High Speed Ferries and Coastwise Vessels: Evaluation of Parameters and Markets for Application

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I. INTRODUCTION

This report presents the findings of Phase II of the Study "High Speed Ferries and Coastwise Vessels: Evaluation of Parameters and Markets for Application." The Study was sponsored by the Center for the Commercial Deployment of Transportation Technologies (CCDoTT). CCDoTT is administered by the Maritime Administration (MARAD) and the U.S. Transportation Command (USTRANSCOM).

The goal of the Study was to define a commercially viable coastal shipping system that could relieve congestion on land-based transport arteries and at the same time can be utilized for defense related mobilizations. Phase I was dedicated to the definition of the scope of the overall program, which was formulated in cooperation with an Industry Advisory Board, representing shipping lines (carriers), ports, military planners (TRANSCOM), shipyards, and Federal agencies.

In accordance with the recommended scope, this report addresses the following main tasks:

- Assessment of cargo potentials, including cargo flows served by land-based and marine transport modes;
- Review of available and mature designs of vessel and port systems;
- Analysis of several operating systems, including performance and cost (required freight rates);
- Assessment of military application.

The sponsored program provided for the research team to address the above tasks at a conceptual level and to recommend which coastal system appears to be most viable for implementation. It is concluded that a system based on high speed Ro/Ro vessel (ferry) with monohull configuration has good prospects to accommodate both domestic trailers and international and domestic containers and relieve land modes of transportation. The completed analyses also indicated that this system might have a significant national impact by:

- Providing a new and viable maritime system along with associated development of shore infrastructure, U.S. shipbuilding, U.S. flag fleet and personnel of U.S. seafarers;
- Relieving congestion and decreasing the number of heavy trucks on the highway system, improving air quality and mitigating other environmental consequences of land-based transportation modes; and

- Creating a modern U.S. fleet reserve for military and other emergencies, which is urgently needed in light of the rapidly declining U.S. flag fleet.

In summary, the coastal system represents a new and promising addition to the national multimodal transportation network, as has been demonstrated by similar systems operating in Europe, Japan and other parts of the world. It appears, therefore, that further research efforts should be devoted to the system, proceeding from conceptual evaluation to implementation-oriented analysis with active participation of stakeholders.

II. DEFINITION OF THE COASTAL SYSTEM

II.1 POTENTIAL COASTAL CARGOES

Domestic Trailers and Containers

Any shipping system involves three basic components: cargoes, routes and vessels. This section is dedicated to the first component, the cargoes that the coastal shipping system is expected to handle. Present U.S. coastal shipping handles two types of cargoes (freight): (a) bulk, mainly liquid; and (b) containers. Bulk cargoes, as indicated by the title of this study, are not of interest here. As to containers, the present coastal operations are limited to international (ISO) containers, providing feeder services for loaded containers and repositioning for empty ones. A detailed review of the feeder system, included in Chapter IV, indicates that the current system is well developed.

The two cargoes that the present coastal shipping system does not handle are domestic containers and trailers. These cargoes are presently served by land-based transport systems, mainly trucks, and mostly over the coastal highways. The overall objective of this study is to devise and assess a coastal system that could relieve congestion on coastal highways. Hence, these two cargoes are the main targets of the coastal shipping system assessed in this study.

Related Cargoes

While the present U.S. coastal system is somewhat limited, there is another highly developed domestic shipping system connecting the mainland U.S. with offshore U.S. territories such as Puerto Rico, Alaska and Hawaii. Neither this shipping system, which resembles common international short-sea and deep-sea systems, or its cargoes are of direct interest here. However, indirectly, the coastal and short-sea shipping systems can be integrated. For example, a domestic container or trailer originating in New York and destined to Puerto Rico could use coastal shipping on the trip from New York to Jacksonville, where it can be transferred to the short-sea system. In this case, it would be desirable for the two services to call at the same port and to use similar handling systems.

Another cargo that may be added to the target cargo is international containers. This does not relate to the terminal-to-terminal transport leg, but to the final, terminal-to-inland point (and vice-versa) leg, assuming this point is along the coast. In both cases, the present transport system includes a highway leg parallel to the coast, which can be eliminated by using coastal shipping.

Finally, the coastal system is also designed to be useful to the military. Hence, in time of military mobilization the system should be capable of handling military cargoes, most of which are rolling cargoes (e.g., trucks, personal carriers, and tanks).

Coastal Passengers

As noted above, none of the present U.S. coastal systems cater to domestic containers and trailers. In contrast, coastal shipping systems of domestic cargoes are quite common in several foreign countries, and will be discussed in Chapter IV. The review of foreign coastal systems, as included in Chapter IV, also reveals that many systems that handle domestic containers and trailers also handle passengers. The coastal system may transport pedestrian passengers, driving passengers and their autos, and truck drivers and their trucks. Usually, when passenger's with/without autos are involved, the system is called "ferry". In fact, there are also many passenger/cargo combination ferries in the U.S., the largest of which are operating in Puget Sound and Alaska.[1]

Inclusion of passengers in the coastal services may increase revenue potentials. However, a passenger/cargo combination system is inherently different from a cargo-only system in the following respects:

a) The coastal vessels would need to provide accommodations for passengers, including sitting/lounge areas, restaurants, amenities and even sleeping arrangements in the case of overnight trips.

b) The coastal terminals would need to include waiting lounges, parking for cars, public transport, etc.

c) The location of terminals would be different, since passenger terminals are usually located in downtown areas, where public transportation is available while cargo terminals are located outside the city, where truck access is more convenient.

d) Service schedules would be different, since passengers are not expected to come on/off board during late night hours. This may limit the operational flexibility of the coastal service, resulting in lower utilization of the coastal vessels and higher operating costs.

Even if a coastal system for a passenger/cargo combination is provided, there are doubts that it will be attractive to U.S. passengers. For example, it is difficult to expect passengers on the New York / Miami route to spend 48 hours on-board, given the alternatives of driving their own car or using available public transport systems such as airline, busses or trains.[2]

Considering the difficulties on the supply side along with the dubious prospects on the demand side, a preliminary determination can be made here, that a European style, mixed

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[1] Pure passenger ferries (e.g., New York, San Francisco) and crossing ferries (e.g., Delaware, North Carolina), are excluded from discussion here.

[2] There is already a train service, which allows passengers to take their cars with them.

passenger/cargo system, has a limited prospect in the U.S. coastal situation. The only passenger element that may be included is truck drivers (see below).

Breakbulk Cargoes

Many foreign systems handle breakbulk (non-containerized) cargoes, mainly forest products and autos, either as an exclusive cargo or as an add-on to trailers. As was the case with passengers, handling loose cargoes requires different port facilities, even if the cargo is unitized (palletized). The terminals should have storage sheds with loading ramps for trucks and, desirably, rail. Forklifts, tractors and flatbed trucks will also be needed to handle the cargo, etc. Hence, as with passengers, an early determination can be made here, that the U.S. system should exclude such cargoes.

A similar consideration involves using loose cargoes in specialized containers or other unitization devices such as cassettes, storaboxes, roll trailers, etc. These devices are common in coastal systems abroad and were previously proposed in a study of coastal shipping for the U.S., however, cassettes and their likes are captive equipment that cannot move on public roads.[3] This restriction mandates an additional handling of the cargo from the cassette into a container or trailer and vice-versa. This handling, in turn, requires handling machines (straddle-carriers, forklifts). Moreover, if the cargo on the cassettes is sensitive to weather (e.g., paper), transit sheds are required as is the case with loose cargo. Altogether, it appears that coastal systems based on specialized cargo equipment are more geared toward specific cargoes and are not suitable to serve as a general transport system.[4] Hence, as was the case with passengers and loose cargoes, cargoes in specialized unitization devices are excluded from further discussion. Figure 1 summarizes all types of cargoes/users of coastal systems abroad.

Figure 1. Coastal System Users

User Type	Description
Pedestrian Passengers	Regulars, Tourists
Driving Passengers	Regulars, Tourists
Accompanied Trucks	Various Sizes
Unaccompanied Trailers	Road Trailers, Containers on Chassis
Roll Trailers, Cassettes	Forest Products
Ro/Lo Cargo	Forest Products, Containers, Autos
Lo/Lo Containers	Feeder or Short Sea Trades

[3] U.S. Department of Transportation, Maritime Administration, *U.S. Flag Coastal Ro/Ro Ships*, by Advance Marine Enterprises, September 1994.

[4] An interesting application could be to use cassettes as an intermediate storage device for containers (4 TEUs) or trailers, as shown in Chapter V. However, it also requires special tractors, translifters, etc.

Cargo Potentials

To recapitulate, the coastal system under study here focuses on cargoes in trailers and containers. Still, this somewhat narrow definition of cargo potentials consists primarily of three segments, including:

- Domestic, unaccompanied trailers and containers;
- Accompanied trailers; and
- International containers.

A fourth segment, military cargo, would be viable in time of national emergency. In terms of cargo form, the military cargo may include containers, trailers or rolling equipment (trucks, tanks).

Domestic and International Flows

The three cargo components have a similar physical form, which allows them to participate in the same coastal shipping system. However, in terms of their flow pattern, or points of origins and destinations, there is an important difference between domestic and international cargoes. The flow of international containers is originated / terminated mostly at deep-sea container terminals, where mother ships call. Domestic trailers and containers targeted for coastal shipping move between coastal cities, some of which do not even have container terminals.

Another, though less critical, difference between international and domestic containers is dissimilarity in dimensions. Domestic containers and trailers are wider than marine containers (8'6" vs. 8') and longer (53' and 48' vs. 40'). The 53-ft units have about 60% more cubic capacity (volume) than the standard 40-ft marine container, the main stay of deep-sea container shipping. This difference in capacity is the main reason for the extensive "transloading", or transferring the content of marine containers into domestic trailers for the inland move.

Still, some marine containers may be attracted to the proposed coastal shipping. In fact, an important subject of this study is to examine ways to combine the domestic and international cargoes into one system. Another subject to examine is the military usefulness of the system, especially in light of the high service requirements put forth by military planners.

Domestic Containers and Trailers Equipment

Finally, there are also differences between domestic containers and trailers. Domestic containers are relatively newcomers, since they were first introduced only in 1987.[5] Since then, the share of the domestic boxes has been growing, reaching over 100,000 units in 1999. While 80% of the boxes are still 48 ft, all new buildings are 53 ft. The capacity of domestic containers and trailers of the same dimensions is the same. Hence, there is not much difference between a container mounted on a chassis and a trailer. There is, however, a difference in handling between the two. Boxes can usually be stacked 2-high, allowing better utilization of the vessel's carrying capacity. On the other hand, handling boxes to/from the vessel requires lifting while trailers or containers on chassis can roll on/off the vessel. Some of the vessels presented in Section II.2 have capacity for both stacked containers and trailers, while others are pure containers or pure trailers. Despite their difference, in the following analysis, domestic boxes and domestic trailers are considered the same.

II.2 POTENTIAL VESSEL SYSTEMS

Vessel Selection Considerations

The general features of the coastal vessels were discussed while defining the coastal cargoes in the previous section. Still, a more detailed description of features, including speed, capacity and handling systems has to be discussed. The discussion includes vessel characteristics, along with a preliminary selection of coastal vessels for further analysis.

A review of vessels currently employed or under advanced design in the U.S. and abroad is included in Chapters IV & V. The review reveals a broad range of vessel designs and related features. However, the focus of this study is not on the vessel design by itself, but on the coastal shipping *system*. Hence, developing a specific vessel design most appropriate for U.S. coastal system is outside the scope of this study.

This study's main concerns are the operational, economic and institutional aspects of viable coastal shipping services. Therefore, the vessel selection process here is somewhat cursory and only relates to identifying vessels that appear to suit the general requirements of the coastal system. The sources include (1) the vessels that are currently employed in coastal services in the U.S and abroad, and (2) new types of vessels that are under consideration for coastal or similar services. A prerequisite condition for the vessels assessed here is the availability of reliable technical and cost data. The latter was proven difficult for the new advanced types of vessels. Hence, the analysis of services based on these ships should be considered as conceptual.

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[5] The domestic containers were developed by a shipping line, American President Lines, in conjunction with the conversion of the double-stack train system to handle domestic cargoes.

Selected Vessel Types

Based on the above considerations, six representative types of vessels were selected for analysis, including:

(a) Pull Barge: 500 TEUs, 8 - 10 knots;

(b) Conventional Lo/Lo ship: 500 TEUs, 15 - 20 knots;

(c) Fast Ro/Ro ship: 200 TEUs, 18 - 24 knots;[6]

(d) High-Speed Ro/Ro Monohull ship: 200 TEUs, 28+ knots; and

(e) High-Speed Ro/Ro Catamaran ship: 100 TEUs, 32+ knots.

The following is a brief discussion about each type of vessel.

Pull Barge

The pull deck barge is the only vessel currently in operations in the U.S. All services, as indicated in the section on potential cargoes, are exclusively for feeder operations and repositioning of international containers. Columbia Coastal, the largest operator of the so-called container-on-barge services, has 11 barges in operation, with capacity for most of its fleet between 400 and 700 TEUs. However, the most recent addition has capacity of 912 TEUs. A typical deck barge, similar to the last series built by Columbia, has a capacity of 690 TEUs and dimensions of 343 x 86 x 24 ft (LOA x beam x depth). Deck barges were also the choice of the presently defunct coastal service for domestic containers operated by Trailer Bridge. These barges have the capacity for 213 53-ft domestic containers (approximately 560 TEUs), and dimensions of 408x100 ft. Sea-Barge also operated two deck barges in their Puerto Rico service but recently replaced them with Ro/Ro Lo/Lo combination vessels.[7]

The cargo stowage of a typical deck barge is quite simple. All containers are staged above water, on a flat deck, without any support structure. The boxes are usually staged one immediately adjacent to the other with no separation across the entire deck. Stacking height is usually 3 or 4 high. In extreme cases, height can reach up to 6 high. Deck stowage makes cargo handling very simple, since there are neither hatches to access or hatch covers to remove, as is the case with Lo/Lo cellular containerships. However, there is a higher exposure to the elements. Securing containers on the deck barge requires extensive lashing, which adds both to the operating cost and port time. Lashing can be avoided if a cellular structure is installed on the barge, similar to that used in Matson's inter-island service in Hawaii. But, efficient handling of a cellular barge requires gantry

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[6] Lo/Lo is a common term for lift on / lift off, or handling cargo between ship and shore by means of a crane. Ro/Ro is a common term for roll on / roll off, or handling cargo by means of driving on wheels. Some vessels have both Lo/Lo and Ro/Ro capacities, sometimes called Ro/Lo.

[7] The line also changed its name to Sea Star.

cranes or a modern mobile harbor crane. These are not available at all terminals.[8] Also, the cellular structure adds to the cost and weight of the barge and may slow handling.[9]

The barges are pulled by an ocean going tug of about 5,000 hp at a typical speed of about 10 knots. Because of the large frictional area between the barge and the water, known as the wetted area, and poor hydrodynamics, barges are more sensitive to weather conditions than self-propelled vessels. This may adversely affect service reliability, especially during the winter in the North Atlantic region, by causing delays and even cancellations.

Coastal shipping based on large pull barges is a U.S. phenomenon. Pull barges are not used in Europe and Japan, where self-propelled vessels are responsible for the majority of the coastal activity. Some *push* barges are used in Europe for containers, but only on protected inland waterways. European barges are mostly narrow and long, to allow navigation in the relatively narrow European channels. Their capacity is typically in the 100 - 200 TEU range.

The proliferation of the pull barge in the U.S. coastal service can be mainly attributed to the U.S. regulatory environment. The regulations of the U.S. Coast Guard stipulate crew size based on the vessel's registered tonnage, which in the case of a pull barge it is the ocean-going tug. The crew of the tug, of about 8, is much smaller than that of a self-propelled ship of similar (to the pulled barge) TEU capacity, where the crew might reach over 20. The relative advantage of a pull barge over a self-propelled vessel may change if crewing regulations are modified in the future to allow for automation. In this case, barges will face a harsh competition from self-propelled vessels and may even be completely replaced by such vessels.

The pull barge system selected for analysis here is based on the most recent Trailer-Bridge design, with a capacity of 500 TEUs. The barge is to be pulled by a 6,700-kw (5,000-hp) tug with fuel consumption of 0.6 ton/hour and speed of 9 knots. Construction cost of the tug and the barge is estimated at $12 million.

