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Double Stack Container Systems: Implications for U.S. Railroads and Ports

U.S. Department
of Transportation
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Intermodal Development

Task I Report
Double-Stack Status

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I. APPROACH

A. STUDY BACKGROUND AND PURPOSE

Rapid growth in double-stack container operations has brought the rail industry to the verge of large-scale domestic containerization. The container capacity of the double-stack fleet has increased from 400 container spaces in 1983 to an estimated 30,000 in 1989, while conventional trailer slots dropped by over 20,000. In that same period, rail transfer facilities have been condensed from over 400 ramps into a system of about 215 high-volume mechanized hubs capable of supporting frequent double-stack service in most major rail corridors. The necessary infrastructure for a domestic container system, seemingly unattainable just a decade ago, is largely in place.

Market forces are already in motion to cross that verge and create large-scale domestic double-stack container services in some markets. Domestic container services are routinely marketed by railroads, ocean carriers, and third parties. Yet the wholesale replacement of other intermodal services with double-stacked containers is not a certainty. There are operational, economic, and institutional issues to be resolved. The issue is not whether there will be domestic containerization: it is here. Rather, the issue is whether there will be an identifiable domestic double-stack network. We believe the answer is "yes": the forces are already in motion. The questions are: Under what circumstances? Where? How large? And how do we get there from here?

Domestic containerization will take place in an intermodal arena populated by railroads, motor carriers, ocean carriers, ports, and third parties, and it will change their interrelationships as containerization changed others in the ocean transportation industry. Recognition of those changes, and accommodation to them, is essential if domestic container services are to reach their full potential.

A body of conventional wisdom has grown up around double-stack container services, based largely on the form and means of their introduction in the mid-80s. Yet notions and concepts that may have been true as late as 1986 may already be outdated. The phrase "westbound domestic backhaul" is rapidly losing its meaning in the face of recent export growth and inland container shortages. The "double-stack unit trains" that began the trend are being joined by growing numbers of common-user and mixed intermodal trains. The belief that double-stack economics can only be realized in solid trains between major hubs is being confounded by regular domestic loading of as little as one five-platform car at regional distribution centers.

This study was undertaken to assemble a comprehensive picture of double-stack systems, to determine the potential for domestic double-stack container transportation, and to identify the implications of expanded double-stack systems for railroads, ports, and ocean carriers. This study, divided into five tasks, is intended to answer six major questions:

- What is the status of double-stack container systems?
- Under what conditions can domestic double-stack container systems be competitive with trucks?
- What form might a potential double-stack network take?
- What implications would such a network have for railroads?
- What implications would such a network have for ports and ocean carriers?
- Are existing market forces sufficient to bring about an efficient double-stack network?

B. TASK I: INFORMATION BASE

This task will provide a comprehensive information base for the study team and for industry and government planners. The study requires both statistical

data (on the relevant market, modal market shares, existing double-stack services, intermodal rail technologies, and oceanborne container movements) and qualitative information (on relationships among the participants and on their plans for new investments).

Rail Traffic Flows. The source for rail data for this study is the 1987 Interstate Commerce Commission Carload Waybill Sample (CWS). The 1987 CWS is comprised of 363,078 records, each of which is a record of a revenue movement of goods by rail which terminated in the United States for the period December 15, 1986 through December 14, 1987. Due to the sampling scheme which was put in place by the ICC in 1981, approximately three percent of all rail revenue waybills which showed terminations in the United States are included in the 1987 CWS. The collection of the sample is done by the Association of American Railroads (AAR) under contract to the ICC, and the enhancement of the sample, including revenue division and distance calculation is done by ALK Associates, Inc., in cooperation with the AAR. More information regarding the sampling methodology and waybill fields may be found in Enhancement of the 1987 Interstate Commerce Commission Carload Waybill Sample available from ALK Associates, or the User Guide to the 1987 ICC Waybill Sample available from the Association of American Railroads, Economics and Finance Department.

Truck Traffic Flows. There is only one current database on motor container movements: the National Motor Transport Data Base (NMTDB), maintained by study team member Transportation Research and Marketing (TRAM). For the past 13 years, the TRAM NMTDB has generated two basic data sets: answers to more than 60 questions asked in a one-on-one interview in selected truckstops; and passing counts of heavy trucks taken by fleet type and trailer type on the interstate highway at or near interview locations. Each year, TRAM compiles 23,000 - 25,000 in-depth surveys and nearly 800 passing counts.

Interviews are currently being conducted at 19 points: Redding, California; Ontario, California; Nevada; Boise, Idaho; Eloy, Arizona; Gallup, New Mexico; Rock Springs, Wyoming; Walcott, Iowa; Portage, Wisconsin; Oklahoma City, Oklahoma; Covington, Kentucky; West Memphis, Arkansas; Joplin, Missouri; Doswell, Virginia; Toledo, Ohio; Carlisle, Pennsylvania; Wytheville, Virginia; Cordele,

Figure I-1
Multi-State Inland Regions



Georgia; and Jacksonville, Florida. At least 80 inter-city drivers are interviewed each month at each location. At those locations where more than 120,000 passings occur, one interview is completed for every 1,500 trucks passing. Random interviews are conducted at all hours of the day and night and at all times of the month.

The NMTDB also uses 21 four-hour continuous heavy truck passing counts taken randomly over a continuous seven-day period twice a year. Each passing truck is counted by type of carrier operation (private, regular route, or irregular route), by type of trailing unit (flat, van, refrigerated, drop frame, moving van, etc.) and by direction. All trailer types are specifically tabulated. The 21 four-hour period counts are then projected to seven-day data, and estimated 30-day passing counts are developed from these data. These counts are then compared to diesel gallonage pumped in each area during that period. Subsequent changes in diesel gallons pumped are used to estimate passings between counts. In states such as California, where reliable counts on class 7 and class 8 truck passings are available at vehicle inspection stations, these counts are used to supplement the sample-derived counts.

TRAM selected the most comparable and useful format for 1987 data, and selected the relevant portions of the NMTDB. In order to maximize the sample size for this project, TRAM combined the results of the 1985, 1986, and 1987 interviews. The regions shown in Figure I-1 were defined to organize the truck data.

To avoid the inefficiency of assembling large amounts of irrelevant data, the truck data was prepared in two stages. In Task I, TRAM extracted from the NMTDB the truck traffic most obviously relevant to this study: the transcontinental movements for which double-stack trains are already competing. In Task II, the study team will determine what categories of truck traffic are subject to potential double-stack competition. TRAM will then extract the available information on such movements from the NMTDB for further analysis.

Rail and Truck Market. A key factor in this study is market penetration: What current and future motor carrier or rail intermodal traffic could be

attracted to an efficient domestic rail container service that could not be attracted to other intermodel services? To answer this question, the study team matched the rail and truck traffic information to establish a preliminary estimate of the relevant market for intermodal rail transportation, and the rail market share.

The Basis of Rail-Truck Competition. The competitive boundary between rail and truck modes is one nexus of this study. The advent of an efficient domestic container service is expected to expand the range of competition between rail intermodal services and trucks. TRAM described the relevant factors in competition between trucks and double-stack service, and formulated methods to determine what truck flows in the relevant market would be susceptible to diversion by domestic rail container services under various double-stack service scenarios.

Profiles of Existing Double-Stack Services. Drawing on reviews of published announcements and contacts with railroad personnel, this task describes the existing (December, 1988) double-stack services in terms of:

- Railroad;
- Inland hub;
- Dedicated or common user; and
- Frequency.

Preliminary results showed that attempting to specify train sizes or equipment types would be futile: these features sometimes change from week to week. The study team also identified the inland hubs now used for regular double-stack service, and their major regional service areas.

