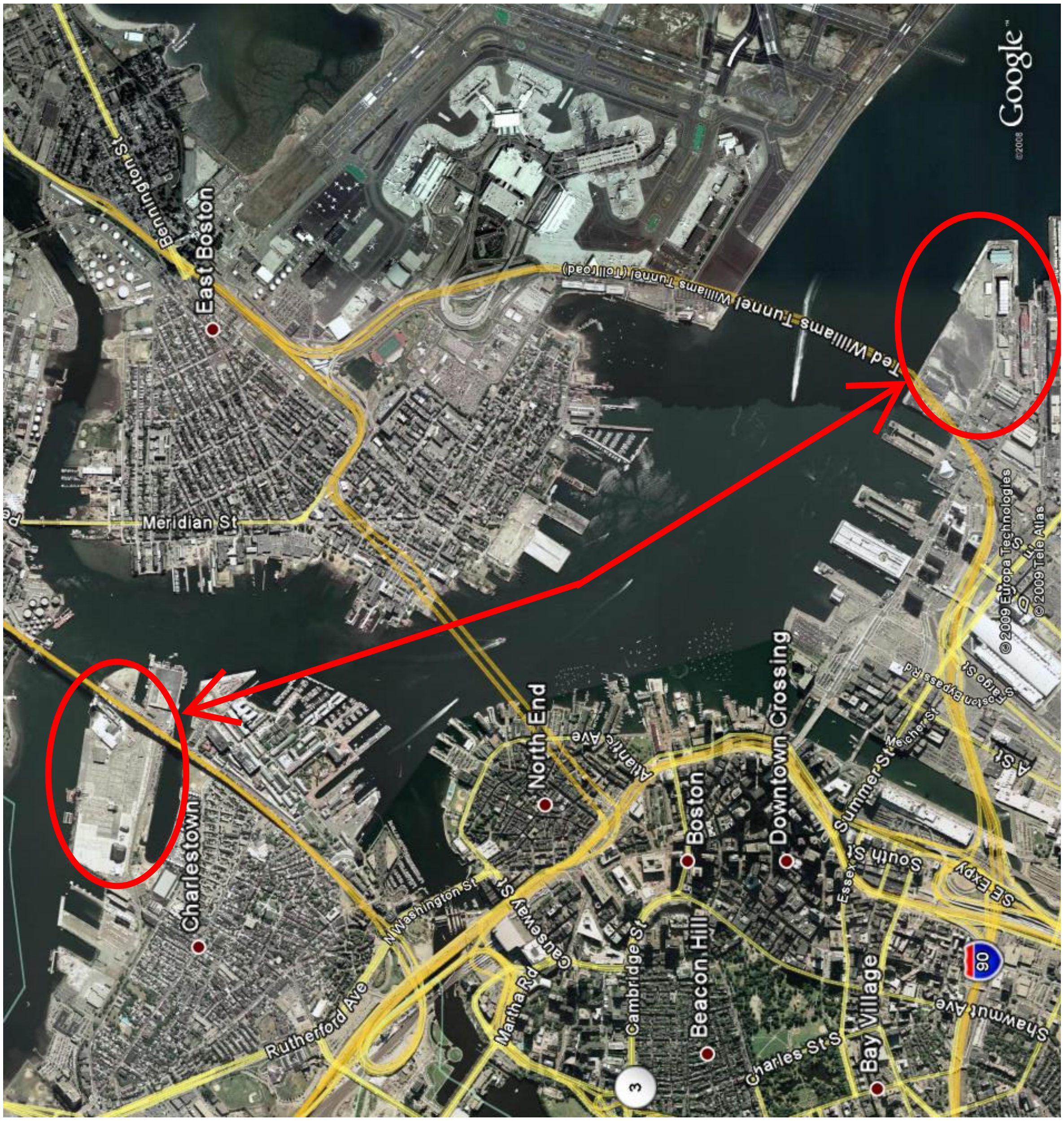


Figure D.1: Boston, Massachusetts

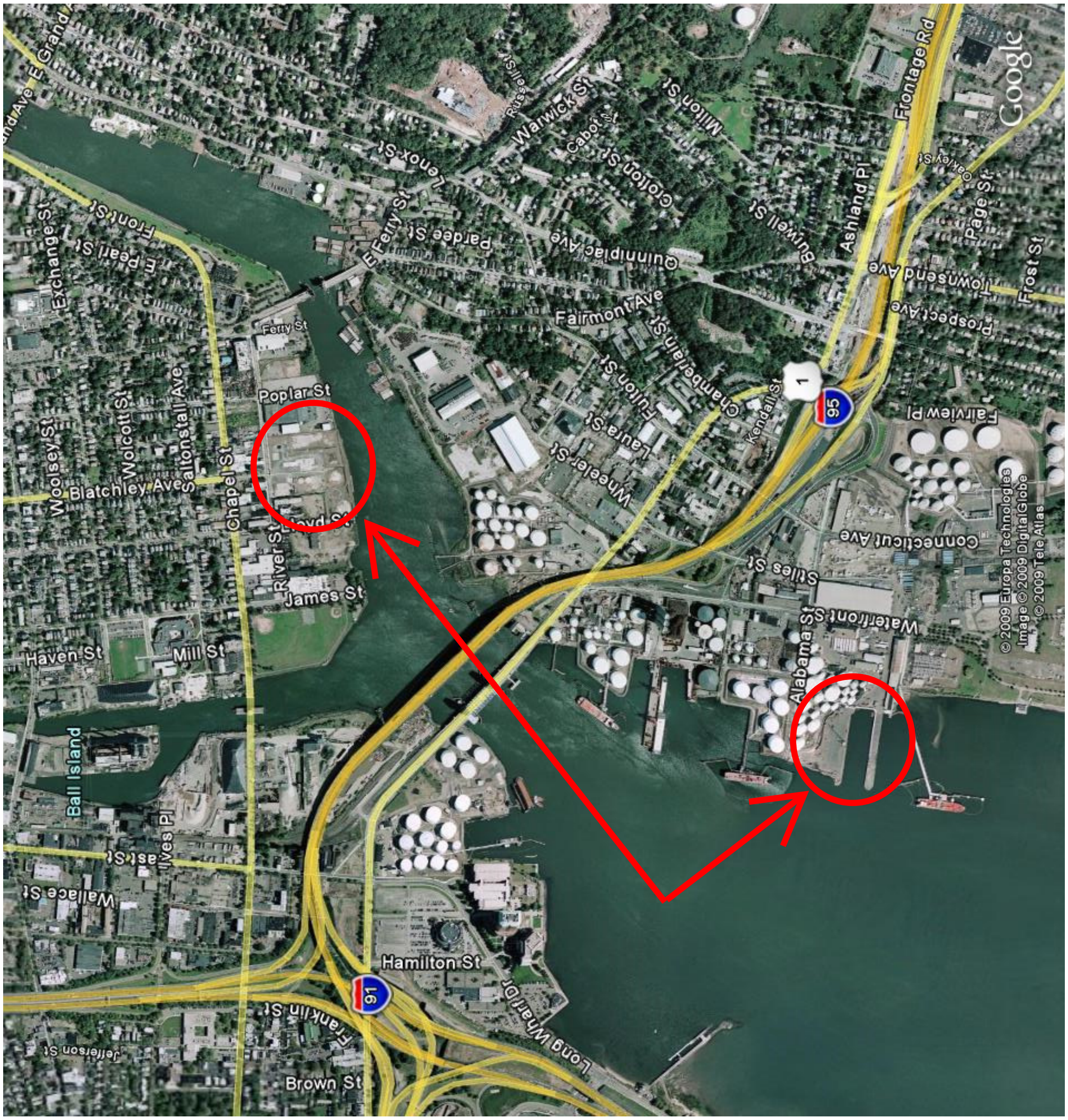


Figure D.2: New Haven, Connecticut

Figure D.3: Wilmington, Delaware

Figure D.4: Charleston, South Carolina

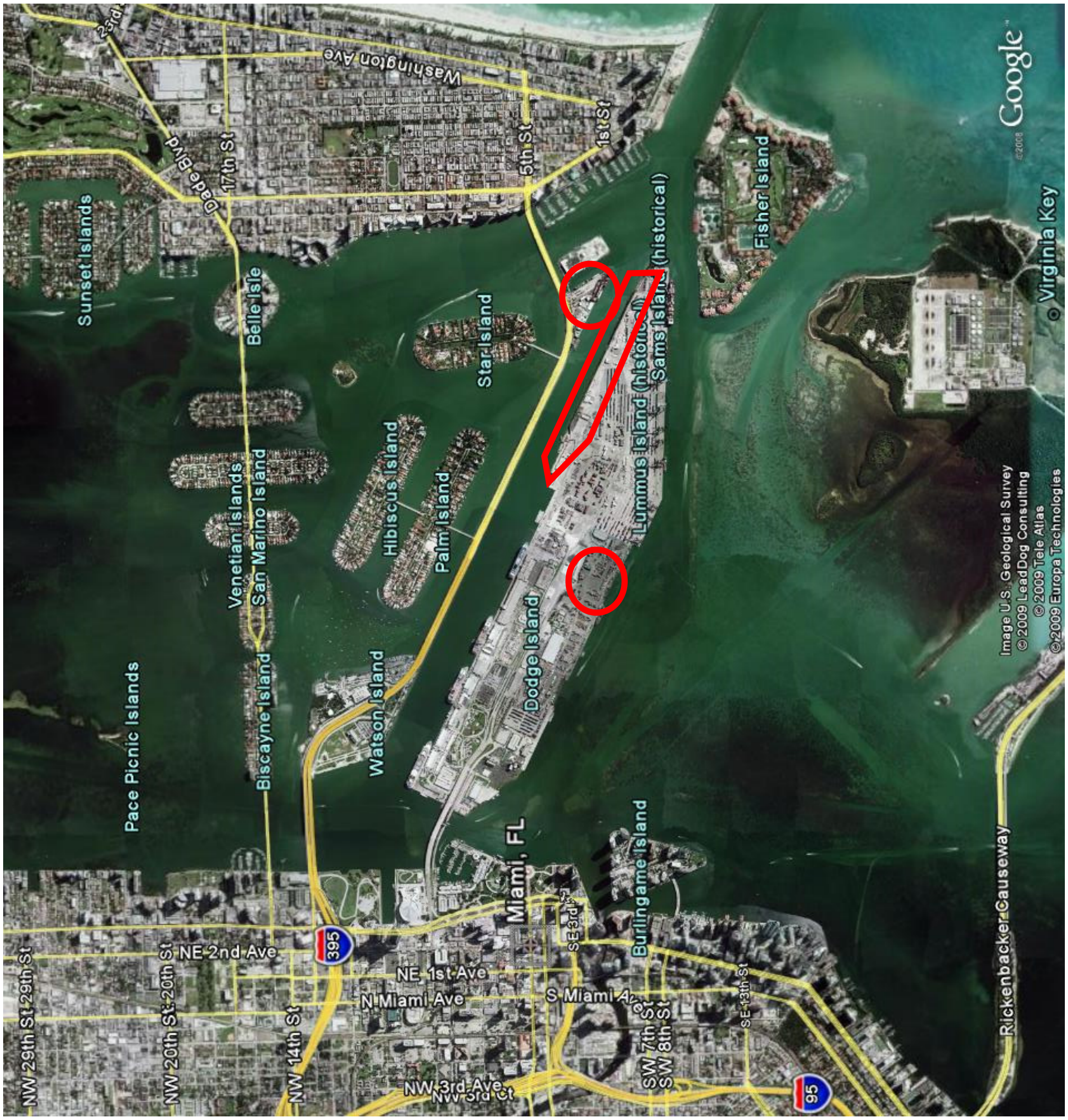


Figure D.5: Miami, Florida

Bibliography

[1] Kathy Adams, "New barge line to Richmond grows rapidly," *The Virginian-Pilot*, 27 February 2009.

[2] Paul H. Bea, "Marine Highway Development: Options and Roadblocks," in *Coastwise Coalition*, 18 June 2008, Roundtable.

[3] David Bierderman, "Dredging for Funds Release," *Traffic World*, 15 September 2008.

[4] Birmimgham Post, "New front in the fight against pollution as London targets truckers," *Birmimgham Post*, 5 February 2008.

[5] Scott G. Borgerson, "Council on Foreign Relations," *The Journal of Commerce*, 12 January 2009.

[6] Cambridge Systematics, "Short Sea and Coastal Options Study," I-95 Corridor Coalition, Tech. Rep., November 2005.

[7] ——, "National Rail Freight Infrastructure Capacity and Investment Study," Association of American Railroads, Tech. Rep., September 2007.

[8] Doug Cameron, "CSX Sees Rail Gains from Chronic U.S. Road Congestion," *Dow Jones Newswires*, April 2008.

[9] Center for Ports and Waterways, Texas Transportation Institute, "A Modal Comparison of Domestic Freight Transportation Effects on the General Public," U.S. Department of Transportation, MARAD and National Waterways Foundation, Tech. Rep., November 2007.