Small Conventional Lo/Lo Containership

This type of vessel is typically employed in two types of services: feeder activities and short-sea trades. Feeder services, following the worldwide proliferation of the hub and spoke system, is by far the larger users. Still, there are many short-sea trades in the Caribbean, North Europe, Mediterranean and Asia utilizing small Lo/Lo ships. Most of the small Lo/Lo vessels are cellular and gearless. However, there are still a large number of geared vessels. Geared vessels are typically equipped with 2 whirly cranes with 30 - 40 ton capacity. Inclusion of cranes adds to the construction cost, reduces capacity and may

[8] Another option is to install the crane on the barge, as is the case in Matson's barge.

[9] The cell structure mandates that the crane path should always be rectangular, tracking the upper tier of the on-deck cells.

also obstruct handling. Cranes are necessary, however, if the ports of call are not equipped with adequate shore cranes.

The configuration of feeder vessels is similar to that of standard (mother) containerships. It is based on cellular storage bays (hatches) and hatch covers, with containers stowed both above and below deck. A recent design, called hatchcoverless, entirely eliminates hatch covers. It allows for faster cargo handling by avoiding the cumbersome process of opening and closing hatch covers (pontoons). This design is somewhat similar to the deck ship, except that the vessel has side walls, which are used for both securing and protecting boxes from seawater. In both designs, all boxes are staged above the waterline.

According to a recent Clarkson Study, there are about 1,050 containerships in the so-called feeder range of capacity between 100 and 1,000 TEUs.[10] The average speed of these ships is about 15 knots. The larger and newer ships are usually faster than the smaller and older ones. Newly built super feeders include vessels with 1,500 TEUs and a speed of 18 knots. There is no technical limitation for even higher speeds (say in the low 20's knot range), except that greater speeds involve much higher construction and operation costs.

While there are no fast feeder ships currently in operation, literature includes several designs that can serve in this capacity. These designs are similar to the fast Ro/Ro's, included in the next categories, except they have a Lo/Lo hull arrangement.

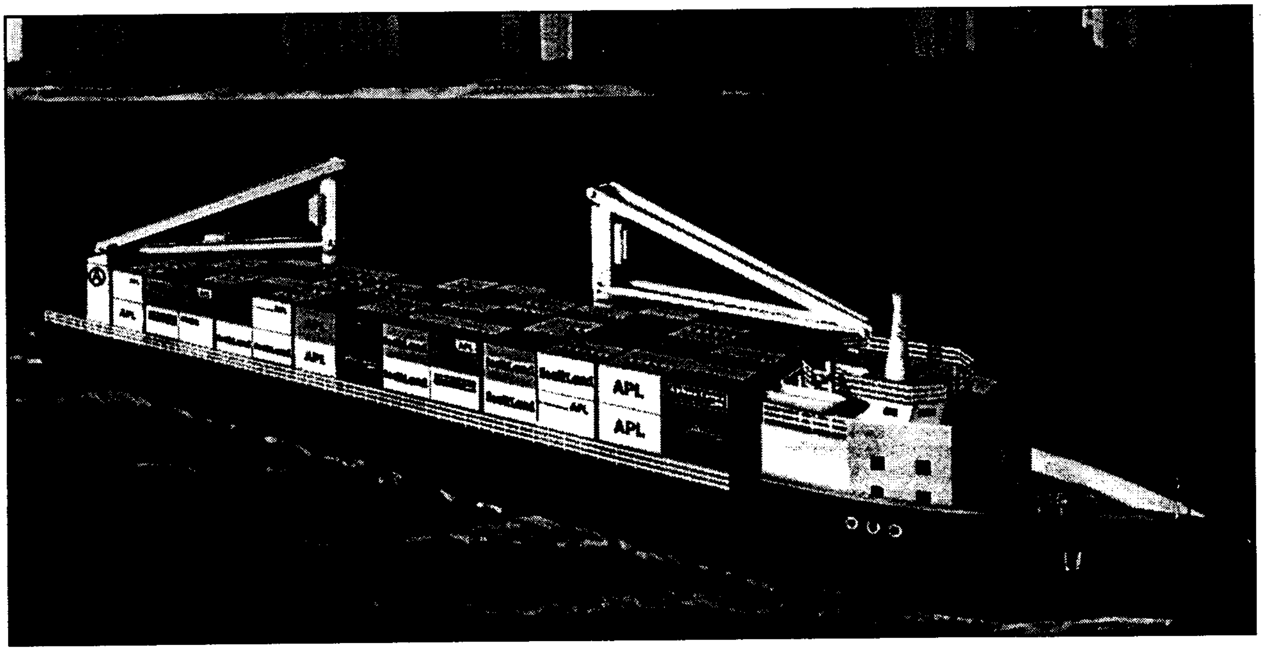
For the purpose of the comparative analysis of a coastal service, a 500 TEU, geared, ship is selected, with a speed of 15 knots. The selected vessel is hatchcoverless, with dimensions of 134 x 19.5 x 5 m (431 x 64 x 17 ft), and deadweight of 6,200 tons. Propulsion is provided by 2 electric motors driving azimuthing propellers, fed by 2 medium speed diesel generators of 4,700 kW. Fuel consumption is 1.6 tons/hour at 90% MCR. The advanced propulsion system is designed to provide superior maneuverability and to save on tug costs and berthing time. Construction cost of the ship is estimated at $25 million, including cranes. Figure 2 presents a small Lo/Lo feeder vessel similar to the one selected for analysis.

Fast Ro/Ro Ships

Ro/Ro vessels, sometimes called freight ferries, have been the traditional type of vessels used in coastal and short-sea trades. The Ro/Ro cargo handling system is usually faster than Lo/Lo and involves lower port cost. Ro/Ro ports require simple berthing arrangements and no shore cranes. In contrast, Lo/Lo ports require marginal berths, with gantry cranes and heavy-load decks. Ro/Ro vessels usually have a lower draft than Lo/Lo vessels, eliminating the need for deep access channels.

[10] Clarkson Research Studies, *The Containership Register 1999.*

Figure 2. Small Conventional Lo/Lo Ship



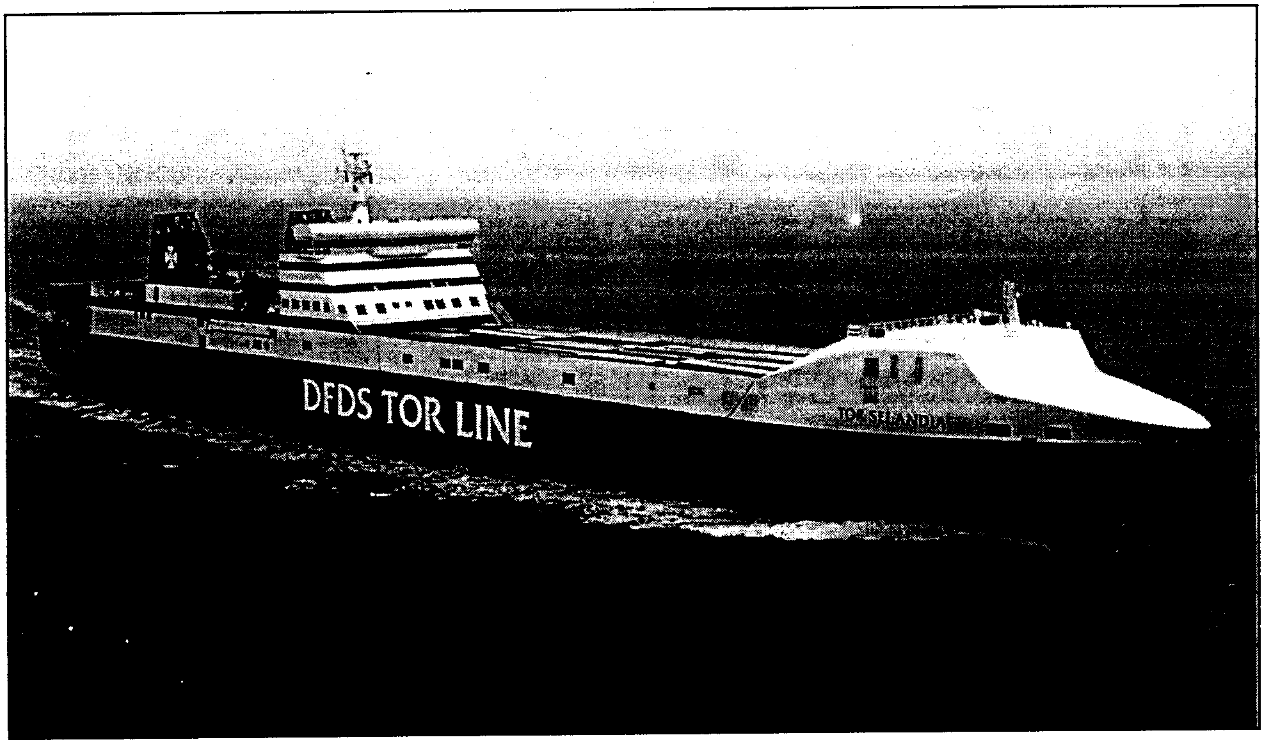
The main disadvantage of Ro/Ro ships is that they usually have half the capacity of Lo/Lo ships of similar dimensions. The capacity is smaller because the cargo units are on wheels. Hence, storage height is wasted underneath the wheels and above the trailers. The decks themselves have deep, space consuming beams. Finally, there is a need for space between trailers, for access to ramps, etc. Altogether, Ro/Ro ships are about twice as expensive as Lo/Lo ships in terms of investment cost per TEU. However, since most coastal trades involve relatively short itineraries, the savings in cost of port handling more than compensate for the higher vessel costs. This explains the common employment of Ro/Ro's for coastal shipping.

The usual configuration of Ro/Ro vessels is based on 2 or 3 decks of parking space where the rolling trailers are staged. The capacity of Ro/Ro ships is normally measured in lane-meters or in sq. m (sq. ft.) of deck area. The vessels usually have a boxy design for easy access and parking of trailers. The most desirable arrangement is based on square deck areas, with parallel parking lanes. Most Ro/Ro vessels employed on coastal and short-sea routes have on-board ramps. The common arrangement includes stern ramps. Sometimes both stern and bow ramps are available. Side ramps, or the three-quarter design ramps, which allow vessels to be handled at regular marginal berths, are only available on large Ro/Ro vessels. Most coastal Ro/Ro's are handled perpendicular to the dock (Mediterranean style).[11] The handling is performed by specialized terminal tractors

[11] Several larger Ro/Ro vessels have a combination of quarter and side ramps, allowing them to be handled in marginal wharf areas of regular container terminals. In some specialized Ro/Ro services, such as Crowley and Trailer Bridge to Puerto Rico and Tote to Alaska, the ramps are part of the terminal.

with swivel steering systems that facilitate driving backwards while loading the vessel. Figure 3 presents a fast Ro/Ro vessel.

Figure 3. Fast Ro/Ro Ship



The Ro/Ro vessel selected here for further analysis is a faster version of the conventional European design developed in the 70's and 80's. It is similar to the Stena's Runner model. In 1998, seven of these ships were ordered from an Italian shipyard (SEC) at a cost of about $35 million per vessel.[12] The vessels' dimensions are 184 x 28 x 6.6 m (the draft is for vessels loaded only with trailers, excluding grounded boxes on the weather deck). Deck capacity is 2,700 lane-meters or 185 trailers of 15 m (including lashing space), equivalent to 370 TEUs. The main engine is a medium speed diesel, with 23,000 kW (4 x 5,760), providing for a service speed of 22 knots. The vessel is also equipped with 2 x 1,000 kW bow thrusters and flap rudders to provide for high maneuverability. Fuel consumption is 4.6 tons/hour. The vessel has accommodations for 12 passengers, presumably drivers. It is interesting to compare this vessel to older, smaller and slower Stena's freight ferries. For example, the Stena Freighter series, built in 1977, only had 1,700 lane-m and a speed of 18 knots.

[12] The construction cost assumed here is based on a quotation from Europe. Presumably, the U.S. would have a similar cost structure.

The Runner series is an all-freight ferry. By contrast, most of the European ferry services are provided by multipurpose ferries, also called Ro/Pax, with combined passenger and freight capacities. In the case of Stena, the newest Ro/Pax design is the Seapacer, which has similar dimensions to the Runner, but has accommodations for 450 passengers in 192 cabins. The crew size is about 40, due to higher safety requirements for passenger ships. Cargo handling is based on the through handling concept for all cargo decks via bow and stern doors/ramps. The latter is required since the ferry is expected to accommodate driven autos and trucks.

Another feature of many Ro/Ro vessels is the ability to carry containers on the weather deck, rendering them into Ro/Lo[13]. For example, the Runner design has capability to stack 1,000 TEUs of containers on the weather deck. The Lo/Lo capacity is not included in this analysis, since handling Lo/Lo containers requires a crane, preferably a gantry crane. Cranes, as it is discussed in the following section on ports, are not considered for the domestic ports.[14]

Some of the Ro/Ro vessels are specifically designed for the cassette system. Cassettes are captive equipment, which does not fit well with the overall concept of the coastal system and will not be discussed here (see discussion in the previous section and in Chapter IV).

High-Speed Ro/Ro Monohull

High-speed vessels, or vessels with speed above 28 knots, represent a new trend in shipping that is affecting both short and deep-sea trades. A comprehensive technical discussion of "fast ships" is beyond the scope of this study, which focuses on the *system performance aspects* of coastal shipping. Hence, only the very basic parameters of these vessels are addressed here.

The common problem facing fast ships is that hydrodynamic resistance and wave making rises exponentially with speed. The resistance, in turn, is affected by the size and configuration of the ship's wetted area. The two general categories of fast ships employ different technologies to reduce the wetted area:

- ***Displacement Ships*** -- modifying the hull shape, using either slender or multi-hull configurations, along with lighter construction materials and lighter engine system; and

- ***Lifting Ships*** -- lifting part of the hull out of the water, using either dynamic or air-pressure forces.[15]

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[13] Many Ro/Ro vessels can store containers 2-high in the main garage.
[14] In some Ro/Lo designs, the decks are strengthened to allow for a special, low mast toplift to roll onto the ship, where it can lift containers and stage them on chassis.
[15] In displacement ships the lift is mainly hydrostatic (buoyancy).

The first category includes modified conventional ships. The second and more innovative category includes hydrofoils, air cushioned and several planning or semi-planning designs.[16] Generally, lifting ships have the potential for higher speeds than displacement ships, with several lifting designs reaching 50 knots. However, all known lifting ships have a small payload and are geared toward serving passengers on short-distance routes. Two interesting types of small-capacity lifting ships are briefly discussed in Chapter IV on Foreign Experience with regards to the Japanese TSL initiative. There have been a few publications on lifting cargo ships with somewhat larger carrying capacity, but cost data are still unavailable. Nevertheless, preliminary estimations suggest that the costs involved with large lifting ships are considerably higher than similar-speed displacement designs.

The two types of ships selected here for analysis belong to the first category of displacement ships. The first design selected is based on the Blohm & Voss FM 147 Trailer Ferry. The vessel has a deep-V hull form, which provides for both extra stability required at high speeds and for the wide decks required by the Ro/Ro configuration. The main engine is medium speed diesel, with 36,600 kW (2 x 16,800), allowing for a maximum speed of 28 knots, and for 25 knots at 90% MCR. Propulsion is by a single screw.[17] The dimensions are 162 x 26 x 7 m, with gross tonnage of 17,300 and deadweight of 4,000 tons. The configuration is based on 2, 7-wide decks, providing space for 100 trailers (1,460 lane-m). Fuel consumption is 6.0 tons/hour. The vessel also has accommodations for 100 passengers, presumably drivers. The vessel is equipped by a single stern ramp. Interestingly, this ship design was also selected for the European Marine Motorways (EMMA) study for short-sea and coastal shipping, funded by the European Commission. A similar, though smaller ship was proposed for a cross-Gulf service between New Orleans and Vera Cruz, Mexico. The cost of the vessel is about $49 million or $245,000 per slot, which is 2.5 times that of the conventional Ro/Ro. Figure 4 presents a high-speed monohull, slightly smaller than the one selected for analysis.