Rail Intermodal Technologies. Existing rail intermodal cars and carless technologies are described in terms of their development, features, capacity, and use. Where possible, comparisons are made on the basis of relative tare weight, cubic capacity, and weight capacity.

Oceanborne Freight Data. At the beginning of the study, the inland origin/destination version of the Bureau of the Census data was made available. Tapes for 1987 liner imports and exports were therefore requested through MARAD. Liner trade is that transported by regularly scheduled ocean carrier operations, as opposed to tanker, bulk, or non-liner operations. A small amount of containerized trade moves in non-liner operations, but is unlikely to be of significance to double-stack train operations.

The origin or destination state information in the Bureau of the Census database is derived from the shipper or consignee address on Customs declarations. If the address is that of a corporate headquarters or other office in a different state from the facility actually shipping or receiving the goods, the database will contain the wrong state information for our purposes, resulting in a "headquarters bias." The Journal of Commerce PIERS database also has a headquarters bias. Since the PIERS data is drawn from Customs manifests rather than from Customs declarations, the incidence of a headquarters bias may differ slightly in PIERS.

There is no means to detect or verify the prevalence of the headquarters bias systematically from the information given in the Census trade data. The headquarters bias may result in an abnormally high number of shipments being attributed to states with major headquarters cities, such as New York (New York), California (San Francisco and Los Angeles), or Illinois (Chicago and St. Louis). The bias may be particularly strong in smaller states with a disproportionate number of corporate headquarters, such as Connecticut or New Jersey. For the most part, the data confirm this expectation.

Relationships Between Ports, Ocean Carriers, and Railroads. The existing relationships between ports, ocean carriers, and railroads affect the operations and economics of domestic rail service using oceanborne containers, as well as the inland movement of oceanborne freight. They may have an even more pronounced impact on the configuration of a domestic container service, especially if combined oceanborne and domestic container trains or on-dock rail facilities are involved. Task I describes the issues in the three-way relationship between ports, ocean carriers, and railroads, the growing need for cooperation, and the major potential points of conflict.

Scope of Current and Planned Capital Investments. Announced capital investment plans provide useful insight into the shape of double-stack services. Announced plans were compiled for 1988, 1989, and future investments in intermodal rail cars, locomotives, containers, trailers, RoadRailers, facilities, and handling equipment.

II. RAIL TRAFFIC FLOWS

METHODOLOGY

Several fields reported on the CWS could be relevant to this study. They are:

TOFC/COFC Plan. This field indicates the arrangements for drayage and trailer/container ownership which have been made for the subject waybill. A "0" in the field indicates that the waybill does not cover an intermodal movement by rail. The drayage and ownership arrangements for TOFC/COFC traffic are not germane to the current purposes, and will not be discussed here.

Number of Trailers/Containers. This field contains the number of trailers and/or containers which are covered by the subject waybill. There is no distinction made in this field between trailers and containers.

Number of Cars. This field reports the actual number of rail cars reported on the subject waybill. Ideally, this field taken together with the trailer/container count field would identify rail movements where the trailers/containers per car figure indicates double stack service. However, many intermodal waybills cover the movement of only one trailer or container, a practice known as "single billing," and each of these waybills reports the movement of the rail car underneath that trailer or container. Thus, the number of rail cars reported in the CWS moving intermodal equipment tends to be overstated, while the number of actual trailers or containers is usually correct. Additionally, in the case of articulated intermodal cars with several platforms semi-permanently attached, there is some confusion as to what constitutes a car. More discussion of the number of trailers/containers per flat car, a statistic known as the "hitch ratio," is included below.

Car Initial and Number. This field reports the rail car owner's initial (or mark) and the number assigned to that car. The car initial and number taken together identify the actual car as listed in the AAR Universal Machine Language Equipment Register (UMLER). The UMLER files container mechanical information about the car such as height, weight, length, fittings, and suitability

for particular uses. The AAR cartype field, explained below, is derived from the car's UMLER entry.

Trailer/Container Initial and Number. This field is the trailer/container owner's initial (or mark) and number for the intermodal unit covered by the waybill. If more than one trailer/container is involved, only the initial and number of the first unit is reported. It is generally true that the last non-blank character in a trailer initial is "Z", and slightly less generally true that the last non-blank character in a container initial is "U". For instance, an intermodal unit marked "APLU" is a container owned by American President Lines, while a unit marked "APLZ" is a trailer or chassis owned by the same company. Bare chassis, that is a flat or open trailer without a permanently fastened box, are marked in the same way as trailers.

AAR Cartype. This field, also called the Lauby code, reports the type of the rail equipment used for the subject waybill. This field is not reported by the railroad, but is determined by matching the car initial and number with information in the Universal Machine Language Equipment Register (UMLER), which is maintained by the AAR. The first character in the cartype code generally describes the type of car ("A" represents equipped box cars, "P" represents intermodal flat cars, etc.), while the last three characters describe some of the mechanical characteristics of the cars such as door size (for boxcars), car length, and so forth. Currently, intermodal rail cars are designated as "P" for general intermodal flats, "Q" for light-weight or articulated flats, or, occasionally, "F" for general purpose flat cars. Cars with a first character of "Q" and a second character of "0" or "9" are intermodal flat cars designed to carry stacked containers. The AAR has proposed new cartype designation "S" for intermodal rail cars designed for double-stack service, but the 1987 CWS does not use this convention.

Identification of Intermodal and Double-Stack Traffic. The identification of intermodal traffic on the CWS is quite reliable using the TOFC/COFC plan field discussed above. This field has been thoroughly edited and cross-checked by the AAR and ALK. Using the trailer/container count field, discussed above, the maps and tables of current intermodal traffic in Section 2 were prepared.

The identification of current double stack traffic as a subset of the reliably known intermodal traffic is not clear cut or reliable. AAR cartype codes QQXX and Q9XX are reserved for intermodal flat cars designed to carry stacked containers. Although railroads are required to report the actual car initial and number which was used to transport intermodal equipment, there are two problems with the use of the cartype field in identifying double-stack traffic.

First, if a CWS record covers the movement of more than one car, only the first car's initial and number are reported. Since rail waybills tend to cover the movement of similar goods, this is not a serious problem, as equipment following the first car is likely to be similar to the reported car.

Second, many railroads simply do not record what actual cars they are hauling. Since the actual waybill covers the movement of the trailers or containers, and not the cars on which this equipment was loaded, the waybill and revenue settlement processes do not capture the actual rail car used. To help alleviate this problem, the ICC has given permission to railroads to report a representative car initial and number. In the case of double-stack intermodal movements of American President containers by the Union Pacific Railroad and its subsidiaries, the car initial and number used is TTX 000105, which is listed as a P530 intermodal flat for training purposes only. This car was identified in movements covering 57,200 containers on the 1987 CWS. It is obvious that UP is not using a training car for revenue moves, and is certainly not using the same car hundreds of times per year. It is clear from the trailer/container initial for these moves, which is uniformly APLU, and from the origin and destination of these moves, that these are dedicated double stack movements for American President to and from the west coast. These APLU movements were included in the double-stack statistics and maps. The remaining question of how many other similar movements were missed which are also likely double-stack services by rail is unanswerable from the Carload Waybill Sample.

Carload Traffic Data. The study team developed criteria to choose a subset of the boxcar traffic represented in the Carload Waybill Sample as part of the

potential domestic container market. The rules described below seek to identify the potential market, but do not address the issues of market penetration.