[10] Hsing-Chung Chu and Michael D. Meyer, "Screening Process for Identifing Potential Truck-Only-Toll Lanes in a Metropolitan Area: The Atlanta, Georgia Case," in *Transportation Research Record*, vol. 2066, 2008, pp. 79–89.

[11] H. Clayton Cook, "Financing the U.S. Market via MARAD's "CCF" Program," *Marine Money*, 1 June 2002.

[12] Larry Copeland, "Waterways could be key to freeing up freeways; 'Marine Highways' proposal would move freight from land to sea." *USA Today*, 11 October 2007.

[13] Jean Labayle Couhat and Bernard Prézelin, Eds., *Combat Fleets of the World 1988/89*. Naval Institute Press, 1988, p. 876.

[14] Mary Davis, "Raritan Transloading Services Prospser in NJ Complex," *Modern Bulk Transporter*, 1 December 2007.

[15] R.G. Edmonson, "MARAD sets short sea pilot," *Pacific Shipper*, 20 October 2008.

[16] ——, "Transportation Infrastructure," *Journal of Commerce*, January 2009.

[17] Federal News Service, "Rep. McHugh works to expand short sea shipping, Port of Oswego," *US Federal News Service*, 22 January 2009.

[18] Bruce Fenimore, "Columbia Coastal Transport," *Journal of Commerce*, 12 January 2009.

[19] Florida Shipper, "Inland waterways face critical investment shortfall," *Florida Shipper*, 5 January 2009.

[20] Porfirio Adolfo Fuentes Aguiluz, "An Economic Evaluation of Fast Displacement Vessels for Ocean Transportation of Perishables and High Value Commodities: A Spatial Equilibrium Approach," Ph.D. dissertation, Mississippi State University, 2002.

[21] Global Insight, "The U.S. Truck Driver Shortage: Analysis and Forecasts," American Trucking Associations, Tech. Rep., May 2005.

[22] GlobalSecurity.org, “T-AKR 287 Algol SL-7 Type Fast Sealift Ships,” *http://www.globalsecurity.org/military/systems/ship/takr-287.htm*, October 2006.

[23] ——, “T-AKR USNS Bob Hope Large, Medium-speed, roll-on/roll-off ships [LMSR],” *http://www.globalsecurity.org/military/systems/ship/takr-300.htm*, July 2006.

[24] Bill Gray, “Reasons to be cheerful about shipping: one, two, three...” *LLoyd’s List*, 26 October 2007.

[25] ——, “Should America continue to build ships or can we leave it to the experts?” *Lloyd’s List*, 11 April 2007.

[26] William O. Gray, “Performance of Major U.S. Shipyards in the 20th and 21st Century,” *Journal of Ship Production*, vol. 24, no. 4, pp. 202–213, November 2008.

[27] Kristopher Hanson, “Long Beach port approves \$35-\$70 cargo fees,” *Press-Telegram*, 18 December 2007.

[28] José Holguín and et al., “Economic and Financial Feasibility of Truck Toll Lanes,” in *Transportation Research Record*, vol. 1833, no. 03-3317, 2003, pp. 66–72.

[29] Institute for Global Maritime Studies, “America’s Deep Blue Highway: How Coastal Shipping Could Reduce Traffic Congestion, Lower Pollution, and Bolster National Security,” Tech. Rep., September 2008.

[30] Erik F. Johnsen, “Some Thoughts on Short Sea Shipping,” Speech, 16 April 2008.

[31] Rajesh Joshi, “Hope springs eternal as politicians rally to push the U.S. Great Lakes agenda: an increase in the dredging budget is a key prong of a fresh bipartisan charge,” *Lloyd’s List*, March 2007.

[32] ——, “MARAD urges ports to build up their intermodal connections,” *Lloyd’s List*, February 2009, special Report – US Maritime p.9.

[33] Journal of Commerce, “Radar Screen,” *Journal of Commerce*, 15 December 2008.

[34] Kazuya Kawamura, “Percieved Benefits of Congestion Pricing for Trucks,” in *Transportation Research Record*, vol. 1833, no. 03-3293, 2003.

[35] Lloyd’s List, “Crewing ‘will be the biggest challenge’,” *Lloyd’s List*, 28 April 2008.

[36] Gary A. Lombardo, “Short Sea Shipping: Planning for its Future in the Western Hemisphere,” 14 April 2008, *http://www.marad.dot.gov/MHI/documents/04%20USMMA%ShortSeaShippingArticle.doc*.