Several fast monohull designs were recently discussed in industry publications, notable among them were: (a) Kaverner's slender monohull, a relatively large 260 x 32 x 10 m, 26,000 ton displacement, 34 knots, 125 MW vessels with gas turbine, along with its Ro/Ro version, the BathMax; (b) Fastship's TG-770, an even larger 265 x 40 x 10 m, 33,500 ton displacement, 38 knots, 335,000 BHP, with gas turbine and water jet propulsion; and (c) Halter's Pentamaran, a much smaller and faster design with 133 x 28 x 4.3 m, 2,150 tons displacement (290 ton payload) and a unique hull shape.[18] All of the above designs seem, to be either too large or too expensive for the coastal application. Likewise, the two larger designs are geared toward deep-sea trades and require dedicated ports with special

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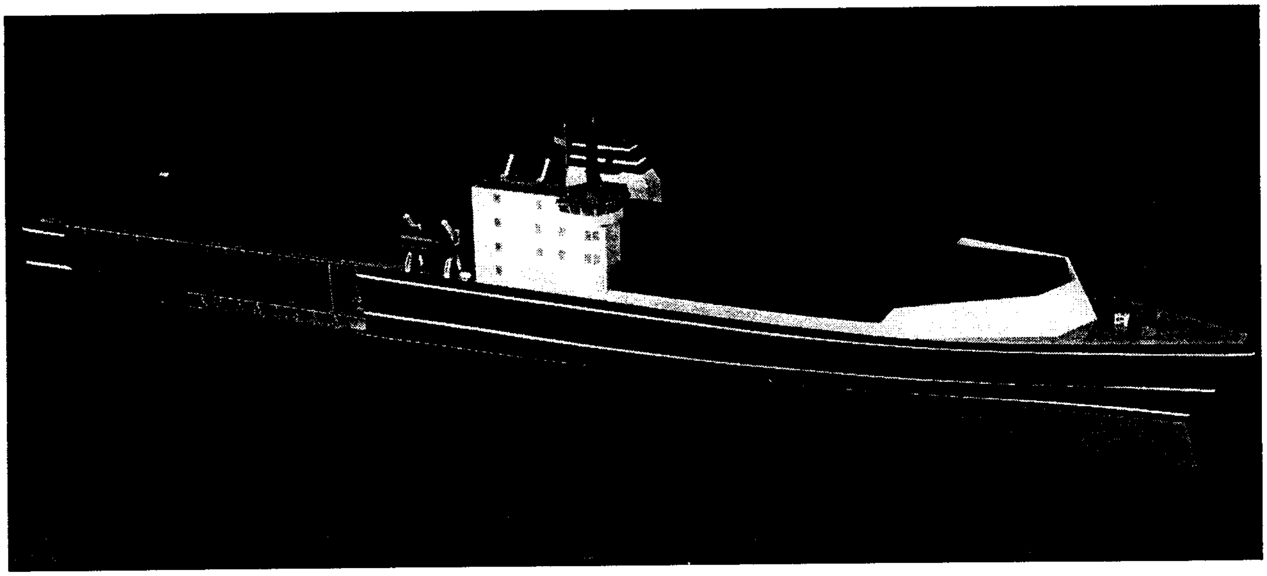
[16] Fincantieri's Fast Ferries series includes dynamic and air pressure designs, the SES and MDV. Another, more exotic technology is based on the Wing In Ground Effect. A concise review of fast ships is included in Marks, Richard, Posford & Duvivier, *Experience with High Speed Ferries*, 29th PIANC Congress, and The Hague.
[17] The discussion is partially based on Topel, Heinz, *Fast Monohulls and Large SES for Specific Application*, Blohm & Voss AG, in Sea 2000 Proceeding, Hamburg Messe.
[18] A comprehensive review of fast ships is included in: Stanely Associates, Inc., *Current and Planned Capabilities of Commercial High-Speed Ships*, for Center for the Commercial Deployment of Transportation Technologies, 1999.

handling ramps. This is in contrast with the general assumption of an "open system" for the proposed U.S. coastal port system, as will be discussed in the next chapter. Hence, these designs are not analyzed.

Figure 4. High Speed Monohull Vessel



High Speed Ro/Ro Catamaran

The second high-speed vessel selected for further analysis is a catamaran. The catamaran configuration provides a "natural" platform for Ro/Ro ships, since it has a wide and relatively short deck, all of which is above water. However, all known high-speed designs handle small payloads and are more geared toward passengers than cargo. The best known design in this passenger/cargo category is the latest Stena's HSS 1500. Stena's design is based on an earlier and much smaller wave-piercing catamaran, developed in the early 1990's by the Australian shipyard Incat.[19] The HSS has a deadweight of 1,500 tons and dimensions of 127 x 40 x 4.6 m with the capacity for 1,500 passengers, 375 cars and 50 trailers or trucks of 16 m in length (including spacing). The hull is made of aluminum and composite materials. The main engine consists of 4 gas turbines, similar to those used on airplanes, with a total of 73,529 kW (100,000 hp), providing for a service speed of 40 knots. Propulsion is provided by water jets. The vessels are handled at the ports with 4 separate shore ramps, two for passengers and two for cargoes. The multi-ramp handling process results in a short port time of only 30 minutes. Stena employs 3 large HSS's and a smaller design, the Lynx II (345 tons, 35 knots) in 3 services between the U.K. and Ireland. These vessels transport passengers during the day and trucks during the night, usually at a lower speed.

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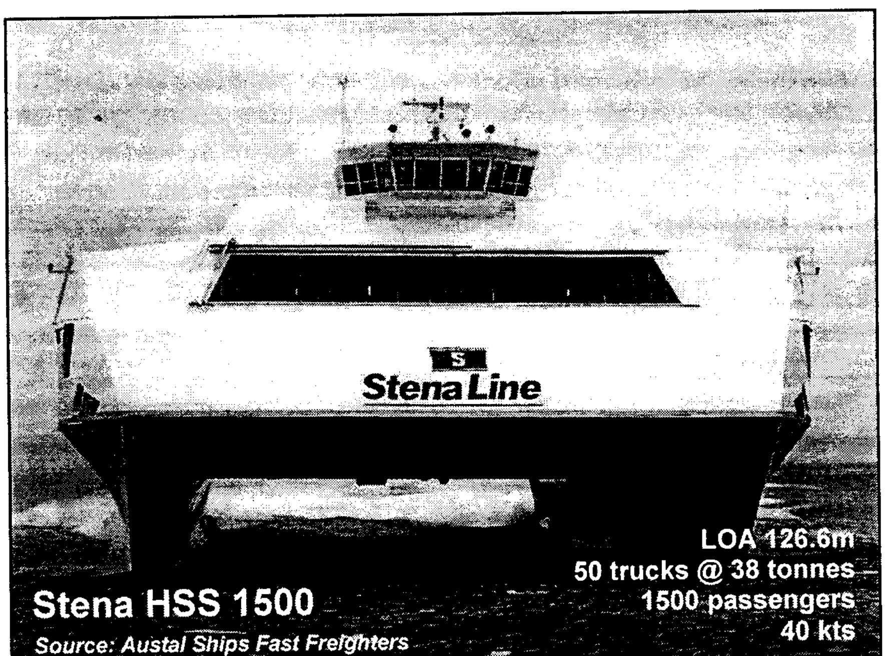
[19] Another Australian shipyard, Austal, also has designs for catamarans, but with smaller capacities.

Other notable designs in this category, besides Stena's HSS, are: (a) Halter's HST 1000 Trimaran with 1,000 tons payload; and (b) Quadmaran's Q-18, with 3,000 tons of payload, and 60 knots speed based on installed power of 90,000 hp. There are several interesting applications of fast freight catamarans. A recent one is for a feeder service between Jakarta, Indonesia and Singapore, a distance of 525 NM. Currently the service is provided by cellular, gearless containerships with a capacity of about 1,500 TEUs and a speed of about 20 knots and a transit time (including port) of about 3 days. The voyage time for the new service may be shortened to 12 hours. Assuming 12 hours are required for port handling in each end, a 2-ship fleet could provide a daily frequency. Another and even bolder plan is to deploy a single vessel of 80 knots with a capacity of about 100 TEUs.[20]

The design selected here for analysis is similar in principle to that presently in operations by Stena, except that it has a smaller, freight-only hull. The design is based on Austal Ships 112-TE catamaran, with hull dimensions of 112 x 25 x 3.6 m, gross tonnage of 6,000 and deadweight of 1,400 tons, providing capacity for 44 trailers. The main engine includes 2 gas turbines with a total of 45,000 kW and a propulsion system based on water jets, providing for a service speed of 40 k. Fuel consumption is 9.9 tons per hour. The vessel has accommodations for 48 passengers, presumably drivers. Construction cost is estimated at $45 million, or about $1.0 million per trailer slot. This is twice the cost of the fast monohull and 10 times that of the conventional Ro/Ro. Figure 5 presents a Stena HSS Catamaran similar to the vessel selected for analysis.

Figure 5. High Speed Catamaran



[20] Source: "Austal Ships Considering High-Speed Freight Service," *Pacific Maritime*, Jan 2000, pp. 6.

Militarily Useful Specifications

As already discussed in the section on cargo definition, in time of national emergency, the usage of coastal vessels may be converted to transporting troops and military cargo. Hence, the coastal vessels are, in principle, dual-purpose vessels.

The exact vessel specifications for military usage are difficult to define. A recent study interviewed the various defense-related agencies and revealed different concepts with regards to the military needs during time of emergency.[21] The general consensus in the study was that a militarily useful ship should have:

- Service speed of 35 to 40+ knots;
- Range, without re-fueling, of at least 3,500 NM (for crossing the Atlantic Ocean);
- Draft equal to or less than 30 ft;
- Cargo capacity (deadweight) for at least 6,000 Long Tons; and
- Accommodations for several hundred troops.

There was, however, a universal unanimity of opinion with regard to ship configuration. All agencies insisted on a "Ro/Ro with the capability to be handled under austere port conditions, with austere meaning limited or no shore equipment." The main role perceived for these ships would be during the initial or so-called surge phase of transoceanic transport. A secondary role would be for intra-theater support, involving a shorter range of about 1,250 NM and a smaller payload of 1,500 Short Tons.

Suitability of Selected Vessels

Of the vessels included in the analysis only the last two, the high-speed monohull and catamaran, would possibly qualify as militarily useful. Still, the fast monohull, based on deep-V, is too slow with a speed of 28 knots. Also, its range in the civil coastal application would only be 500 NM. This is much shorter than the intra-theatre range of 1,250 NM. The catamaran would qualify in terms of speed, but its carrying capacity is limited. The load capacity of the aluminum-made deck may be inadequate to support armored vehicles. Most importantly, due to the high fuel consumption and the limited deadweight, the range of the Catamaran is limited. The two vessel designs are equipped with loading ramps, an important military feature.

Theoretically, both vessels may have a dual configuration with "dormant" features that will only be used during military emergency. For example, if higher speed is necessary, a larger engine will be installed but not used in the commercial application. Likewise, extra fuel tanks may be available but not regularly used. A cursory examination suggests that the additional military features are only possible with the larger monohull, but not with the catamaran. If such features are added to the commercial application, they may affect the

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[21] Stanely Associates, Inc., *Potential DOD Use of Commercial High-Speed Sealift (2000 - 2010)*, for Center for the Commercial Deployment of Transportation Technologies, 1999.

initial construction cost and the operating cost. These impacts are due to the extra weight of the additional engines, tanks and scantling that may come at the expense of payload.

Another, important military contribution of coastal shipping is training of sea-going personnel. Following the recent acquisition of U.S. carriers by foreign operators, the availability of such personnel for future emergency situations is likely to dwindle. A live system of coastal shipping could provide a readily available basis for ships' crews, even if the vessels themselves are not equipped according to the military specifications.

II.3 COASTAL PORTS

The Critical Role of Ports

Ports are the most critical component of the coastal shipping system. Moreover, in previous studies conducted in the U.S. and abroad, ports were observed as the main "obstacle" for the implementation of the coastal system. This negative observation relates to deep-sea ports that were expected to provide coastal services. It stemmed from high charges assessed by ports for cargo handling and their operational inflexibility. The latter results in: (a) long port times for coastal vessels; (b) long port times for trucks/rail delivering coastal cargoes; and (c) long port (dwell) times for coastal cargoes.

Efficient and low-cost ports are a key component in *any* shipping system. However, the importance of ports for the coastal system is particularly high because of the relatively *short distance* of coastal services. Previous studies estimated that in coastal services:

- Vessel's time in port may account for about half of the total rotation (voyage) time; and
- Cargo handling cost at ports may account for about half of the total cost.[22]

The excessive time of vessels in port has two additional implications: (a) lengthening trip time, which could make the water service noncompetitive with land-based transport services; and (b) increasing vessel operating cost.[23] The latter is especially critical for high-speed vessels because their operating cost (e.g., $/hour) is 5 to10 times higher than that of conventional vessels. The critical role of the port in coastal shipping can be illustrated by the following statement made by a prospective ship owner: "There is no point in racing a vessel to 30 knots for a 2-day voyage and then spending a day at a port, mostly for waiting."

Deep-Sea Container Terminals

The U.S. has a highly developed network of deep-sea container terminals extending to all coasts. Theoretically, these terminals could accommodate all types of shipping services:

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[22] By comparison, in a deep-sea port cargo handling may account for 20 - 30% of the vessels' rotation time and 30 - 40% of the cost.

[23] The two are port users' costs, the first one relates to the cargo owner and the second to the ship owner.

deep-sea, short-sea and coastal. This, in fact, is the case with the present coastal shipping services on the East and West coasts (e.g., Columbia Coastal and Matson) that use deep-sea terminals. However, present coastal services call at these terminals because they provide feeder and repositioning services to the deep-sea services that call. The origin and destination points of these services are at deep-sea, since feeder services substitute for a direct call by the mainline service that would otherwise have called at the deep-sea terminal. Restated, feeders are an integral part of the deep-sea system and as such, begin and end their services at the terminals of this system. This is also the case in most European and Asian ports.

Presently, deep-sea terminals are the only terminals available to handle coastal services, with no viable alternative to them in the U.S. However, deep-sea terminals are designed to handle large containerships, the so-called mother ships that are their main clients, and not small coastal vessels. These terminals are comprised of expensive and specialized facilities, including deep access channels, deep and heavy-load docks, gantry cranes, large container yards, intermodal yards, etc. Terminal operations are governed by stringent Customs regulations and labor practices. Because of Customs and the clearance procedures of foreign trade, an extensive system of documentation along with physical examination is needed. This, in turn, requires a complex system of gates with appropriate manning.

Labor practices in deep-sea terminals are geared toward handling large ships with large quantities of cargo. Hence, the work is structured around shifts and gangs. There are agreements on gang size and composition, working hours and payment. Likewise, there is an elaborate system to assess overtime and other labor-related charges. Due to high overtime costs, terminal gates are usually open 1 shift a day with limited extensions.

Naturally, preference at deep-sea terminals should be given to the primary customers handled there, the deep-sea (mother) ships. These ships have much higher operating cost than coastal ships and they generate much more revenue than the coastal ships. As a result, it is reasonable to expect that smaller and supposedly less important coastal vessels may have to wait for berth or crane -- as already reported by present coastal services. In fact, from discussions with present operators it seems that a Lo/Lo coastal service with 300 containers (moves) considering calling at a deep-sea terminal will have to allocate 24 hours for the port call, out of which only 8 - 12 will be consumed by the actual handling. The rest of the time is expected to include waiting for a berth, a pilot and tugs, clearance by immigration and customs, shift starting times, etc.

Because of the combination of expensive facilities and labor, a typical handling charge at a deep-sea container terminal is $150 - 200 per box. In addition, there are charges for pilotage, tuggage, line handling, dockage and other vessel-related expenses, which may add $6,000 - 10,000 per call for a small containership of about 500 TEUs, or $40 - 50/box. Altogether, the terminal cost could range $200 - 250 per box ("lift"). Since each trip includes 2 lifts, the total port cost would be $400 - 500 per box. Assuming that the typical distance of a coastal trip is about 500 miles, port cost alone is equivalent to about $1/

trailer-mile. For comparison, typical rates as quoted by truck lines are at about $1.50/trailer-mile (see Section II.6). It is quite clear that under the existing cost structure of deep-sea container terminals coastal shipping cannot compete with road transport.

One way of partially resolving the high cost issue is for the deep-sea terminals to recognize the special circumstances of coastal service and offer them reduced handling rates. This is already the case in several ports.[24] But, even if the cost could be somewhat lower, the operational rigidity of deep-sea terminals would make them not viable for handling coastal domestic cargoes. Simply put, it is hard to imagine a domestic trailer going through the gate procedures of a deep-sea container terminal and/or waiting the whole night for the gate to open. A preliminary conclusion of the study can be derived at this stage: a coastal system for domestic trailers/containers cannot be based on the existing system of deep-sea container terminals.