The first step in selecting the carload traffic of interest is to define "boxcar" traffic. In contemplating the diversion of "merchandise" traffic from general-purpose boxcars and refrigerator cars to general-purpose dry and refrigerator containers, we want to eliminate bulk loading, exceptionally heavy or dirty commodities, and some traffic carried in specialized boxcars. The following UMLER/AAR cartype code restrictions achieve that purpose.

Cartype A _ _ _ , Equipped Boxcars
1st Numeric: include 1-4 (under 59')
exclude 5-8 (over 59')
2nd Numeric: exclude 0-1 (specialized)
include 2-4 (general)
exclude 5 (specialized
3rd Numeric: include all (door sizes)

Cartype B _ _ _ , Unequipped Boxcars
1st Numeric: include 1-4 (under 59')
exclude 5-8 (over 59')
2nd Numeric: include all
3rd Numeric: include all

Cartype R _ _ _ , Refrigerator Cars
1st Numeric: include 1-4 (under 59')
exclude 5-8 (over 59')
2nd Numeric: include all
3rd Numeric: include all

These restrictions eliminate oversized and specialized equipment, giving us more confidence that the remaining traffic will fit in containers.

Within the cartypes defined above, we can accept almost all commodities, assuming that commodities travelling in general purpose boxcars are suited to that

type of handling. Even commodities such as petroleum products or chemicals travel in boxcars in packaged form. On the other hand, some products such as large steel shapes or concrete blocks are not well suited to movement by container, and would be at best secondary candidates for domestic containerization. Accordingly, we have examined the entire Standard Transportation Commodity Code, and adopted the following choices.

01 - Farm Products
include: 0112 - Cotton
01191 - Fodder or Hay
01194 - Sweet potatoes
01195 - Other potatoes
012 - Fresh fruits
013 - Fresh vegetables
exclude: all others, since bulk grains or feeds would be poor candidates.

08 - Forest Products: exclude, since primary barks, logs and gums would be poor candidates

09 - Fresh Fish: exclude

10 - Metallic Ores: exclude

11 - Coal: exclude

13 - Crude Petroleum, Natural Gas: exclude

14 - Non-metallic Minerals: exclude

19 - Ordinance or Accessories: exclude

20 - Food or Kindred Products
include: 2012 - Meat, frozen
2013 - Meat products
except: 20139, Meat products, NEC; a dirty commodity
2023 - Condensed or evaporated milk
2025 - Cheese or special dairy products
203 - Canned foods
20431 - Cooked cereals
2047 - Pet food
205 - Bakery products
206 - Sugar

207 - Confectionary or related products
208 - Beverages
209 - Misc. food preparations

exclude: all others, mostly bulk or highly perishable products

21 - Tobacco Products: include

22 - Textile Mill Products: include

24 - Lumber or Wood Products

include: 24214 - Hardwood stock or parts
24215 - Hardwood flooring
24219 - Lumber or dimension stock, NEC.
2429 - Misc. mill products
243 - Millwork, plywood, veneer

exclude: all others. Most dimension lumber, as opposed to high-value specialties, is more likely to stay in boxcars or shift to center-beam cars.

25 - Furniture or Fixtures: include

26 - Paper, Pulp, or Allied Products

include: 262 - Paper except: 26211 - Newsprint, which requires special handling
263 - Fibreboard, paperboard
264 - Paper products
265 - Containers or boxes
266 - Building paper or building board

exclude: all others, such as pulp

27 - Printed Matter: include

28 - Industrial Chemicals: include, under the assumption that chemicals packaged to ship in boxcars can also travel in containers.

29 - Petroleum or Coal Products: include, under the same assumption.

30 - Rubber or Misc. Plastic Products: include

31 - Leather or Leather Products: include

32 - Clay, Concrete, Glass, or Stone Products

include: 322 - Glass or Glassware
326 - Misc. Pottery

329 - Abrasives, asbestos, or misc. non-metallic mineral products

exclude: all others, such as flat glass, brick, or cement blocks.

33 - Primary Metal Products: exclude, since these are heavy-loading commodities and poor candidates for regular containerization.

34 - Fabricated Metal Products: include.

35 - Machinery: include, assuming that most such products that are shipped in boxcars, rather than on flat cars, can be containerized.

36 - Electrical Machinery, Equipment, or Supplies: include, on the same assumption, and knowing that Maytag regularly ships appliances in containers.

37 - Transportation Equipment:

include: 37112 - Set-up (assembled) autos
37115 - Knocked-down (disassembled or unassembled) autos
3712 - Auto bodies
3714 - Auto parts and accessories
375 - Motorcycles, bicycles, and parts
379 - Misc. transportation equipment
38 - Instruments, Photographic goods, etc.: include

exclude: all others.

39 - Misc. Products of Manufacture: include

40 - Waste or Scrap: include, under the same packaging and fit assumptions made in other categories. Containers regularly carry waste and scrap as exports.

41 - Misc. Freight Shipments: include

42 - Containers, Carriers, or Devices, Shipping, Returned Empty: include, since we have by equipment choice eliminated marine containers on flatcars.

43 - Mail or Express: include

44 - Freight Forwarder: include

45 - Shipper Association: include

46 - Misc. Mixed Shipments: include

47 - Small Packaged Freight: include

Although exceptions can be found to every rule, the intent is to capture the vast majority of the likely traffic and to reject the vast majority of the unlikely traffic, so small exceptions are marginally relevant.

Commodity Densities. This section sets forth a basis for converting boxcar tonnage to container equivalents. The commodity densities shown in pounds per cubic foot in Table I-1 were derived from Manalytics' foreign trade commodity density files. These in turn were derived from historic foreign trade and port data, and were most recently updated in October, 1985. Export densities were used throughout to correspond to U.S. loading practices.

The commodity groupings in the foreign trade data do not correspond precisely to the STCC categories used for rail data. Where the match was not precise, the available foreign trade categories were reviewed and picked either a typical commodity or a judgmental average of the range. Attempting further precision would be of little use, since almost all of these commodities are weight-limited, and since there is little experience with actual domestic container movements of boxcar traffic.

It was assumed that all of these commodities would be carried in dry containers or self-contained refrigerator containers 48 feet long, 102 inches wide, and 9 feet 6 inches high. These are the dimensions of the 48-foot containers introduced by American President Intermodal for domestic use, and now being acquired by leasing companies. A dry van of this size has a tare weight of about 8100 pounds and a capacity of 3450 cubic feet. A notional self-contained (i.e. with generator set) refrigerator container of this size would weigh about 13,100 pounds (allowing 5000 pounds for genset and refrigeration equipment -- typical of Canadian self-contained reefers) and would have a capacity of about 2950 cubic feet (losing about 500 cubic feet to refrigeration equipment).

Table I-1

BOXCAR-CONTAINER CONVERSIONS
FOR SELECTED COMMODITIES

DRY COMMODITIES

STCC	Name	Lbs/ Cu. Ft.	Limit: Wt/Cube	Short Tons/ Container
0112	Cotton	30	wt	24
01191	Fodder/Hay	25	wt	24
2013	Meat Products	31	wt	24
2023	Condense Milk	37	wt	24
203	Canned Foods	39	wt	24
20431	Cooked Cereals	33	wt	24
2047	Pet Food	31	wt	24
205	Bakery Products	21	wt	24
206	Sugar	45	wt	24
207	Confectionary	25	wt	24
208	Beverages	39	wt	24
209	Misc. Food	30	wt	24
21	Tobacco	17	cube	23.5
22	Textile Mill Prods.	23	wt	24
24214	Hardwood Stock/Pts.	35	wt	24
24215	Hardwood Flooring	35	wt	24
24219	Lumber/NEC	32	wt	24
2429	Misc. Mill Products	32	wt	24
243	Mill Wk. Plywd, Veneer	37	wt	24
25	Furniture	13	cube	17.9
262	Paper	31	wt	24
263	Fibre/Paper Board	30	wt	24
264	Paper Products	29	wt	24
265	Containers/Boxes	25	wt	24
266	Bldg. Paper/Board	29	wt	24
27	Printed Matter	31	wt	24
28	Indust. Chemicals	45	wt	24
29	Petrol/Coal Products	35	wt	24
30	Rubber/Misc. Plastic	13	cube	17.9

Table I-1 (Cont'd.)