[37] Hon. Kenneth M. Mead, “Title XI Loan Guarantee Program: Statement of Hon. Kenneth M. Mead, Inspector General, U.S. DOT,” Testimony before U.S. Senate Committee on Commerce, Science and Transportation, 2003.

[38] Rebecca Mowbray, “Firm’s collapse spawns sale of 2 ships; Bad loans cost federal program,” *Money*, 19 June 2008.

[39] National Ports and Waterways Institute, Louisiana State University, “High Speed Ferries and Coastwise Vessels: Evaluation of Parameters and Markets for Application,” Center for the Commercial Deployment of Transportation Technologies (CCDoTT), Tech. Rep., June 2000.

[40] David Osler, “Turning the tide; The government has emphasized its commitment to getting freight off the roads and onto coastal freighters and inland waterways. So why isn’t it happening?” *Lloyd’s List*, 12 December 2008.

[41] Janet Porter, “Horizon Lines plans U.S. shortsea feeder services,” *Lloyd’s List*, 17 April 2008.

[42] ——, “Horizon Lines ready to launch U.S. coastal service,” *Lloyd’s List*, 24 April 2008.

[43] Ambresh Ranjan, “Rep. Cummings Introduces Short Sea Shipping Promotion Act,” *US Federal News Service*, 5 February 2009.

[44] Gregory Richards, “Railroads are expanding at a record clip,” *The Virginian-Pilot*, 6 April 2008.

[45] Emelie Rutherford, "Shipbuilding, MILCON Spending Eyed for Stimulus Package," *Defense Daily*, vol. 241, no. 6, 13 January 2009.

[46] Michael Schirer, "Summary of "How to Procure Quality High Performance Naval Ships at Half Price" by Ernst Frankel," in *MIT Defense & Arms Control Studies Seminar*, 4 March 1992.

[47] Shipping Digest, "House panel hears maritime industry's recruiting woes," *Shipping Digest*, 29 October 2007.

[48] Katherine Siggerud, "Highway Infrastructure: Physical Conditions of the Interstate Highway System Have Improved, but Congestion and Other Pressures Continue," U.S. Government Accountability Office, Tech. Rep., September 2002.

[49] Michael Tarm, "AP IMPACT: US freight rail congestion a concern," *http://www.foxnews.com/wires/2008May30/0,4670,RailCongestion,00.html*, 30 May 2008.

[50] The Maritme Executive, "Horizon Lines Chairman and CEO Unveils Rodmap for U.S. Marine Highway at MARAD Conference," *The Maritime Executive*, 2 April 2008.

[51] Transportation Business Associates, "Class 8 Operational Costs: How Fuel Costs Vary With Operations – Using a Typical Class 8 Over-the-Road Tractor-Trailer as an Example," *http://www.tbabz.com/OperationalCosts.htm*, 2009.

[52] U.S. Department of Transportation, Federal Highway Administration, "Policy Information: Highway Statistics 2007, Bridges by Year Built," *http://www.fhwa.dot.gov/policyinformation/statistics/2007/nbi332.cfm*, 2007.

[53] ——, "Policy Information: Highway Statistics 2007, Federal Highway Trust Fund," *http://www.fhwa.dot.gov/policyinformation/statistics/2007/balchrt.cfm*, 2007.

[54] U.S. Government Accountability Office, "Federal User Fees: Substantive Reviews Needed to Align Port Related Fees with the Programs They Support," U.S. Congressional Requesters, Tech. Rep., February 2008.

[55] U.S. Maritime Administration, "America's Marine Highway Program," Film, 2007, *http : //www.marad.dot.gov/video/Americas_Marine_Highway_ Program.wmv*.

[56] David Weldon, "Statement before Ways and Means Subcommittee on Select Revenue Measures," http://weldon.house.gov/News/DocumentSingle.aspx?DocumentID=63515, 24 April 2007.

[57] Kenneth R. Wykle, Isaac Maya, Richard A. Meyers, Thomas A. Remus, and J. Richard Williams, "High-Speed Sealift / Agile Port Operational Concept," in *Transportation Research Record*, vol. 1620, no. 98-1001, 1998, pp. 34–42.

[58] Luca Zamparini and Aura Reggiani, "Freight Transport and the Value of Travel Time Savings," in *Transport Reviews*, vol. 27, no. 5, September 2007, pp. 621–636.