Domestic Terminals

Coastal services for domestic cargoes mainly compete against trucks. Hence, their marine terminals should resemble truck terminals, so they can provide a truck-like service, especially with regard to avoidance of delays and handling costs inherent in deep-sea terminals. Ideally, coastal vessels should to be able to call at their terminals at any time of the day or night, begin working immediately upon arrival and leave as soon as the handling is finished. For example, a coastal ship may call at 4 a.m., begin working a few minutes later, complete the unloading/loading process within 3 hours, and sail to the next port with no delay. Since the number of moves may be small, say 50 - 100 containers/ trailers in each direction, the number of people required for terminal handling is limited. It could well be that the ship's crew could perform the port handling.[25] This would eliminate the need for gangs waiting for ship arrivals, shift start-up times and the related overtimes, etc. If vessels carry accompanied trailers or trucks, their drivers should be allowed to handle them from ship to shore, as is the case in most ferry systems. Once discharged, containers and trailers should be able to immediately leave the terminal, at any hour of the day or night. Cut-off times for containers and trailers should be about an hour before the ship's arrival.

The above performance requirements of coastal ports are considered as pre-requisite for any coastal shipping system geared toward handling domestic trailers and containers. Since these requirements cannot be met in present deep-sea terminals, implementation of coastal shipping in the U.S. mandates the development of an alternative system of marine terminals. The new coastal terminals are hereafter defined as *domestic terminals,* to distinguish them from the deep-sea terminals that mainly handle international cargoes. Domestic terminals can be located adjacent to deep-sea terminals, but not within (inside) them, since they should not be subject to Customs' jurisdiction. The adjacent location

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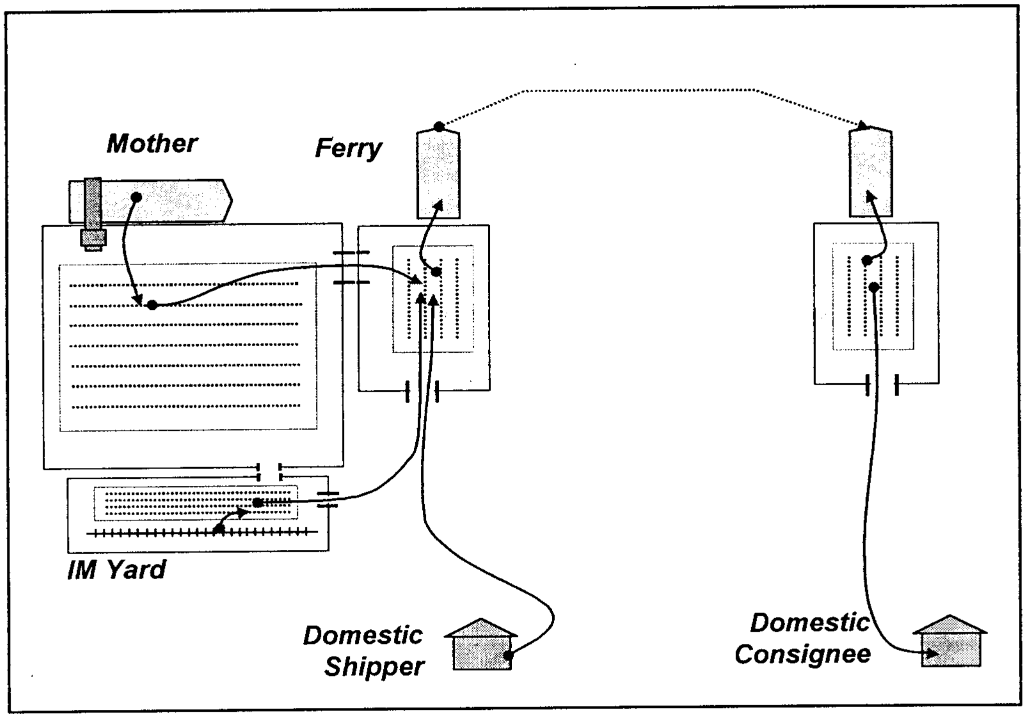
[24] The coastal barge service enjoys reduced rates due to a special arrangement with labor and port authorities. Still, the barges have lower priority in obtaining port services.

[25] Handling by ships' crew is also suggested in several studies of European coastal systems, e.g., the Swedish MariTerm.

could save on terminal construction costs, since both terminals could share in water and land accesses.

The adjacency of location will facilitate the transfer of international containers between the two terminals. This will improve the competitive position of coastal shipping in the market for offering feeder services for international containers. In the ideal layout, domestic and the international terminals should have a common fence with a special gate between the two terminals for exclusive transfer of containers, avoiding the need to go through the main gate. Such layout will allow the inter-terminal transport to be performed by terminal tractors. Altogether, the inter-terminal transfer could be fast and low-cost. Figure 6 presents such a conceptual layout of the deep-sea and coastal terminals.

Figure 6. Proposed Terminal Arrangement



Specialized Terminals

The main feature of domestic terminals is their high productivity and low cost. One way of achieving this is to create a system based on specialized coastal vessels and terminals. This technology-oriented approach is advocated by both European and Japanese planners who have devised a wide range of vessel and terminal handling systems for coastal shipping (see Chapter IV).

The least technology-extensive handling system is based on Ro/Ro with intermediate handling devices. The three common variations of these devices are rolltrailers, cassettes and Stora boxes, all of which are presently being utilized in several European short-sea services. The advantage of using these devices is that their carrying capacity is at least twice that of a road trailer used by regular Ro/Ro services, because they allow the double-stacking of containers. Another advantage over regular Ro/Ro is the higher utilization of vessel's space.[26] The main disadvantage is that all of these handling devices are captive equipment that cannot be driven on public roads. Hence, there is always a need for an extra handling say between the cassette and road chassis.

Another disadvantage is that the system requires heavy investments in the devices and in specialized yard machines. For example, in a system based on 4-TEU cassettes, there is a need to invest in cassettes ($10,000 per unit), lifters ($100,000) and special tractors ($150,000). A coastal shipping service between 2 ports, based on 2 100-cassette ships, may require 600 cassettes, 4 tractors and 4 lifters at a total cost close to $7 million. Then, there is the related cost of storing and maintaining all loaded and empty cassettes. And, finally, there is the extra terminal handling cost (see above). This transfer of boxes between cassettes, ground storage and road chassis requires straddle carriers, reach stackers or toplifts, as well as professional labor to operate them on a permanent basis. Finally, the extra terminal handling may result in delaying the cargo at the terminals (dwell time) which may require larger terminals.

Universal Terminals

Even if successfully implemented, the coastal system is not expected to remove all or even the majority of the eligible cargoes from the road system. The road transport will always be far larger than coastal shipping.[27] The coastal system will simply substitute for some coastal parts of the road system. Hence, the coastal system should be adjusted and integrated into the much larger road system and not vice-versa. It seems that the European experience with cassettes, rolltrailers and Stora boxes, is only applicable to the European setting of short-sea shipping where one party controls the entire point-to-point routing of cargoes. Such systems are not expected to be viable for the U.S. coastal system where the intention is to serve *existing* truck traffic, using the "water" highway for part of their routing.

The overall configuration of the U.S. domestic terminals should be universal ("open") and not specialized. This would allow any type of cargo or vessel to be handled. For example, the layout of domestic ports should be able to accommodate all the 5 types of vessels listed in the section on coastal vessels. Likewise, they should be capable of handling any type of trailer and container, including future 57-ft trailers and non-standard straight trucks.

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[26] The wheel height is saved since only one set of wheels is used for two boxes. See also the discussion of conventional Ro/Ro in Section II.2 on vessel systems.

[27] Road transport encompasses the entire continent while coastal shipping is limited, by definition, to the coastal regions.

High-Tech Ports

The assertion above that domestic terminals should be based on "open" design also suggests that high-tech systems for coastal shipping are irrelevant for the U.S. This mainly relates to a wide range of technologically advanced handling systems developed in Europe such as the Trailer Cassette System, the CASH and the Container Pallet Transfer System, all of which are briefly reviewed in Chapter IV.

All-Wheel Terminals

To simplify terminal handling and shorten dwell time of coastal cargoes in the domestic terminal, all cargoes should be on wheels at all times. In this way, the marine domestic terminals of the coastal system will be similar to truck terminals. However, both of the vessel types selected for further analysis are Lo/Lo. It is proposed that the handling of boxes between ship and shore be performed by ship's gear or mobile cranes. In the case of deck barges, top-loaders and reach-stackers can be used on deck. In all cases, the boxes should be handled to/from road chassis so that all boxes at the yard will be with their own wheels and ready to move. No permanent equipment should be allowed to be permanently staged at the berths (e.g., shore cranes).

Layout and Cost of Domestic Terminal

The envisioned domestic terminal will need a shallow access channel of about 20 - 25 ft, a berthage of about 500 ft with a Ro/Ro ramp and a staging area of about 5 - 10 acres, sufficient for holding 2- 300 trailers. Both the berth and the yard should be lighted and fenced. The terminal should have only a security gate and limited office space. The terminal should also have a waiting lobby for drivers and limited workshop for maintenance of tractors and trailers. Total investment in such a terminal, excluding access road, channel, and the purchase of land, should be in the $6 - 8 million range.[28] In comparison, a deep-sea terminal of similar dimension involves investment of $20 - 30 million (including lifting equipment). That is more than 3 times the cost of a domestic terminal.

Based on the estimated investment above, a domestic terminal should be able to handle trailers charging about $40/unit using an all wheel system. A similar charge is estimated for the geared Lo/Lo ship. The charge for handling Lo/Lo barges should be slightly higher at about $50 - 60. These barges use top-lifts and reach-stackers, relatively inexpensive container handling machines.

Pilotage & Tuggage

All coastal vessels considered here, including the coastal barges, are equipped with bow thrusters and advance rudder systems. As a result, all vessel types are basically self-

[28] This estimate is based on $10,000 per linear foot of berth and $5 per sq. ft of yard. The construction costs are obviously much higher if a new channel or breakwater is required.

sustained in terms of berthing / de-berthing.[29] Hence, it is assumed here that coastal vessels will not employ tug assist, resulting in considerable savings.

All coastal vessels are expected to be crewed by U.S. personnel, including ships' masters. Since the coastal services will follow the same itinerary on a daily basis (see later), it is assumed that an independent pilot will not be necessary for entering coastal terminals as is the case with inland waterways. This will also result in considerable savings.

Altogether, assuming a domestic system of ports can be developed according to the above stipulation, the *total* port cost (cargo and ship charges) for the coastal systems is expected to be in the range of $40 - 50 per box. This is about 1/5 of the typical cost at a deep-sea terminal of $200 - 250.

II.4 COASTAL RANGE

Combined Coastal and Short Sea Range

In principle, coastal services can be established along all three coasts of the U.S., including the Atlantic, Gulf and Pacific. Also, coastal systems can be expanded to include short-sea routes to offshore destinations. In fact, one line, Trailer Bridge, has already operated a combined coastal / short-sea service that included New York, Jacksonville and Puerto Rico (see Chapter III). Combined coastal and short-sea services are also common abroad, where the distinction between the two is even more blurred. For example, Grimaldi, an Italian line, has a service that combines calls in the U.K., France, Spain and Italy.

There is an inherent advantage for expanding the range of any transport system: the larger scope of transportation services generates a larger demand. This, in turn, allows for the employment of larger and more efficient vessels. Hence, it is logical to assume that the U.S. future coastal system will also attempt to incorporate short-sea routes.[30]

East Coast Range

Presently, the trade routes between the continental U.S., Puerto Rico and Alaska are served by a wide selection of U.S. flag short- sea lines. Likewise, there are many foreign-flag services between the continental U.S., Central America and the Caribbean Islands. This availability of services on these routes is expected in light of the fact the unavailability of land transports there.

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[29] The tug and barge may be exceptions.

[30] A service operating foreign flag vessels can presently offer a service with an itinerary that includes Central America, Miami and New York -- except that it cannot carry cargo between New York and Miami.

Since the short-sea trades are well defined and developed, including technology and operating systems, they are not analyzed. The study is solely focused on coastal services, or services with itineraries that follow the coastline. This focus is in line with the overall objective of the study to relieve coastal highways congested with truck traffic. Also, for simplicity of analysis, the selected range is limited to the Atlantic and the Gulf Coasts, both are hereafter defined as East Coast. The underlying assumption is that conclusions regarding the viability of coastal shipping based on the East Coast analysis are generally applicable to the West Coast.

Minimum Distance between Ports of Call

The cost structure of any shipping system involves two main components: port costs and vessel (voyage) costs, both were discussed in the previous sections II.2 & II.3. Port costs are fixed and independent of the route distance. The cost structure of trucking, the chief competitor of coastal shipping, also has a fixed cost component (see section II.5), but it is much smaller than that of shipping. As a result of the smaller fixed costs, trucking is more cost effective for short distances. Based on foreign experience, the minimum distance where a shipping system can be competitive with trucks is about 250 NM. This threshold distance may be lower in congested areas where trucking charges are high. For simplicity, this 250 NM was also used for locating potential ports of call for coastal services in this study.

Coastal shipping becomes more and more competitive as the distance between origin and destination points increases. Its competitive position especially improves once the distance is beyond the daily driving distance of a single ("solo") driver, which is usually about 400 to 500 miles. Trucking beyond this range: (a) is more expensive since the truck driver requires compensation for the night as well as accommodation expenses; and (b) has a longer trip time, because of the mandatory 8-hour rest. Truck lines can avoid the mandatory rest by providing team drivers. However, this may increase the cost of trucking by 50%. Also, truck lines try to avoid team drivers due to the shortage in truck drivers.

Altogether, coastal shipping has both cost and time advantages over trucking in longer routes. Hence, for a coastal service to become viable, it should incorporate the longest routes available.

Border Crossing

When routes require border crossings, coastal shipping has another inherent advantage over trucking. The present land border crossings, especially between Mexico and the U.S., are congested, resulting in long waiting lines for trucks. Also, while crossing by road there is a need to change both the tractor and driver. However, following the North America Free Trade Agreement (NAFTA) and the resulted simplification of trade between the U.S., Mexico and Canada, the NAFTA trade is expected to be similar in many respects to domestic U.S. trades.

The proposed coastal shipping could exploit its advantage in border-crossing and long distance routes by extending the coastal range to the entire NAFTA region. In this case, the East Coast range could encompass Halifax, Canada, several U.S. Atlantic and Gulf ports and Veracruz or Tuxpan, Mexico[31], a total of about 2,600 NM.

Inland Coverage

Coastal shipping is usually limited to serve the traffic in the coastal region. However, coastal cargoes, unlike feedering of marine containers, are not originating or terminating at coastal ports. Hence, a full coastal trip always involves, in addition to the water leg, two land transport legs, to and from the ports at the two ends. The length of the land transport legs depends on the distance between the final origin/destination points to the coastal port. The land legs add to both the cost of coastal shipping and to the trip time. The length of the land legs, or the "depth" of the coastal region that can be competitively served by coastal shipping, depends on the length of the water leg. Longer routes, where coastal shipping is more cost effective, allow longer land legs or deeper (wider) coastal range. Wider coastal range generates, in turn, more traffic for coastal shipping.

For example, Atlanta, GA, the most important commercial and industrial center of the southeast U.S., generates large volumes of traffic. Atlanta is located about 320 miles away from Charleston, SC. The traffic between Atlanta and New York, a trucking distance of 830 miles, will most probably not use coastal shipping because of the additional land leg to Charleston. But, the traffic between Atlanta and Mexico City, a trucking distance of 2,400 miles, may prefer the coastal route, especially when the elimination of a border crossing is considered. Hence, Atlanta will be within the catchment area of a Mexico service, but not within that of New York.

Ports of Call

The volume of cargo that can be generated there determines ports of call. At this preliminary stage, detailed traffic data are missing (see next section). Hence, for purpose of analysis only, the selected ports of call simply include the major deep-sea ports of the East Coast. The list of ports includes: Halifax, Boston, New York, Norfolk, Charleston, Jacksonville, Miami and Tuxpan. These ports can also generate feeder cargoes for the coastal service, although feeder is considered here as a secondary target.

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[31] Both serve Mexico City and the Federal District, the main region of traffic generation in Mexico but Tuxpan is the closest port.

II.5 SERVICE PATTERN AND PORTS OF CALL

Shuttle Service Pattern

Service pattern is a common term in deep-sea shipping. It is used to describe the route (itinerary, rotation) that vessels undertake for serving a certain trade. The route consists of several ports of call, some of which may be called twice. The selection of a route and ports of call is determined by both geography and preferences of the specific shipping line. In coastal shipping, the most common service pattern is also the simplest one -- the shuttle. This pattern is based on a rotation that includes only 2 ports, one at each end of the route, with vessels sailing back and forth between the two. A prime example of the shuttle pattern is a ferry crossing service, which usually include vessels sailing back and forth between ports located on opposite sides of a channel or a bay (e.g., English Channel).