BOXCAR-CONTAINER CONVERSIONS
FOR SELECTED COMMODITIES

DRY COMMODITIES

STCC	Name	Lbs/ Cu.Ft.	Limit: Wt/Cube	Short Tons/ Container
31	Leather & Products	25	wt	24
322	Glass/Ware	16	cube	22.1
326	Misc. Pottery	13	cube	17.9
329	Abrasives/Asbestos	31	wt	24
34	Fabr. Metal Prods.	25	wt	24
35	Machinery	25	wt	24
36	Elect. Machinery	15	cube	20.7
37	Trans. Equipment	25	wt	24
38	Instruments	15	cube	20.7
39	Misc. Prods. Manf.	21	wt	24
40	Waste/Scrap	29	wt	24
41	Misc. Freight Shpmts.	21	wt	24
42	Empty Containers	14	cube	19.3
43	Mail/Express	21	wt	24
44	Freight Forwarder	21	wt	24
45	Shipper Assoc.	21	wt	24
46	Misc. Mixed Shpmts.	21	wt	24
47	Small Packaged Freight	21	wt	24

REFRIGERATED COMMODITIES

STCC	Name	Lbs/ Cu.Ft.	Limit: Wt/Cube	Short Tons/ Container
01194	Sweet Potatoes	25	wt	21.5
01195	Other Potatoes	25	wt	21.5
012	Fresh Fruits	27	wt	21.5
013	Fresh Vegetables	23	wt	21.5
2012	Meat, Frozen	33	wt	21.5
2025	Cheese, Dairy Prods.	39	wt	21.5

Source: Manalytics' proprietary density data.

Actual loading of such containers is further restricted by rail and highway weight limits and by imperfect packing or stowage. American President Intermodal currently limits loading in 48-foot containers to 48,000 pounds to allow for a variety of chassis weights and to meet highway limits, which are more stringent than rail limits. The corresponding reefer limit would be 43,000 pounds. Regarding utilization of cubic capacity, Manalytics' historic trade data show an average container cubic utilization of 80 percent, meaning that, on average, 20 percent of the cubic capacity is either used for dunnage or bracing, or is wasted due to an inexact fit of commodity packages or pallets. Thus, the practical loading limits are as follows:

Container	Weight Capacity	Cubic Capacity
48-foot dry	48,000 lbs.	2760 cu ft.
48-foot reefer	43,000 lbs.	2360 cu ft.

Breakeven densities are 17.4 lbs/cu ft. for dry containers and 18.2 lbs/cu ft. for reefers. Denser commodities will weigh-out, reaching the weight limit before filling the cubic capacity. Less-dense commodities will cube-out, filling the cubic capacity before reaching the weight limit.

A review of Table I-1 shows that the results are intuitively reasonable. Only a few commodities are cube-limited: tobacco, furniture, rubber and plastic goods, glass, pottery, electrical machinery (appliances), instruments, and empty containers. This list is fairly consistent with known shipping and packing practices, and with railroad acquisition of extra-large boxcars for some of these commodities. Moreover, the 48-foot container was developed in response to the perceived inadequate cubic capacity of 40-foot containers for domestic use.

Choosing a large domestic container with a higher tare produces a liberal estimate of container equivalents for weight-limited commodities. Were highway weight limits to increase, the 48,000 lb. weight limit would be low, and the estimate of container equivalents would again be high. Thus, the estimate of container equivalents for boxcar commodities tends toward the upper bound.

RAIL TRAFFIC FLOWS

Identifiable Double-Stack Flows. Figure I-2 shows the 1987 double-stack traffic flows that could be identified from the Carload Waybill Sample. As explained above, an unknown portion of the other container traffic also moves on double-stack cars. Nonetheless, the movement pattern shown in Figure I-2 closely matches the major double-stack operations described later. The three major western rail corridors each handled substantial double-stack volumes. The Burlington Northern handled double-stack traffic between Seattle/Tacoma and Chicago, and to a lesser extent between Seattle/Tacoma and Kansas City or Memphis. Union Pacific's double-stack traffic from the Pacific Northwest moves through the Central Corridor to Chicago via CNW.

In 1987, only UP regularly carried double-stack traffic through the Central Corridor, and only a small portion moved to or from Northern California. All three carriers -- UP, SP and Santa Fe -- moved double-stack traffic to and from Southern California. UP's traffic moved through the Central Corridor. The relatively small volume on Santa Fe was split between Chicago and Texas destinations. Southern Pacific's traffic was likewise split, at El Paso, between Kansas City or St. Louis (with BN or SOO connections to Chicago) on one hand, and Dallas, Houston, or New Orleans (with NS connections to Atlanta) on the other. The major eastern corridor was the Conrail route between Chicago and New York. Smaller volumes were spread out through the Southeast.

The live widths shown in Figure I-2, although not exact, indicate the magnitude of the balance issue. UP's Central Corridor route shows a serious import in eastbound imbalance -- 128,000 units eastbound but only 38,000 units westbound. The Santa Fe and SP Southern Corridor routes were relatively well balanced. Even allowing for deficiencies in the data, these figures indicate that directional imbalance remains a serious problem.