The main advantage of a shuttle service pattern is its operational simplicity. Since the itinerary only includes 2 ports, voyage times and schedules are easy to maintain. Coordination between vessels is limited and even unnecessary if the service is provided by one vessel. Likewise, since all cargoes (and/or passengers) are destined to one port, the stowage plan is simple. The disadvantage of the shuttle pattern is that a pair of ports may not generate sufficient traffic to fill an entire vessel. Or, the traffic accumulation will only justify an infrequent service that will not be in line with the market requirements. For example, in the coastal context, the available traffic between New York and Miami may only support a weekly or twice weekly service but not a daily one. A daily frequency is presumed necessary for a coastal service to be competitive with land transport modes. This presumption will be further discussed in the section on competition.

In fact, none of the existing U.S. coastal services is provided on a daily basis. Columbia Coastal services have frequency ranging between weekly and 3/week, Matson's frequency is 1/week and Trailer Bridge had only 1/week in its Jacksonville - Newark service that was dedicated to domestic cargo (see Chapter IV).

Multiple Ports Rotation

The only data available for demand evaluation (see next section) for coastal services are based on secondary sources. The data are very general and do not allow for reliable estimation of traffic volumes between various port pairs on the East Coast. Nevertheless, it appears that there is not enough cargo to support a series of high-frequency shuttle services between these ports using the types of vessels listed in Section II.2.

Deep-sea services, which usually employ larger and more expensive vessels, solve the problem of insufficient cargo volumes by using multi-port service patterns, instead of shuttles. In a multi-port pattern vessels combine several ports of call in the same rotation to increase the service "'catchment range." For example, the rotation of a typical transatlantic service may include 6 ports, 3 on each side of the Atlantic.[32] In this way, vessels can accumulate more cargo and can achieve the desired space utilization (load factor) of 80%. In fact, a multi-port service operates like a commuter bus, which accumulates passengers from a series of stations.

Port and Trip Times

Despite its apparent advantage, the multi-port service pattern is usually not practiced in coastal shipping. Almost all existing and planned coastal services in the U.S. and abroad are shuttles.[33] The main reason for avoiding multi-port services is the extended trip time inherent in such a service. For example, a multi-port New York / Miami service, attempting to increase its revenue, might consider a stop en-route at Norfolk and Charleston instead of sailing directly between its two end ports. As already discussed in Section II.3 on ports, if these stops are made at present deep-sea terminals, they may add 48 hours (24 hours per port) to the trip time between New York and Miami, rendering the service non-competitive. Hence, in order to make a multi-port service viable, port times must be no greater than 4 - 8 hours. Short port times were a main stipulation in the definition of domestic ports in Section II.3.

Even if the port time is shortened the multiple port service pattern is suitable only for the high-speed ships, such as ship types (d) and (e) in Section II.2. Conventional ships, due to their low speed, have such long trip times that even short port times may render them noncompetitive.

Counter-Rotating Loops

The main disadvantage of coastal shipping vs. land transport is its longer trip time. Therefore, even for high-speed vessels with port times of about 4 hours, the trip time between end ports might be too long. One way to overcome this problem is to combine a shuttle and a multi-port pattern into one service. That is, vessels will call at way ports only in one direction, while the service in the other direction remains non-stop (express), similar to a shuttle. Two counter-rotating services are required to provide the full array of express services to all ports.

Differences in trip times between the express and shuttle legs make the counter-rotating service pattern difficult to develop. One way for solving it is to allow for some flexibility in schedule times. Another interesting feature of the counter-rotating loop service pattern is that it creates 2 service levels, non-stop and multi-stop. This difference could be reflected in the pricing policy of the coastal service. Altogether, despite the inherent complexity, the counter-rotating loop service pattern seems to be the most suitable for coastal shipping.

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[32] There are no shuttle services in the transatlantic or any other deep-sea trade. Fastship Atlantic plans to offer a transatlantic shuttle service between Philadelphia and Cherbourg in France.

[33] The newest coastal service in the Mediterranean is a shuttle between Barcelona and Genoa. The Emma project only analyzed shuttles. The only study that includes a multi-port rotation is MariTerm, where the "hopper" service includes 13 ports (!) in the same rotation (see Section IV.1).

Interlocking Loops

Cargo (freight) volumes in the different segments of the Halifax-to-Tuxpan East Coast range are not expected to be equal. Based on preliminary estimates, the central segment, between New York and Miami will have the largest cargo volumes. Within this range, the largest flow is likely to be between Miami and New York. The northern range, between New York and Halifax, will probably have the smallest volume and the Gulf segment somewhere between the two. There will also be inter-regional flows, although they will probably be in inverse relationship to distance. For example, the smallest flow would probably be between the two end ports of the East Coast range, Halifax and Tuxpan.

A common way of handling different volumes of cargo on various segments of a route is by deploying different vessel sizes on each of the segments. A possible segmentation of the East Coast service could be into three loops (see Figure 7):

- North Loop -- including Halifax, Boston and New York;
- Central Loop -- including New York, Norfolk, Charleston and Miami; and
- Gulf Loop -- including Miami, New Orleans, Houston and Tuxpan

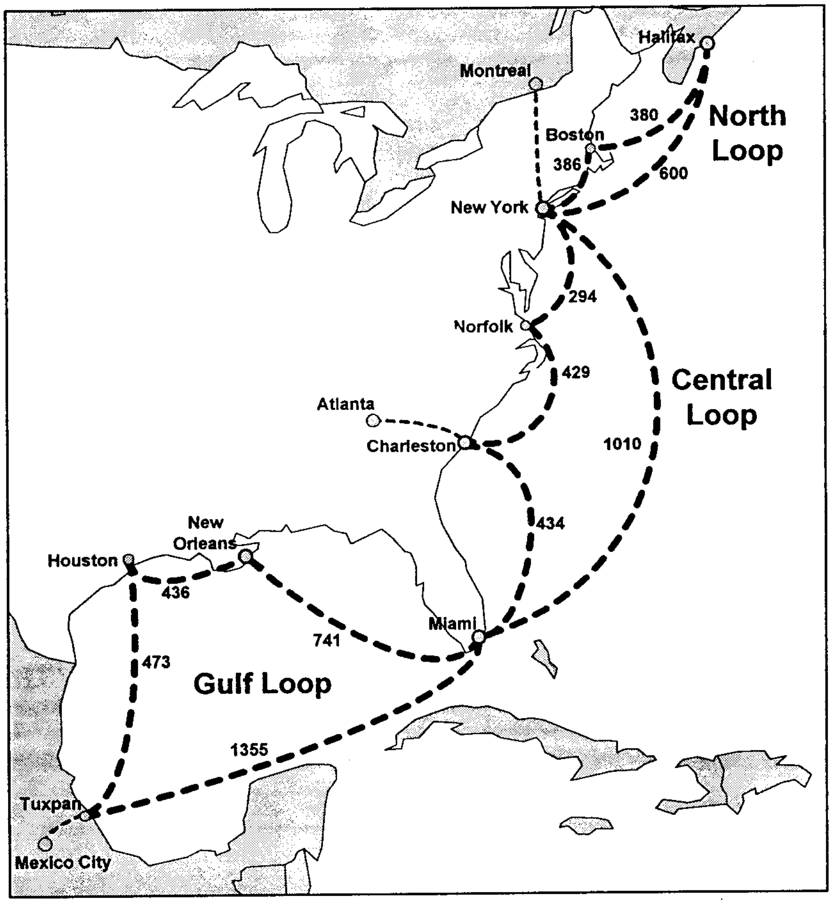
In this setting, the Central Loop will deploy the largest vessels to handle the largest volume of cargo. Another possibility to increase the Central Loop capacity is by utilizing the same capacity vessels, but with a higher rotational frequency. [34]

The itineraries of the various loops should be coordinated or "inter-locked". In this way, the transfer between loops will be smooth, eliminating long waiting times. For example, to provide a timely service from Halifax to Miami, the two services would be tightly coordinated, with the North Loop vessel arriving at New York 4 hours before the departure of the Central Loop vessel to Miami. Similar coordination is already common in deep-sea services (e.g., transshipment) as well as in air services.

Traffic for the long trips is expected to be limited. Nevertheless, since it is difficult to provide such a service by land as well, it might generate considerable revenue. For example, coastal shipping may have a significant advantage in providing connection between Halifax and Miami. Presently there is no rail service between the two and trucking is very costly.

[34] This also implies a related advantage in vessel cost and deployment flexibility. Utilizing a uniform fleet reduces construction and maintenance costs and allows for substitution between services.

Figure 7. Coastal Service Network on the East Coast



Hub and Spoke and Future Regional Services

A further expansion of the coastal service to smaller ports can be achieved by employing an even more innovative service pattern, called hub & spoke. This pattern, which is common in deep-sea services, is based on the interaction of two "levels" of services, mainline (linehaul) and feeder services. Mainline services usually employ larger and faster mother vessels that only call large "hub" ports, where they transfer (transship) their cargo to smaller and slower feeder vessels. Feeders, in turn, call at smaller, regional ports.

The coastal application of this bi-level service pattern could be based on two types of vessels: (a) regional, or feeder ferries, employing relatively small and slow vessels (speed is not critical for short distances); and (b) inter-regional, or express ferries, with large capacity and high speed. This will allow the coastal system to expand its coverage to smaller ports, some of which may be located on inland waterways (e.g. Albany, NY). As with the inter-locking loops mentioned above, the sailing schedule of the two types of ferry services should be coordinated so that the inter-ferry time is minimized.

At this stage of the analysis, the hub & spoke system is not analyzed. Likewise, another expansion of the system to short-sea (off-shore) ports is not analyzed.

II.6 Potential Traffic and Competition

Interchange with Land Transport

The primary cargoes of the proposed coastal shipping, as described in Section II.1, are domestic containers, trailers and trucks. Feedering and repositioning of marine containers is considered as a secondary cargo for the proposed coastal shipping, since they are already served by the existing coastal shipping system based on pull barges and deep-sea terminals. Only the part that is not served by barges, presumably because of barges' relatively-low level of service (see below), would be attracted by the proposed coastal shipping system. Both primary and secondary cargoes are hereafter defined as *target cargo.* The range in which this cargo is expected to originate/terminate is the East Cost of NAFTA partners, between Halifax and Tuxpan.

At present, the target cargo is transported by land-based transport modes, mostly by trucks. Rail transportation is limited to long distances and a limited number of points. During discussion with the industry, it was understood that most of the rail cargo is controlled by truck lines. In such a so-called "intermodal" service, truck lines contract with a railroad for the long leg (linehaul), while the short leg(s), usually the local drayage to/from the intermodal yard, is provided by trucks. Likewise, the equipment (trailer) is usually owned by the truck lines.

As seen above, the target cargo of the coastal shipping is presently controlled by truck lines. Hence, the market potential of coastal shipping should be based on cooperation with truck lines, assisting them in moving cargoes presently transported by road. This, indeed, is in line with the overall objective of the study, to assess ways to relieve coastal highways from truck traffic.

Intermediate Transport Service

The fact that the source for target cargoes is truck lines does not mean that there is a conflict of interest between coastal shipping and truck lines. On the contrary, the concept of coastal shipping that seems most appropriate for the U.S. circumstances is *not* as a provider of a full point-to-point transportation service, but as a provider of services for certain legs. The proposed coastal shipping system should operate similar to public ferries, where the main users are truck lines. Truck lines, in turn, will include the coastal service as part of their own comprehensive service package. A similar concept is presently taken by truck lines with regards to rail when they offer intermodal services. However, there is still an important difference between the proposed shipping system and the present rail system. U.S. railroads own and operate their tracks, while the water route is open to all shipping lines. Shipping lines, in turn, can employ any type of vessels to any destination they desire. Likewise, unlike railroads that own their intermodal terminals, coastal ports are expected to be open to all.

The proposed U.S. approach is in contrast with the European one, where shipping lines attempt to provide point-to-point transport services, including control over the water leg, inland legs and the ports. In the European case, the equipment (boxes, trailers), also belong to the shipping line, similar to the practice of deep-sea lines. The thrust for total control also explains the European tendency to employ specialized ships and port handling systems.

Inter-Regional Cargo Volumes

The study team was unable to identify a reliable source of data for truck traffic within the service range. Despite the growing public interest in relieving I-95 and I-5 from truck traffic, it appears that Federal and state agencies do not compile detailed data on this traffic, at least on a regular basis. Limited data are currently collected in weigh stations, but the data do not include origin and destination points, without which it has limited value for analysis and planning purposes.

As a substitute to direct traffic data, Reebie Associates has used secondary sources to develop a database for truck movements. The data are mainly derived through the analysis of tonnage flowing between Business Economic Areas and later on converted into equivalent truck trips. Some complementary data are also gathered directly from truck lines. Figure 8 illustrates the regions defined along the I-95 corridor to analyze truck traffic.

Analysis of sample data from Reebie for the I-95 corridor for 1997 indicates that most of the truck traffic is within regions and for relatively short distances. For example, in region 2, where most of the truck movements are recorded (about 13,000 per day), the average distance is 110 miles. This distance is far below the threshold of coastal shipping assumed before at about 250 miles (see Section II.4). Altogether, about 85% of the truck count and 61% of the truck miles are for distances smaller than 250 miles.[35] Hence, it seems clear at this early stage of analysis that coastal shipping cannot capture most of the truck traffic in the I-95 corridor. Another observation is that truck traffic is relatively small between the pairs of regions that initially appeared most promising. For example, the traffic between the New York and Miami regions, a potential route for coastal shipping, is about 100 trucks per day in each direction. Figure 9 presents the distribution of truck counts and miles in the U.S. East Coast. Figure 10 presents the inter-regional traffic.

It should be noted, however, that the above figures are based on 1997 data. It is reasonable to assume that traffic increased since then. The traffic will most probably continue to grow until the time of implementation of a coastal shipping system. Also, Reebie's data exclude: (a) cargo movements by rail; and (b) international containers. For

[35] Both statements relate to all traffic, including traffic that does not use I-95.

lack of information, these two elements are estimated here to be equal to an additional 50% of potential cargo.

Figure 8. Traffic Regions along I-95

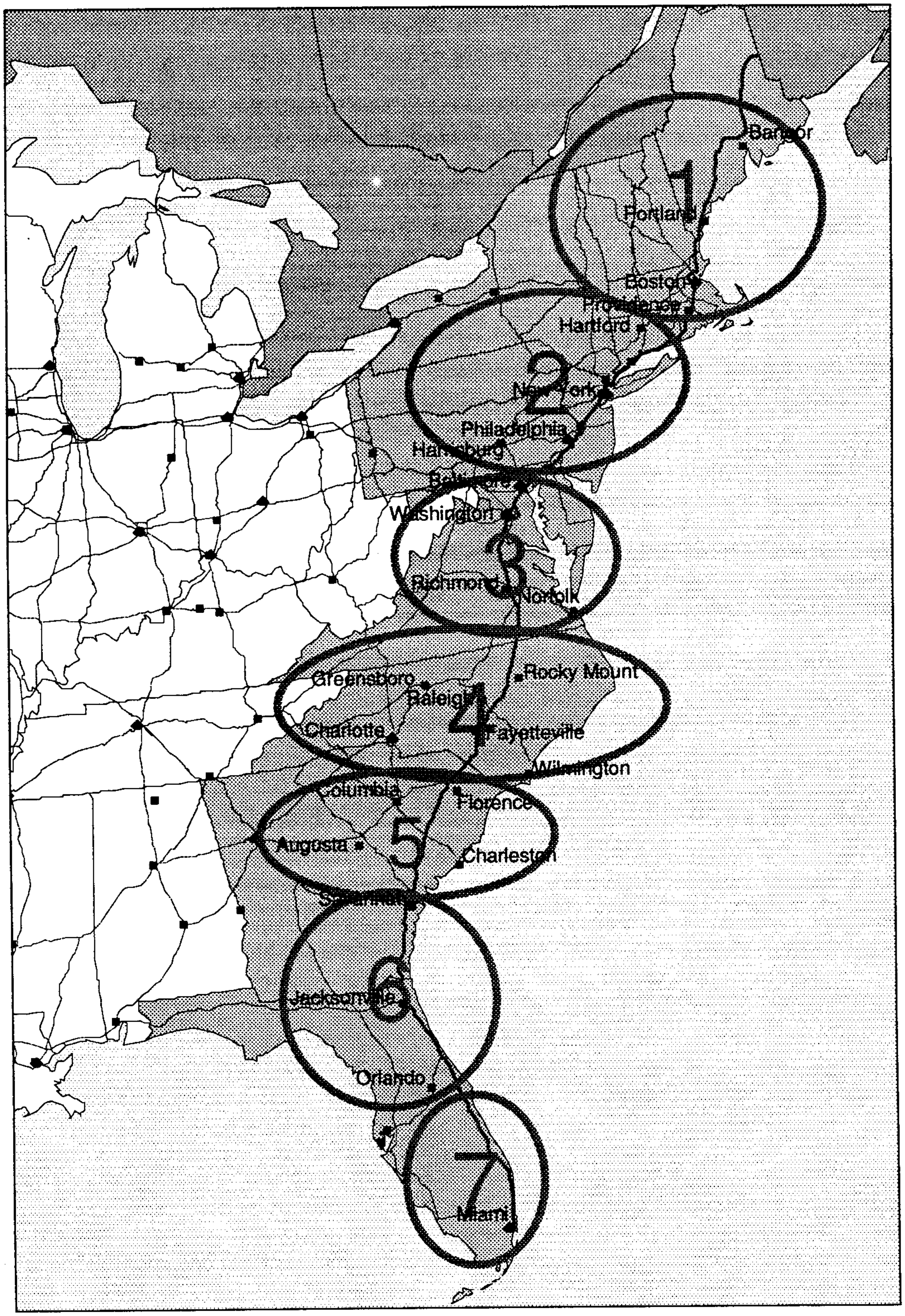


Figure 9. Distribution of Truck-miles by Trip Distance

Category	Average Trip	Truck Counts	Truck Counts	Truck Miles	Truck-Miles
1-250 miles	125	20,527,196	84.61%	2,558,236,176	60.68%
251-500 miles	331	2,799,498	11.54%	927,525,847	22.00%
501-750 miles	604	542,833	2.24%	327,838,726	7.78%
751-1000 miles	860	201,580	0.83%	173,300,164	4.11%
1001-1250 miles	1,099	101,253	0.42%	111,298,864	2.64%
1250-1500 miles	1,316	78,437	0.32%	103,211,288	2.45%
1501-1750 miles	1,600	8,982	0.04%	14,373,233	0.34%
Total	174	24,259,779		4,215,784,299	

Source: Reebie Associates data on 1997 truck traffic between 26 cities along US I-95.