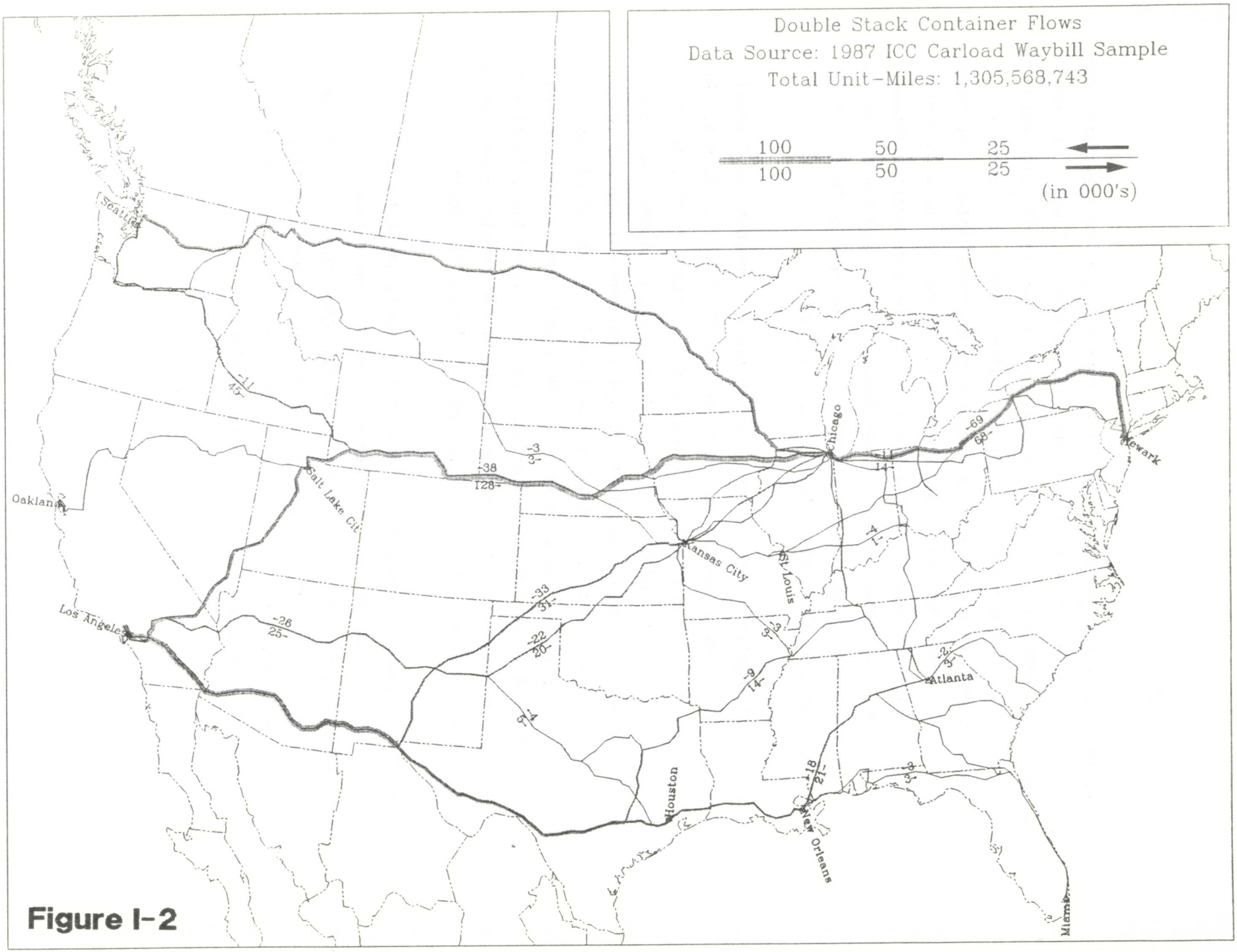

Double Stack Container Flows
Data Source: 1987 ICC Carload Waybill Sample
Total Unit-Miles: 1,305,568,743
100
50
25
100
50
25
(in 000's)
Seattle
Oakland
Los Angeles
Salt Lake City
Kansas City
Chicago
St Louis
Atlanta
Houston
New Orleans
Newark
Miami
11
45
3
38
128
69
68
4
1
33
51
26
25
22
20
9
14
4
5
18
21
3
3
2
3

Figure I-2

COFC Flows. Figure I-3 combines all container flows, including those identified as double-stacks in Figure I-3. It is immediately apparent, as expected, that the overall flow pattern closely resembles the double-stack pattern. Aside from the higher unit counts on all routes, the major difference is the presence of signifant COFC flows in secondary markets where, as of 1987, double-stack services had not penetrated. Double-stack services were extended to several of these markets in 1988. Overall, 42 percent of the unit-miles in flows shown in Figure I-3 were identified as double-stacks in Figure I-2.

TOFC Flows. The pattern of trailer flows shown in Figure I-4 is markedly different from the pattern of container flows. Most obvious are the much greater participation of Santa Fe in TOFC traffic, and the heavy volume on Conrail. In fact, Figure I-4 vividly portrays the long-standing cooperation of Santa Fe and Conrail on east-west transcontinental TOFC movements.

A second major difference is the much greater north-south traffic, particularly in the Midwest and Southeast. Routes such as Chicago-Dallas (which received double-stack service in December of 1988) and Atlanta-Detroit carried far more trailers than containers in 1987.

A comparison of unit counts and unit-mile totals in Figures I-3 and I-4 suggests that trailers have a different distribution of haul lengths than containers. The total number of TOFC unit miles (3,599,184,927) is somewhat greater than the COFC unit miles (3,135,297,041). With the exception of Santa Fe, however, the COFC unit counts on long western routes are higher than the trailer counts. (The length of haul issue will be addressed in Task II.)

Total Intermodal Flows. Figure I-5 combines the TOFC and COFC data to illustrate the overall pattern of rail intermodal movement. As expejcted, current (1987) intermodal traffic is concentrated on long hauls between major population centers and hubs.

The role of Chicago as a hub is striking. Chicago functions as both a hub for connecting truck service to and from points in the Midwest, and as the largest interchange point between railroads. A significant number of intermodal move-

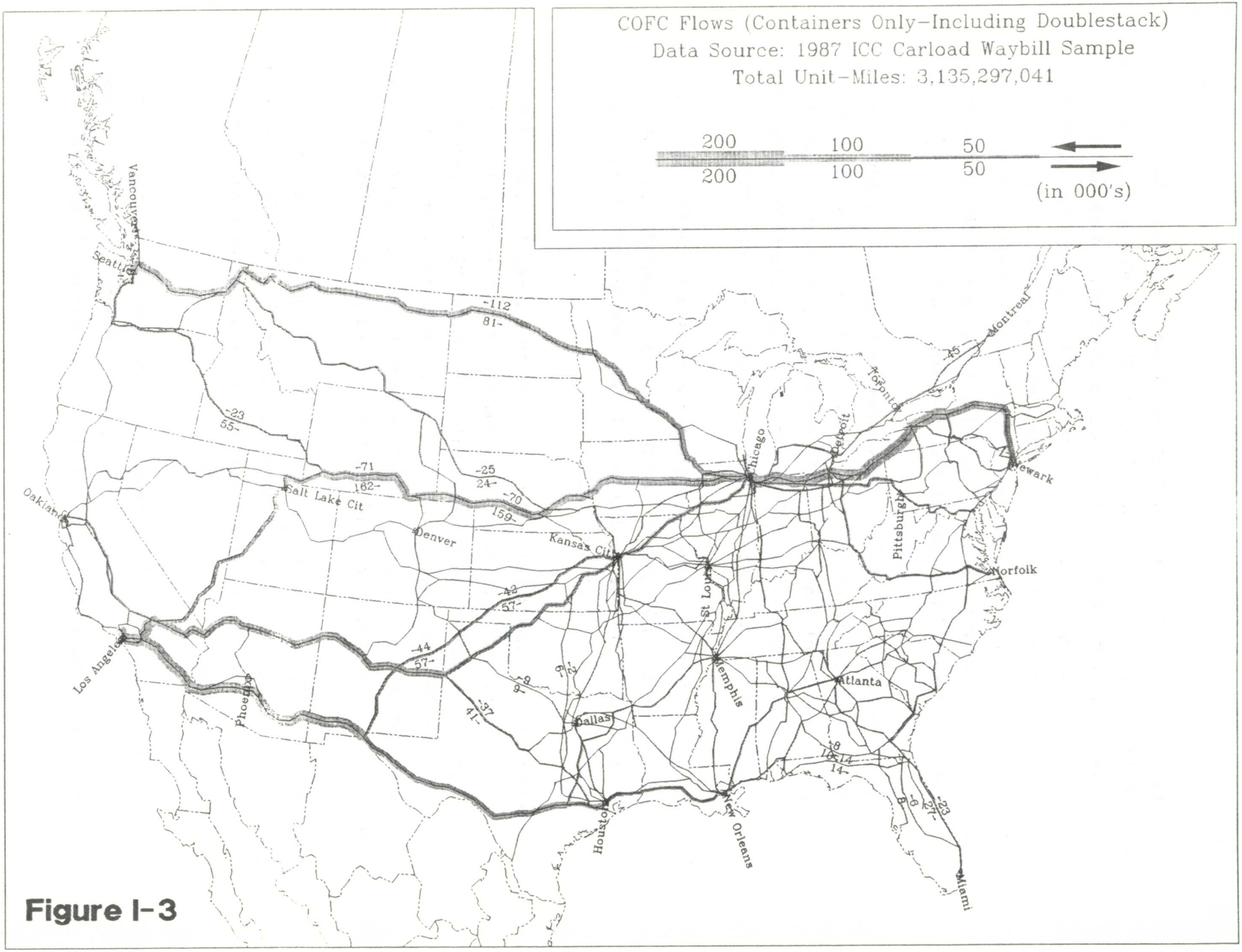

COFC Flows (Containers Only–Including Doublestack)
Data Source: 1987 ICC Carload Waybill Sample
Total Unit–Miles: 3,135,297,041
200
100
50
200
100
50
(in 000's)
Vancouver
Seattle
Oakland
Los Angeles
Phoenix
Salt Lake Cit
Denver
Kansas Cit
Chicago
Toronto
Detroit
Montreal
Newark
Pittsburgh
Norfolk
St Louis
Memphis
Atlanta
Dallas
Houston
New Orleans
Miami
-112
81-
-23
55-
-71
162-
-25
24-
-70
159-
-42
57-
-44
57-
-37
41-
-45
-9
-6
-8
-14
-27
-23