Figure 10. Regional Flows (trucks per day, *average trip miles*)

Regions	1	2	3	4	5	6	7
1 Bangor, ME, Portland, ME, Boston MA, Providence RI	2,987 *119*	2,486 *162*	232 *559*	214 *869*	14 *917*	32 *1,370*	28 *1,549*
2 Hartford, CT, New York, NY, Harrisburg, PA, Philadelphia, PA	2,718 *155*	12,968 *108*	2,629 *158*	348 *508*	96 *663*	124 *994*	115 *1,242*
3 Baltimore, MD, Washington, DC, Richmond, VA, Norfolk, VA	54 *449*	2,087 *184*	7,542 *80*	1,400 *252*	97 *422*	27 *740*	22 *1,025*
4 R. Mount, Wilmington, Fayetteville, Raleigh, Greensboro, Charlotte, NC	113 *754*	864 *528*	1,922 *276*	12,238 *123*	2,414 *176*	217 *351*	49 *769*
5 Columbia, SC, Florence, SC, Charleston, SC, Augusta, GA	42 *912*	152 *682*	176 *438*	1,651 *168*	2,071 *105*	529 *177*	46 *601*
6 Savannah, GA, Jacksonville, FL, Orlando, FL	25 *1,213*	101 *998*	77 *713*	181 *382*	323 *206*	1,390 *121*	2,271 *277*
7 Miami, FL	27 *1,466*	98 *1,238*	42 *1,020*	45 *771*	65 *599*	3,114 *267*	- -

Traffic Density

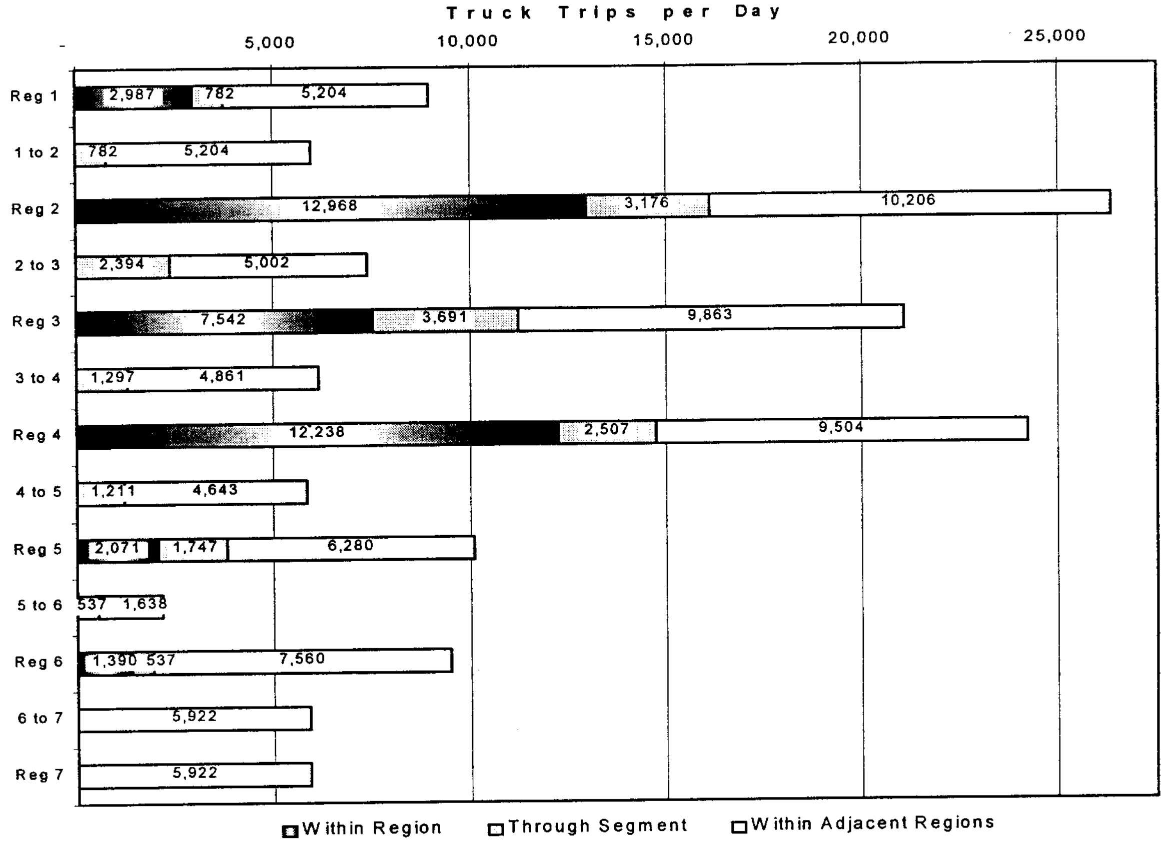
Another way of analyzing the traffic data is to calculate the traffic density along the regions. Traffic density is defined as the cumulative number of daily trips that pass through a region. This traffic includes, in addition to the three traffic segments above, a fourth segment:

- Intra-region traffic -- trucks movements within a region;
- Regionally-generated traffic -- truck movements generated / destined in/to the region; and
- Through traffic - truck movements generated / destined in/to another region, but going through the region.

For example, in region 2, the traffic southbound direction includes: (a) trips that originated and terminated at region 2; (b) trips that originate at region 2 but terminate in other regions such and trips that originate at other regions and terminate in region 2; and (c) trips that originated in region 1 and are passing through region 2 to regions south of it (e.g., 1 to 3, 1 to 4, etc.) and trips that originated at regions south of 2 and are destined to 1. As a result, the total traffic in region 2 is about 26,000 trucks/day. Naturally, traffic density at the end regions is much smaller, since there are no regions beyond them to generate through traffic. For example, in region 7, the traffic southbound ends at this region (there is no region 8). Hence, the total traffic is only 5,922 trucks/day. Figure 11 illustrates the regional traffic density by categories.

The importance of traffic density is because it directly relates to creating or relieving congestion. For example, a coastal shipping service that hauls trucks between regions 1 and 7, reduces the number of trucks/day in 7 regions, although not necessarily in the same day. A shorter haulage, between region 1 and 2, only impacts road congestion in two regions. The density calculations also indirectly relates to the required vessel capacity in a multi-port route, since the onboard cargo is the result of the accumulation of cargo flows from regions before to regions beyond the current region in which the vessel sails.

Figure 11. Traffic Density along the I-95 Corridor



Specification of Transportation Services

A shipper (user) evaluating a transportation service takes into considerations two attributes:

- "Cash Cost" -- The rate (tariff, charge, price) paid to the provider of the service; and
- Level of Service (**LOS**) -- The quality of the service, mainly relating to trip (transit) time and service frequency.[36]

There is a direct relationship between the two; a higher LOS usually warrants a higher rate. The common problem in market assessment of transportation services, however, is to quantify this relationship. For example, a common problem is how to estimate the

[36] Cash cost also includes any volume discount or other rebates or surcharges. Other LOS components are reliability, damage, value added services (packaging, usage of container / trailers), scope of service (geographic coverage), invoicing and booking convenience, etc.

premium that a fast service can command over a slow one. Or, vice-versa, how to estimate the required reduction in rates that a slower and less frequent service should offer.[37] These questions are critical especially for the coastal shipping since, as described in Section II.2, it may use a wide selection of ships with different speeds. Before assessing the required LOS of the coastal shipping, a review of the LOS of its competitor is warranted.

Truck Services

Trucking has two inherent advantages over coastal services: (a) trucks offer their services on demand, while coastal services are offered at a fixed frequency; and (b) trucks travel directly between origin and destination points, without going through terminals. Hence, theoretically, trucking has the highest frequency and shortest transit time -- and could command the highest rate.

Presently, truck services are offered in two main variations: single ("solo") and team drivers ("team"). A single driver can only drive 10 hours, after which he needs to rest for 8 hours. This mandatory rest means that "solo" trucking, the most common variation, has a natural barrier of about 400 - 500 miles, assuming average trucking speed of 40 - 50 mph. For distances beyond this range, service time is almost doubled, along with the additional cost for accommodation for the driver. Team drivers can drive continuously and do not have the above "range barrier". However, the cost of team drivers is much higher (see below).

Trucking Cost

Data on the overall cost of trucking, usually referred to as the average Dollar Per Mile (DPM), were collected at the beginning of 2000. The overall average was at about $1.6 per mile for solo and $2.5 for team.[38] The average might be misleading since trucking rates are commonly based on a formula consisting of fixed and variable components. Usually, the fixed cost covers the truck time required for local pick-up and delivery time, while the variable component covers the truck time underway which, in turn, is related to the distance. Hence, short-distance trips have a higher average rate.

A regression analysis of rates between East Cost points as quoted by a major truck line indicates that the fixed cost is about $325. Since the hourly charge for a driver and truck is $50, it seems that the fixed charge accounts for 3 to 4 hours at each end needed for local delivery, including 2 hours free. The variable cost in the regression analysis is about $1.09

[37] Professional literature uses the term general cost to denote the combination of all the cost and cost equivalent factors that affect shippers' decision. It should also be noted that different users may have different preferences (taste) with regards to these factors.

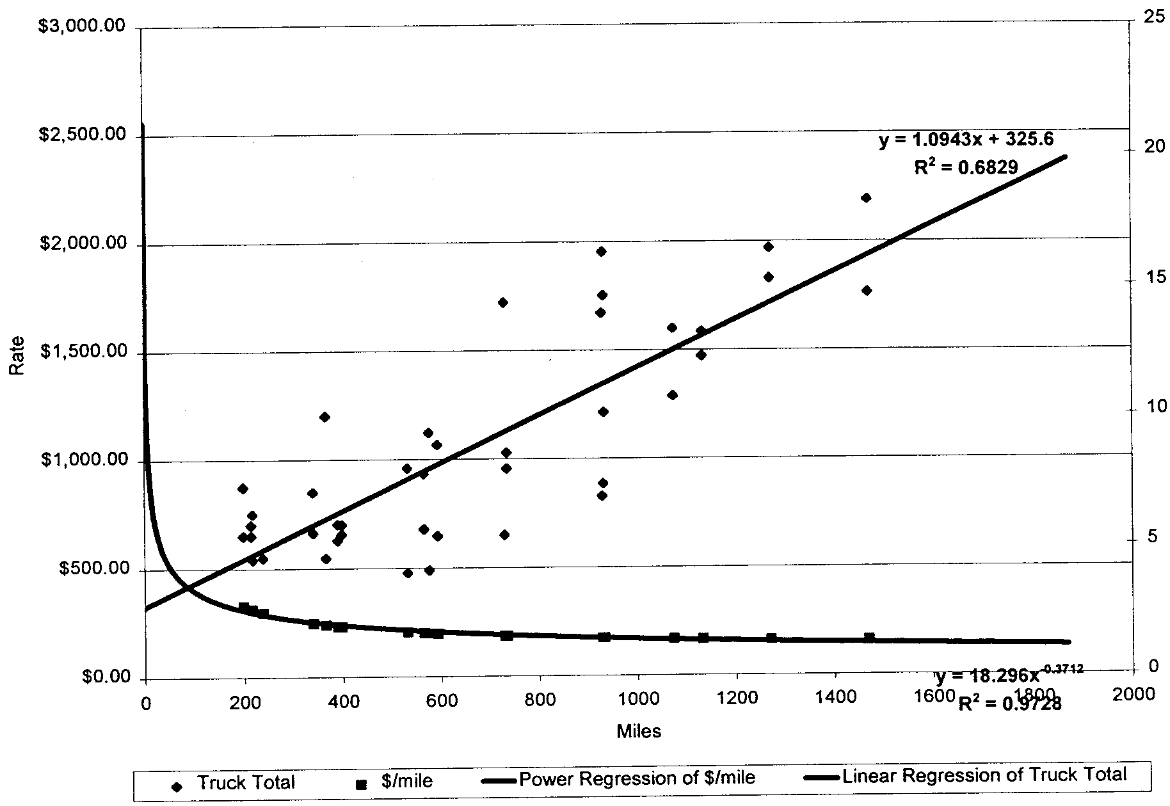
[38] The DPM quotations here do not reflect the recent rise in fuel price. Also, the U.S. Department of Transportation is expected to issue new driving hours regulations, putting drivers on a 24-hour cycle that includes 12 hours on the job and 12 hours off, and resulting in higher labor cost for long trips.

per mile. Both costs relate to solo. Figure 12 presents the regression chart and related equation.

Trucking is very sensitive to road congestion that lowers speed and increases cost. Congestion is severe especially near the major cities along the I-95 corridors, where average speed is way below the 40 - 50 mph. In addition, there are waiting in tollbooths, fueling time and other interruptions that add to trip times. Hence, rates in these areas are higher. For example, rates quoted in the ranges Baltimore / Boston and Miami / Jacksonville are more than twice the overall average, ranging between $2.5 to 3.3.[39] It should also be noted that rates also reflect directional imbalances (relations between front and back haul) and the general situation of demand / supply for trucking services.

Trucking rates have been on the rise in recent years, mainly as a result of continuing shortage in professional labor. When combined with the long anticipated rise in fuel price and increasing congestion, it seems that the upward trend in trucking rates is bound to also continue into the long term.

Figure 12. Trucking Costs and Cost per Mile



[39] Rates are also affected by the supply / demand relationships, relative cost of fuel and labor, insurance, taxes, etc., which vary between regions.

Rail Services and Cost

Rail services for domestic trailers and containers are somewhat limited along the I-95 corridor. The limited coverage is either because of lack of intermodal yards or because of problems in coordination between railroad companies. Unlike trucking, rail has a fixed intermodal terminal cost (lift on/off), estimated between $80 -100 (2 ways). Hence, rail transport is competitive with trucks for longer distances, say for over 500 miles. Rail service is provided on a fixed frequency, between once and twice daily. The service is marketed mainly by truck lines and not by the railroads themselves, as already indicated. Transit time is between 20 - 50% longer than all-truck services, with the difference decreases as the distance increases. For example, trip time between Miami and New York (New Jersey) for rail is about 3 days, vs. 2.5 days for solo and 1.5 for team drivers.

Rail rates as quoted by truck lines under Intermodal tariffs are between $0.20 - 0.25 per truck-mile lower than solo trucking. This difference, for a typical haul of about 1,000 miles, amounts to $200 - 250. Recently, due to shortage in drivers especially for the long-haul, truck lines attempt to encourage shippers to shift their long-haul freight to rail.