Figure I-3

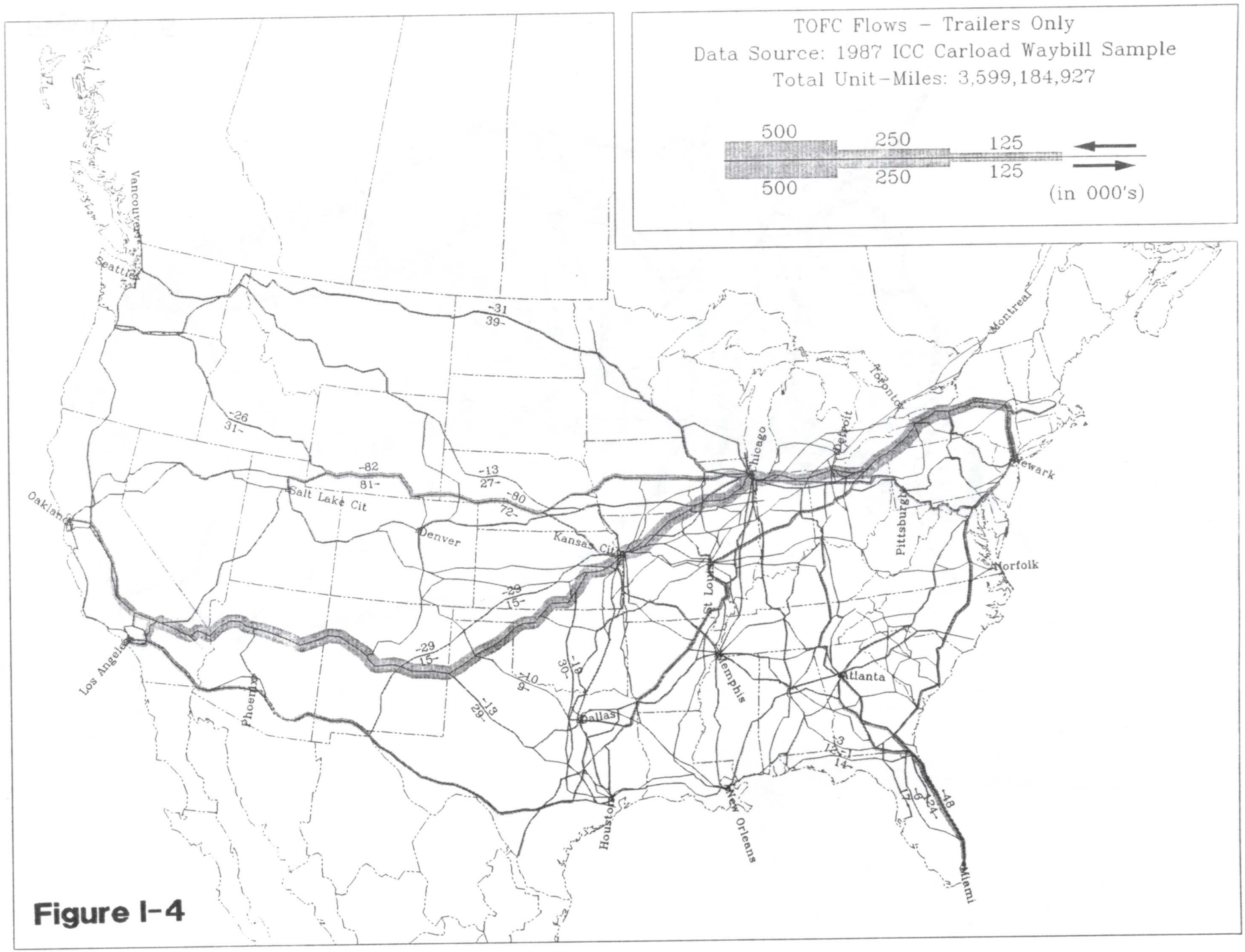

TOFC Flows – Trailers Only
Data Source: 1987 ICC Carload Waybill Sample
Total Unit-Miles: 3,599,184,927
500
250
125
125
250
500
(in 000's)
Vancouver
Seattle
Montreal
Toronto
Detroit
Chicago
Newark
Pittsburgh
Norfolk
Salt Lake Cit
Oakland
Denver
Kansas Cit
St Louis
Memphis
Atlanta
Los Angeles
Phoenix
Dallas
Houston
New Orleans
Miami
-31
39-
-26
31-
-82
81-
-13
27-
-80
72-
-29
15-
-29
15-
-19
30-
-10
9-
-13
29-
3
14
18
24
48

Figure I-4

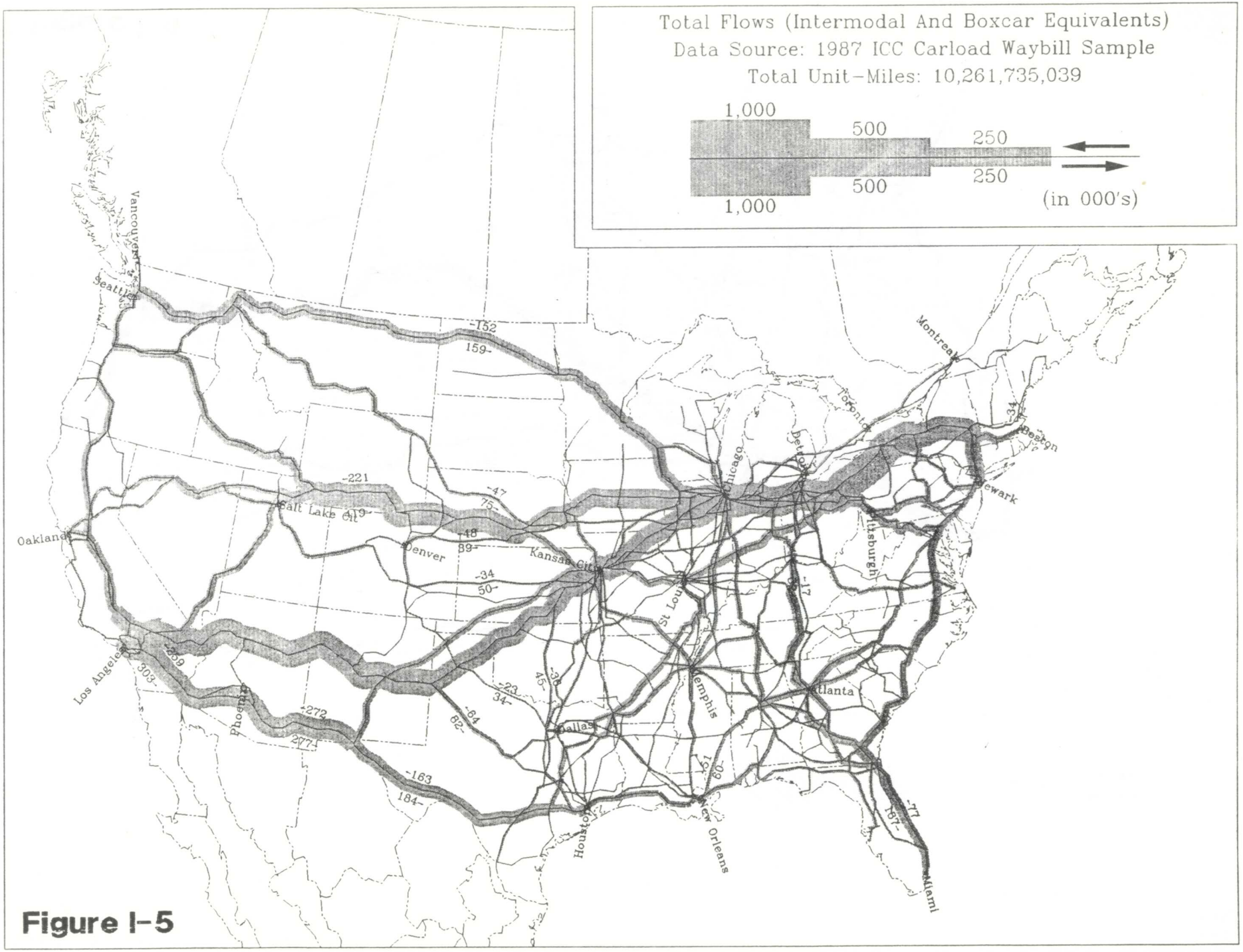

Total Flows (Intermodal And Boxcar Equivalents)
Data Source: 1987 ICC Carload Waybill Sample
Total Unit-Miles: 10,261,735,039
1,000
500
250
250
500
1,000
(in 000's)
Vancouver
Seattle
Oakland
Salt Lake City
Denver
Kansas City
Los Angeles
Phoenix
Dallas
Houston
Memphis
New Orleans
Atlanta
Miami
Chicago
Detroit
Toronto
Montreal
Pittsburgh
Newark
Boston
-152
159
-221
219
-47
75
-48
89
-34
50
-269
303
-272
277
-64
82
-23
34
-36
45
-163
184
-80
-17
-77
167

Figure I-5

ments are still interchanged over the road ("rubber-tired"), and such movements generate two waybills rather than one. Some of the movements apparently originating and terminating in Chicago are therefore actually through movements interchanged there. This affects the total unit count, but not the route volume or unit-mile estimates.

Figure I-5 places the eastern and western railroads in much different postures. In the East, with the exception of Conrail's major route, intermodal volumes are diffused over the network. In the West, intermodal volumes are concentrated on the transcontinental mainlines, giving the appearance of a tree-like structure. Overall, the national pattern is hub-and-spoke, with the western spokes being much longer.

Selected Boxcar Flows. The commodity-by-commodity selection process described earlier results in the boxcar flows illustrated in Figure I-6. The unit-mile total in 1987 was 3,527,253,072, very close to the TOFC total. Figure I-6 shows, however, that the boxcar traffic flows are much more diffuse, particularly in the lower Midwest and Southeast. A comparison of the ten largest intermodal and boxcar flows is revealing:

Intermodal Flows	Boxcar Flows
Los Angeles - Chicago	Eugene - Los Angeles
Chicago - Los Angeles	Portland - Los Angeles
Chicago - New York	Houston - Houston
New York - Chicago	Portland - Chicago
Seattle - Chicago	Tampa - New York
Chicago - Seattle	Detroit - New York
Chicago - Philadelphia	Detroit - Los Angeles
Jacksonville - Miami	Detroit - Boston
Chicago - Oakland	Miami - Savannah
Chicago - Omaha	Detroit - Philadelphia

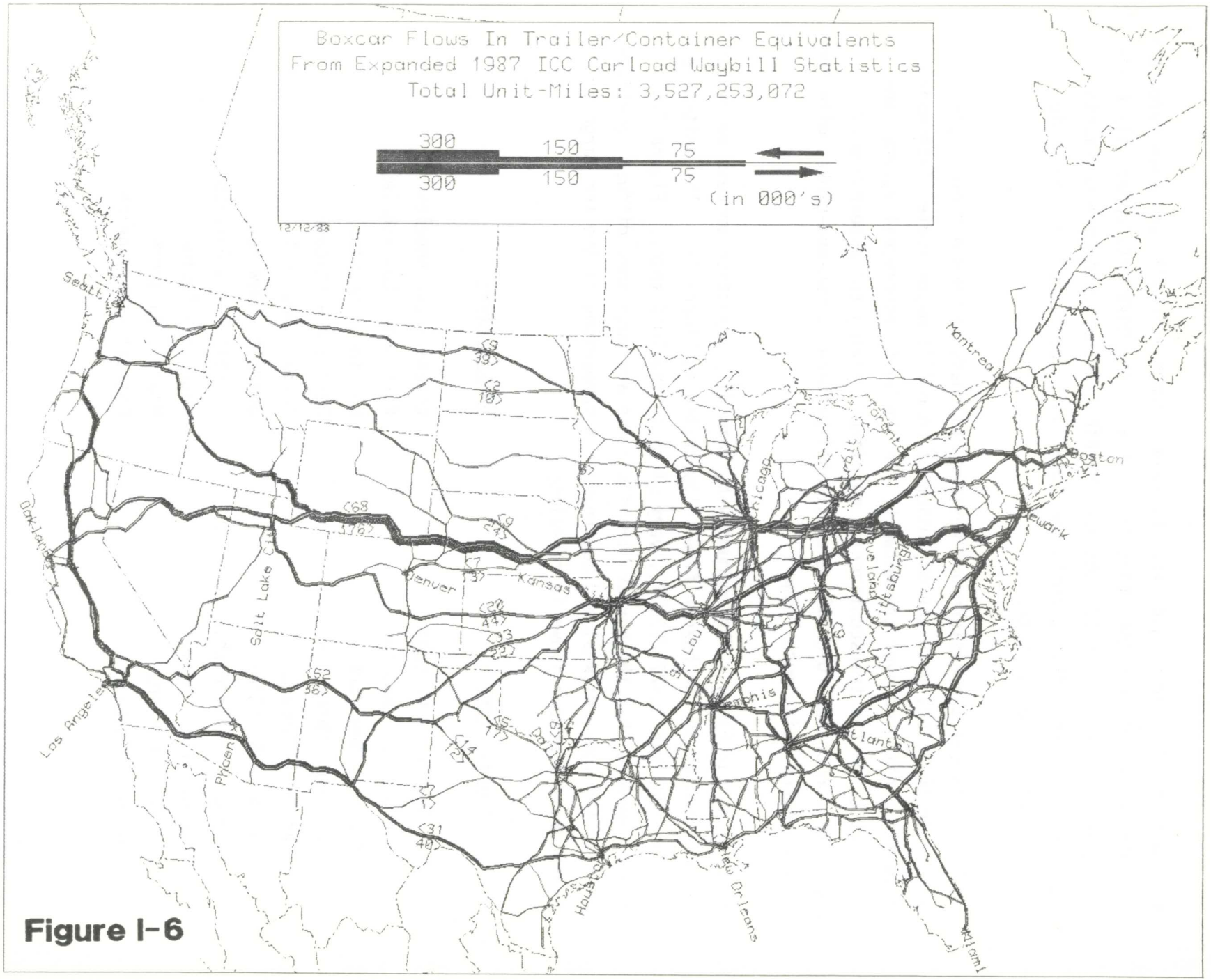

Boxcar Flows In Trailer/Container Equivalents
From Expanded 1987 ICC Carload Waybill Statistics
Total Unit-Miles: 3,527,253,072
300
150
75
300
150
75
(in 000's)
12/12/88
Seattle
Montreal
Boston
Newark
Chicago
Pittsburgh
Denver
Kansas
Salt Lake
Oakland
Los Angeles
Phoenix
St Lou
Memphis
Atlanta
Dallas
Houston
New Orleans
Miami

Figure I-6

The boxcar flows show the importance of lumber, paper, and auto parts, which move in different corridors than existing intermodal traffic.