Shipping Cost

Trucking is especially expensive for routes that involve longer distances and border crossing. Long-haul trucking is expensive because of the logistics that relate to the driver and equipment (returning empty trailers). Border crossing, especially with Mexico, involves waiting at border crossing points and change of equipment and drivers.[40] A possible alternative to all-trucking could be an intermodal combination of truck and rail. However, the coverage of rail services that link between the U.S. and Mexico is still limited.

Another alternative is to use a combination of truck and vessel from one of the existing short-sea services. For example, a trip from New York to Mexico City may involve, first, trucking to a Florida's port, then taking a vessel to Veracruz and, finally, trucking from Veracruz to Mexico City. Rate quotation obtained from a shipping line indicated that the overall cost of the land-water-land trip is quite high, at about $4,500, partially because of charges at the deep-sea ports. However, this cost is still considerably lower than the all-truck alternative, quoted at about $5,000. High cost is not the only problem on this route. An even more severe problem is with the LOS of the service. First, the water voyage to Mexico could take between 4 and 11 days, depending on port of call. Second, the service frequency is weekly.

[40] U.S.- Mexico trades rose from $108 billion in 1995 to $200 billion in 1999. At Laredo alone, 7,200 trucks per day cross from Mexico.

Level of Service and Cost of Coastal Shipping

Truck lines are expected to be the main users of the proposed coastal shipping. They would be expected to use coastal shipping the way they do now with rail. Hence, coastal shipping should be perceived as a complementary service to the rail; in certain routes coastal shipping might have an advantage and in other regions rail. In order for coastal shipping to be incorporated into trucking services like rail, it has to provide a rail like service. That is, the LOS of coastal shipping (speed and frequency) and its charges should be similar to that of the rail.

Put differently, a coastal system that could not fit the requirements of truck lines will not be used by them and will have great difficulties to survive as a stand alone system. In any event, such a system will have to resort to special market niches and will not be able to serve the majority of the truck traffic, which, presumably, requires a truck-like LOS.

Not all the five vessel systems introduced in section II.2 can provide the required LOS. Nevertheless, for comparison, all are included in the cost analysis in Chapter V.

III. U.S. COASTAL SYSTEMS

III.1 GENERAL

Presently coastal shipping in the U.S. is quite limited. At the end of 1999 the system included only three shipping lines: Columbia Coastal Transport, Matson Navigation and Hale Intermodal Transport. A fourth line, Trailer Bridge, inaugurated a coastal service at the beginning of 1999 but quit after several months. In contrast to the limited scope of coastal shipping, the companion, short-sea shipping, is well developed. This system, which connects the mainland to Puerto Rico and Alaska, includes 5 lines: Totem Marine, CSX Lines (ex-SeaLand), Crowley Marine, Navieras and Sea Star.

The difference in vessels and services between coastal and short-sea shipping is small and future integration between the two is possible. The first attempt in this direction was undertaken by Trailer Bridge, operating a combination short-sea / coastal service between San Juan, Jacksonville and New Jersey. In addition to reviewing coastal lines and services, this chapter will include one short-sea line. This line, Totem Marine, operates an Alaskan service based on fast Ro/Ro vessels.

III.2 COLUMBIA COASTAL TRANSPORT (CCT)

Services

CCT began operations in 1990 as a tug & barge service dedicated to feeder service for international containers on the U.S. East Coast. Recently, the line added a feeder service to Freeport, Bahamas, using foreign flag, Lo/Lo containerships. In addition to containers, CCT has a project cargo division specializing in heavy and rolling cargoes.

Presently, the line offer 5 services on the East Coast, including:

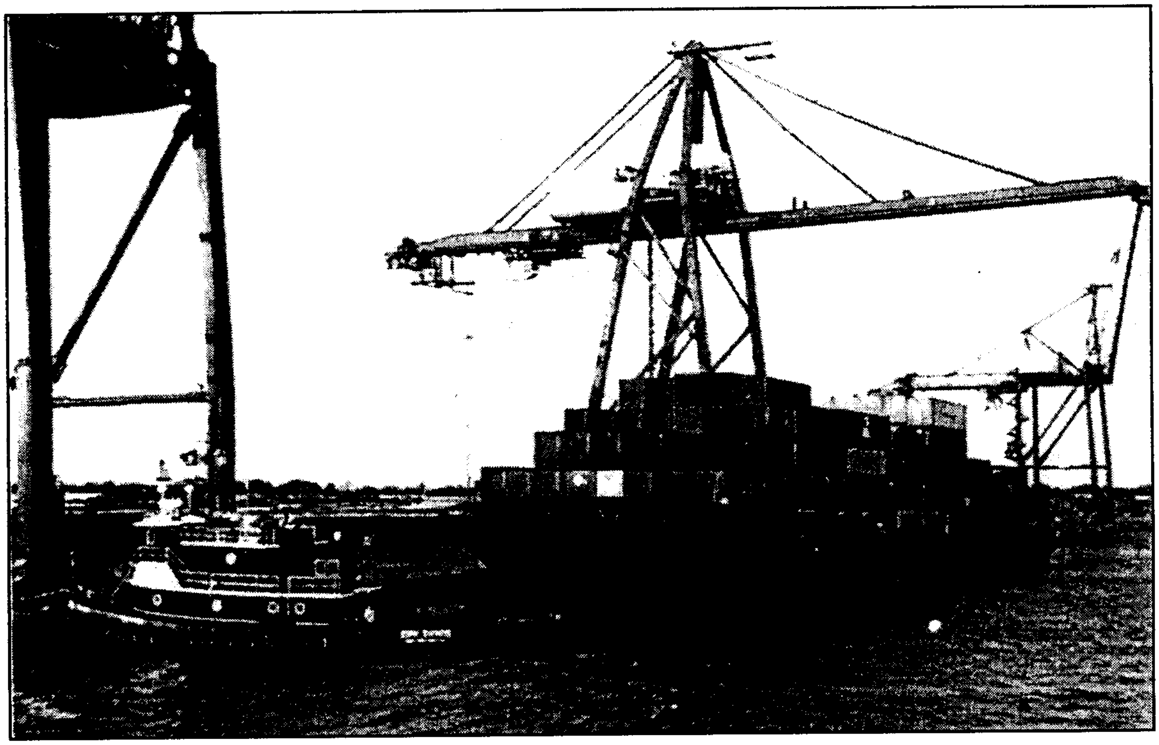
- Northern -- New York/New Jersey / Boston, 2/week;
- Mid-Atlantic -- New York/New Jersey / Baltimore / Philadelphia, 2/week;
- Chesapeake -- Norfolk / Baltimore, 4/week ;
- Wilmington -- Wilmington / Charleston / Savannah, 2/week; and
- Southern -- Charleston / Savannah / Port Canaveral / Miami, 2/week.

CCT also plans to offer a barge service between Houston and New Orleans, making it the 6th coastal service. There are plans to expand the Freeport feeder to Miami, Port

Everglades and eventually to Norfolk in the north and Mexico to the west. In 1999 CCT handled about 200,000 boxes.

A feeder service is an extension of the deep-sea service from the direct (actual) ports of call of the mother vessels to the port that they do not directly call. For example, lines that call Norfolk but not Baltimore will barge their boxes between Norfolk and Baltimore. Although not directly calling Baltimore, the BOL of the mother ship indicates Baltimore as the port of receipt. Since many deep-sea trades are unbalanced, there is a need to reposition (move) empty boxes at the ports where they are needed. Feeder activities and repositioning are the main activities of CCT. Figure 13 shows a CCT barge handled by a gantry crane at a deep-sea terminal.

Figure 13. Columbia Coastal Barge Handled at a Deep-Sea Terminal



All CCT's services are based on a weekly cycle. For example, the southern service includes the following rotation: Charleston - Monday, Savannah - Tuesday, Port Canaveral - Thursday, Miami - Friday, Savannah - Sunday, and Charleston - Monday. Accordingly, the trip time between Miami and Charleston is 4.5 days (4 days northbound and 5 days southbound). The long trip time is the result of slow speed, intermediate stops at way ports (including calls at two terminals in one of the ports), and long port times. The latter, is the result of the large capacity of the barge and the need to fit within the shift schedules of the ports. Also, since the service is built on a weekly rotation, it has planned slack times. If the service were direct, the voyage time between Miami and Charleston, a water distance of 416 NM, would only take 40 hours, or less than 2 days.

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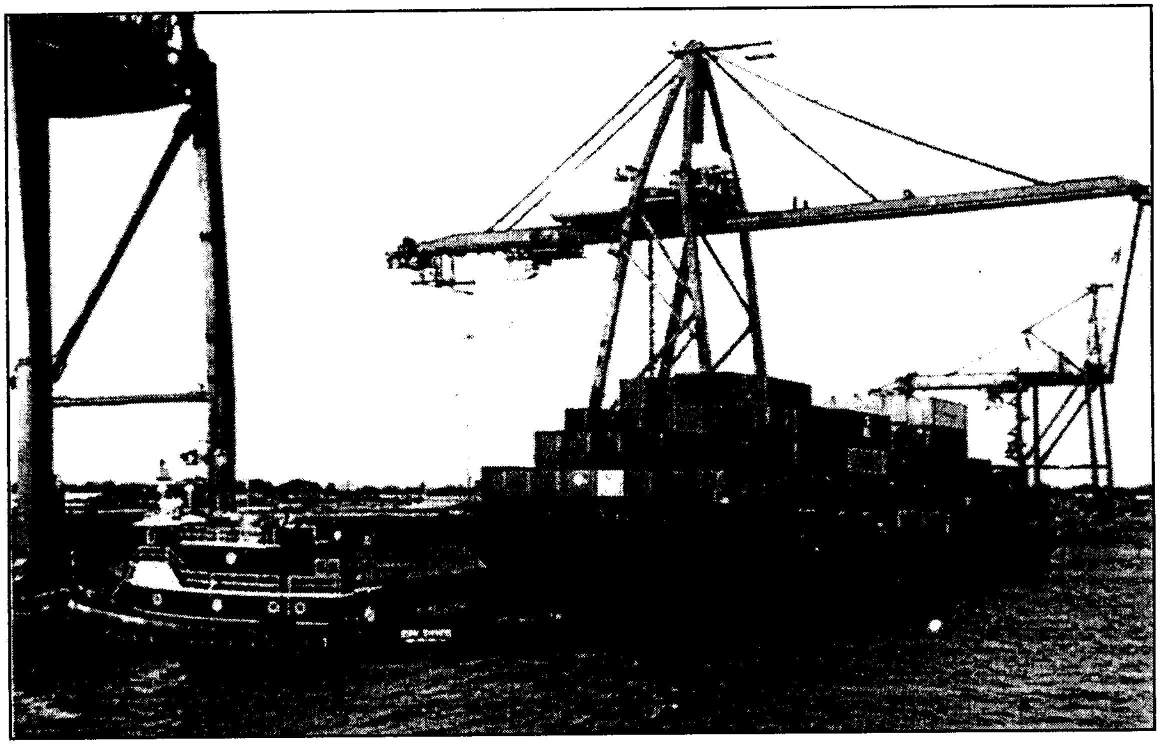

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The barges' trip times are not comparable to trucks, which cover the 576 miles between Miami and Charleston within 10 - 12 hours. Also, truck service is on demand while the barge service is 2/week. However, the coastal feeder service is perceived as part of the deep-sea service, whereby trip times are typically 20 - 30 days and the service frequency is weekly. Hence, the feedering time for deep-sea services is not as critical as it is in the case of domestic cargoes. Also, since barges operate between deep-sea terminals, boxes do not leave the terminal gate, which saves time and cost. It was understood that barges would benefit from a reduced stevedoring cost resulting from a special agreement. Altogether, it was reported that the barge charges are 30 - 50% lower than truck charges.[41]

Fleet

The fleet includes 11 barges with capacity varying from 400 to 912 TEUs. The largest one, the Columbia Elizabeth is 343 x 94 x 21 ft (length x width x depth) and has the cargo capacity of 10,267 Long Tons. This large, new barge was built to achieve speeds up to 11 knots. It can carry 20, 40 and 45-ft boxes. All barges are deck barges and all are pulled by tugs. Some of the barges are equipped with portable generators, allowing the transport of refrigerated containers. The tugs are of 5,000 - 6,000 HP. The typical northbound speed (with the Gulf Stream) is 10.5 knots and southbound 8 knots.

III.3 HALE TRANSPORT

Hale is a tug & barge operator. Presently, Hale offers only one scheduled service between Norfolk and Baltimore, with 2/week frequency. The service employs 2 vessels with a capacity of 450 TEUs. In the past, Hale had a service between Baltimore and Philadelphia, using the C & D Canal. In addition to scheduled services, Hale charters out several barges, including one sailing between Houston and New Orleans for Maersk-SeaLand.

III.4 TRAILER BRIDGE (TB)

Services

TB began its operations in 1991 with 2 Ro/Ro barges providing a weekly service between Jacksonville, FL and San Juan, Puerto Rico. In 1998, using a Title XI loan guarantee of $16.9 million, TB began construction of 3 deck (Lo/Lo) barges for a domestic, coastal service between Jacksonville and New Jersey.[42] Simultaneously, TB ordered 1,100 53-ft domestic containers.

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[41] Barge charges are terminal-to-terminal while truck charges are terminal-to-inland point. Hence, there is an additional local drayage cost that needs to be added to the barge cost.

[42] Title XI loan guarantee is a Federal program that provides underwriting for 87.5% of the construction cost of vessels. Due to the government backing, the 25-year bond carries a below-market interest rate of 6.25%.

TB's coastal service was a combination service, with a coastal and a short-sea leg. The sailing time between Jacksonville (Jax) and New Jersey (NJ) is about 4.5 days and between Jacksonville and San Juan (SJ) about 5 days. TB devised a multi-port rotation that included SJ / Jax / NJ / Jax / SJ, with twice calling at Jacksonville (northbound and southbound). Since, the rotation time was 3 weeks, 3 barges were needed for a weekly service. An important advantage of such deployment was that on its main Jax / SJ route, TB would add a second weekly departure to the one it already had with its Ro/Ro service. TB's competitors already had 2/week services on the run between Florida and SJ.

Due to insufficient market response, TB decided to quit the domestic, Jax / NJ service after several months of operations. Statistics provided by the line indicate that during the third quarter of 1999, the last period of operations, the line handled about 800 loaded boxes (southbound & northbound). Presumably, the capacity of the 213-box barges on a weekly service was about 5,400 boxes per quarter. Hence, space utilization was about 15% (800 / 5,400).

Currently the 3 Lo/Lo barges are deployed as follows: (a) 2 barges on a 4-week rotation of NJ / SJ / Jax / NJ; and (b) 1 barge on a 2-week rotation of Jax / SJ / Jax. As a result, TB offers a biweekly NJ / SJ and a twice-a-week Jax / SJ service, but no NJ / Jax service.[43]

Reach Stackers for Port Handling

TB's transition from Ro/Ro to Lo/Lo, despite the dominance of Ro/Ro in coastal shipping, is interesting to analyze. The main reason for this transition was the lower vessel cost. Usually, the construction cost of Lo/Lo vessels is half that of Ro/Ro, on a per capacity unit basis (e.g., per-TEU). Additional savings were supposed to be generated by the elimination of chassis during the long voyage. The elimination of chassis and their weight (5 tons) allowed carrying of more cargo.

A second cost saving feature stemmed from TB's unique Lo/Lo port handling system. Instead of using deep-sea terminals with gantry cranes, as it is the case with Columbia, TB's Lo/Lo barges were handled by two Reach Stackers, one on the barge and the other on the dock.[44] Each cost about $400,000 vs. a $6 million cost for a modern gantry crane, used in deep-sea terminals. The terminal used in Newark was a breakbulk terminal with a relatively shallow water depth. The use of TB's Ro/Ro barges was more expensive, since they did not have their own ramps. The barges were handled by a triple-deck ramp mounted on another barge and anchored permanently at the ports of call. Figures 14 and 15 show two views of reach stackers handling TB's Lo/Lo barges at a domestic terminal.

[43] The Puerto Rico market is currently served by 5 lines: Trailer Bridge, Crowley, CSX Line, Navieras, and Sea Star. The first two operate barges while the rest operate self-propelled vessels. The speed of self-propelled vessels is about twice that of barges.

[44] A variation of this lift-truck system, sometimes called "pass-pass", is based on two machines, one on the barge and the other ashore.

Figure 14. Trailer Bridge Terminal

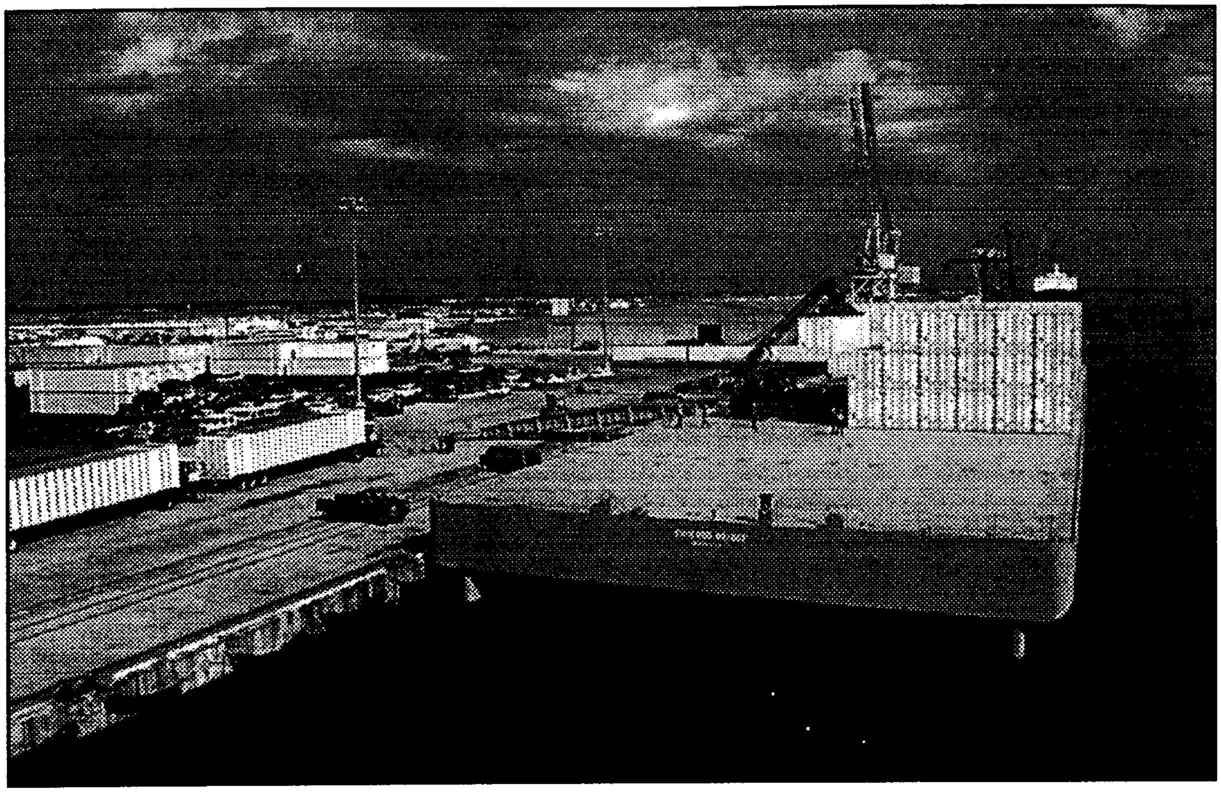
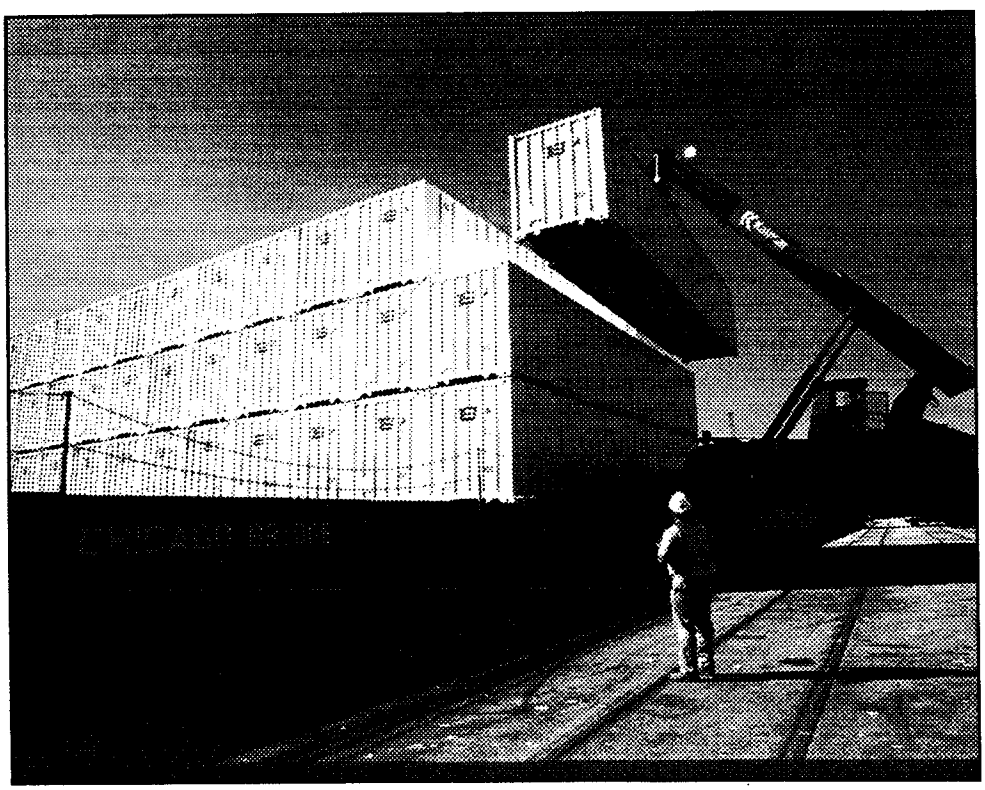


Figure 15. Trailer Bridge Barge Handling System

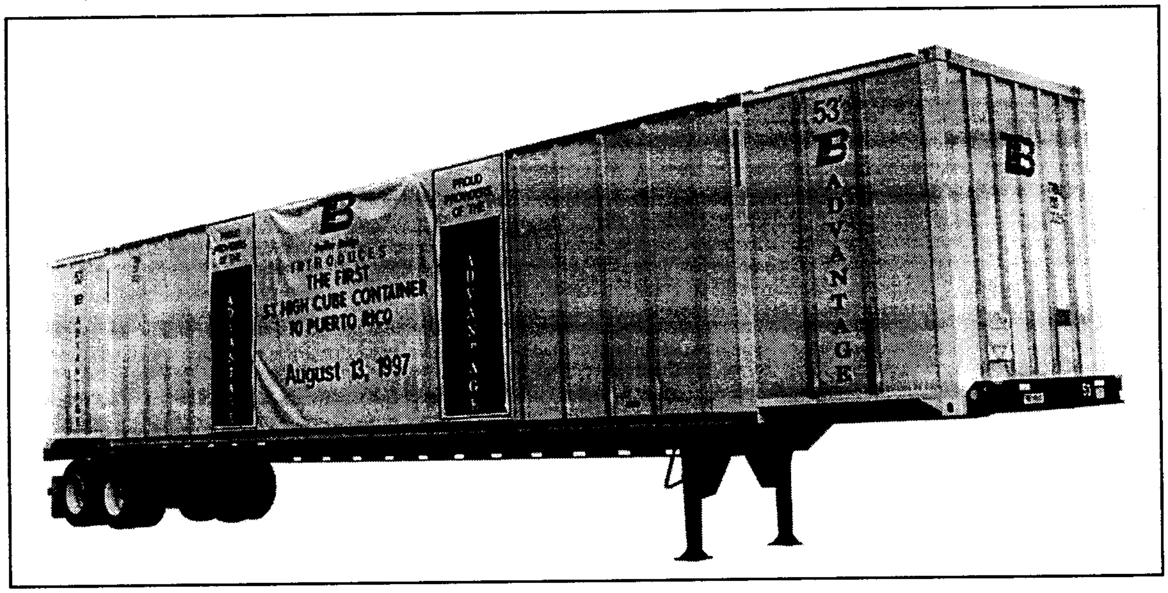


Fleet

The current TB fleet includes 5 barges: 3 Lo/Lo (described above) and 2 Ro/Ro barges. The Ro/Ro barges are triple-deck, and with the dimensions of 736 x 104 ft (length x width) and capacity for 340 48 and 53-ft trailers and 1,050 autos (or 413 trailers without autos).[45] These barges are the largest of their kind in the world.

The Lo/Lo barges are single-deck, with dimensions of 408 x 100 ft (length x width) and capacity for 213 53-ft containers. The boxes are arranged 11 rows wide and 3 high. The Lo/Lo barges were reported to cost about $6.5 million each. Together with the barges, TB ordered special domestic containers with enhanced cubic capacity. The boxes, measuring 53 x 8.5 x 9 ft (length x width x height) and 3,850 cu ft, have 50% more capacity than standard 40 x 8 x 8.5 ft marine container. It should be noted that TB's Lo/Lo competitors, which operate small cellular containerships, are limited to ISO boxes. Figure 16 shows a TB domestic container on chassis.

Figure 16. Trailer Bridge Domestic Container



III.5 MATSON NAVIGATION

Services

Matson is the only U.S. operator of a coastal service using self-propelled containerships. The Pacific Coast service was created in July 1994 but as of December 1998 was not profitable. Annual revenue was about $25 million. Presently, Matson operates 2 weekly services on the Pacific Coast: (a) the "Pacific Coast Shuttle", rotating between Los

[45] The barges were enlarged several years ago by inserting a 250-ft extension. Ro/Ros are more than twice the size of the new Columbia barge of 343 x 94 ft, but with similar capacity (TEUs).

Angeles, Seattle, Vancouver BC, Los Angeles; and (b) Seattle, Oakland, Hawaii, Seattle. It is interesting to note that Matson does not offer a feeder and/or domestic service on the short haul between Los Angeles and Oakland due to the competitive truck market.

The lines serve three market segments: (a) feedering of marine containers for South Pacific Central, South American and European lines whose northernmost port of call on the Pacific is Los Angeles; (b) repositioning of empty containers; and (c) moving domestic freight between Southern California, the Northwest and Canada. The first market segment, feedering, is Matson's primary activity. For this, Matson has signed connecting carrier agreements with 46 lines offering services between USWC, Europe and Australia/ New Zealand. Domestic freight includes 75% U.S. and 25% Canadian cargoes, including northbound frozen cargoes and southbound newsprint, lumber and wood pulp. According to Matson's publications, in 1998 the coastal service handled 47,000 containers, 40% of them full, and in 1997 35,000 containers. The domestic cargo accounted for about 25% of the total cargo.

In the domestic freight, Matson competes against trucks and rail. Matson claims that its sailing time from Vancouver, B.C. to Los Angeles takes 2.5 days (55 hours) vs. 11-18 days via rail.

Matson's service calls at deep-sea terminals and has to abide by their practices. The published gate hours are, on weekdays, between 8:00 am and 4:30 p.m., with a noon break between 12:00 and 1:00 p.m. There are no Sunday gate hours. Likewise, cut-off times are 6 - 10 hours before departure times and cargo availability times are 5 - 24 hours, depending on day of the week and time of the day.

Rates for "all-in" Freight All Kind (FAK) between Los Angeles and Vancouver were quoted (March 2000) at $466 per 40-ft container for shippers with 5 or more containers per week (260/year) and $975 per 40-ft container for a single container.

Fleet

The coastal shuttle service is provided by a single vessel, the SS Manulani, with a 1,476 TEU capacity. The Manulani is a 1970 steam turbine vessel with maximum speed of 22.5 knots. Because of its past involvement in Matson main trade to Hawaii, the ship is still equipped with 5,300 Short Ton Molasses tanks

Matson's uses deep-sea marine containers for domestic services. These are the same ones used in the deep-sea service to Hawaii. Hence, the line does not offer big-capacity domestic containers, similar to the 53-ft boxes of Trailer Barge. In addition to the added cost, the larger and wider domestic containers have limited stackability and do not fit well with marine containers, the dominant cargo units handled in deep-sea containers.

III.6 TOTEM OCEAN TRAILER EXPRESS (TOTE)

Tote does not provide a coastal service, although the general route of Tote's ships is along the coastline. The service, based on the definitions in Section II.4, is better defined as short sea. However, Tote's service employs fast Ro/Ro ships calling at dedicated terminals and therefore has much similarity to the service proposed here. Hence, a brief discussion of Tote is included in this section.

Services

Tote operates a shuttle service between Tacoma, WA and Anchorage, Alaska, using 3 Ro/Ro vessels. Tote service began in 1975. Currently, with 3 vessels, Tote provides 3 departures per week during the summer and 2/week in winter. The water route, with 1,447 NM, is much shorter than the land route through the Alcan Highway, a distance of 2,400 miles. The rotation time of the vessels is 1 week. Transit time for the 24-knot vessels is 66 hours and turnaround times in ports are 8 hours in Tacoma and 12 hours in Anchorage. Unlike most large Ro/Ro vessels, Tote's vessels do not carry any on-board ramp, saving on both space and weight. Vessel handling at the two ports is performed by using 3 shore-based side ramps. Figure 17 shows a Tote vessel and terminal (left of the vessel).

Fleet

The current vessels are the last Ponce-class vessels that were built by Sun Shipbuilding. Their dimensions are 790 x 105 x 60 ft (LOA x beam x depth). The trailer equivalent capacity is 410 FEUs.[46] The total deck area of each vessel is 198,000 sq. ft., with the displacement of 17,900 long tons, and a net cargo tonnage of 2,500 long tons. A 30,300 SHP steam turbine provides a speed of 24 knots. Cruising range is 6,000 NM. All ships were built in the 70's but have been refurbished several times since then. Currently, they are valued at $120 million each. Because of the harsh sea conditions, the ships have special design features, including a reinforced bow for ice, a special cooling system and double-hull fuel tanks.

Recently, Tote announced an agreement with National Steel and Shipbuilding Company (NASSCO) to build 2 new ships, at a cost of $150 million each.[47] Ships' dimensions are 839 x 118 x 29.5 ft and the capacity is 648 FEUs, based on 360,000 sq. ft of deck area. The internal arrangement is based on 5 trailer decks and 2 car decks. Interestingly, the deck design could accommodate the 57-ft trailers of the future. There are no internal elevators only sloping ramps. A diesel electric propulsion system, with 68,000 HP, drives twin propellers. Only 53,000 HP will be consumed at the shaft with the remainder providing auxiliary power, especially refrigeration. Speed at 90% MCR is 24 knots. Speed on the return trip, when empty, is up to 26 knots.

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[46] These vessels are much larger and faster than the type of vessel defined as Fast Ro/Ro in Chapter II, with a capacity of 200 TEUs and a speed of 18 - 24 knots.

[47] There is a similarity between the new Tote ship and the recent USNS Red Cloud, which was launched August 7 at NASSCO. It is estimated that foreign building would have saved $30 - 50 million.

Since the capacity of the new vessels is 50% higher, the 2 new vessels are designed to replace the existing 3-vessel system. The new vessels also will follow the present service pattern based on a weekly rotation. The higher speed of the new vessels will provide better ability to maintain schedule integrity. Because of the rough route, with seas surging up to 60 ft, winds of 100 knots and ice during winters, the ships are built to higher strength and reliability standards. Because of the Alaskan environmental sensitivity following the Valdez incident, the ships are built to tighter environmental specifications.

Crew size is 22 (vs. 28 at older ships). Still, the crew is larger than that common in Lo/Lo vessels. The relatively large crew is needed to attend the cargo in the rough seas. Smaller crews and the replacement of the steam turbine engine with a diesel engine will reduce operating cost. The vessels do not provide accommodations for passengers or drivers.

Most of the cargo will be stowed in Tote's trailers. However, customers who have trailers with similar specifications can use their own equipment. In addition to trailers, the vessels can carry other rolling cargoes such as bulldozers and autos.

Figure 17. Tote's Vessel and Terminal in Tacoma

III.7 SUMMARY

This review of coastal services corroborates the statement made earlier regarding the limited scope of U.S. coastal shipping. Except for Matson's Pacific Coast Shuttle, there is no coastal service that is geared toward handling domestic containers and trailers. However, Matson's main activity is to provide a feeder service for deep-sea containers. Therefore, its domestic service uses marine containers with a relatively small capacity, deep-sea terminals with limited hours of operations, and has a weekly frequency. Therefore, it is not competitive with trucking. In fact, Matson perceives as its main competition not the trucks, but the rail service between Canada and California.

An attempt to provide a dedicated service on the East Coast for domestic cargo was made by Trailer Bridge (TB). TB service was based on specially designed barges and dedicated domestic ports. However, the slow speed of barges along with the low service frequency made it difficult for TB to provide a competitive service. As it is the case with Matson, only part of the capacity was dedicated to coastal traffic with the rest geared for short sea (Puerto Rico).

Altogether, the two attempts by U.S. shipping lines to divert meaningful truck traffic to coastal shipping have not been successful.