Combined Intermodal and Boxcar Traffic. All of the rail traffic selected for analysis in this study is shown in Figure I-7. This figure can be most succinctly described as a U.S. rail map with long-haul intermodal flows highlighted and coal and grain flows deleted. Major origin and destination hubs that stand out include Seattle, Portland, Oakland, Los Angeles, Kansas City, St. Louis, Chicago, Dallas, Houston, New Orleans, Memphis, Detroit, Atlanta, Miami, Philadelphia, New York, and Boston. All of the largest rail systems are well-represented but some of the regionals such as SOO, KCS, ICG, and the Guilford System are not. Due to its heavy Jacksonville->Miami intermodal traffic, the Florida East Coast is quite prominent.

The 10 billion unit-miles shown in Figure I-7 are evenly divided:

	Unit Miles
Containers	3.1 billion
Trailers	3.6 billion
Boxcars	3.5 billion

It is clear, however, that not all the boxcar traffic will be relevant.

DETAILED RAIL TRAFFIC DATA

Rail traffic flows between BEA's are given for each category in Appendices I-1 through I-6.

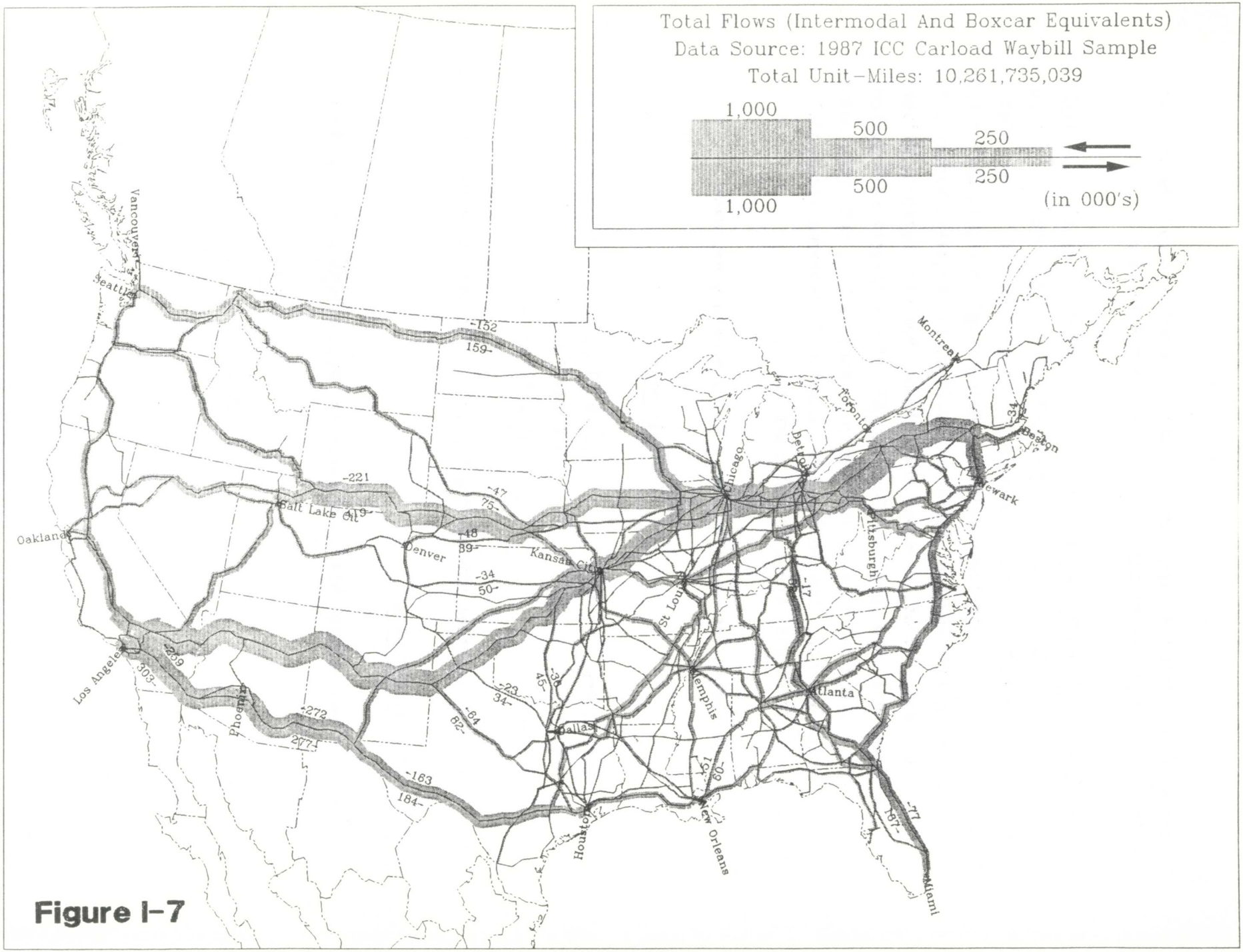

Total Flows (Intermodal And Boxcar Equivalents)
Data Source: 1987 ICC Carload Waybill Sample
Total Unit-Miles: 10,261,735,039
1,000
500
250
250
500
1,000
(in 000's)
Vancouver
Seattle
Oakland
Los Angeles
Phoenix
Salt Lake City
Denver
Kansas City
Chicago
Detroit
Toronto
Montreal
Boston
Newark
Pittsburgh
St Louis
Memphis
Atlanta
Dallas
Houston
New Orleans
Miami
152
159
221
119
47
75
48
89
34
50
259
303
272
207
163
184
23
34
45
36
84
82
17
20
34
77
187

Figure I-7

III. TRUCK TRAFFIC FLOWS

TRANSCONTINENTAL TRUCK TRAFFIC

For the initial phase of this study, the study team identified that body of truck traffic for which rail intermodal services -- trailer and container -- are presently competing with some sign of success. The rail data in Figure I-5 show quite clearly that the greatest strength of intermodal service is in transcontinental east-west traffic.

From the NMTDB, TRAM selected the truck traffic for which these major intermodal services compete. As shown in Figure I-8, this includes dry van and refrigerated (reefer) movements to and from the two westernmost regions: California and Oregon/Washington. To identify such traffic, passing counts and survey data was used from three sites: Rock Springs, Wyoming (Interstate 80); Eloy, Arizona (Interstate 10); and Gallup, New Mexico (Interstate 40). Relevant traffic on the northernmost route (Interstate 90 and 904) was investigated but found to be negligible. To account for north-south traffic between California and Oregon/Washington, passing count and interview information from Redding, California (Interstate 5) was also used.

Initial data compilation was restricted to dry vans of truckload carriers on the grounds that container services do not presently compete for more specialized motor carrier freight. Upon review of the data and further investigation, it was determined that refrigerated (reefer) movements should also be considered because:

- o although existing refrigerated container service by rail is minimal, technical and commercial approaches are being actively pursued; and

- o from NMTDB interview data, it appears that about 50 percent of the westbound movements (commonly considered to be backhauls) carry non-temperature-sensitive freight.

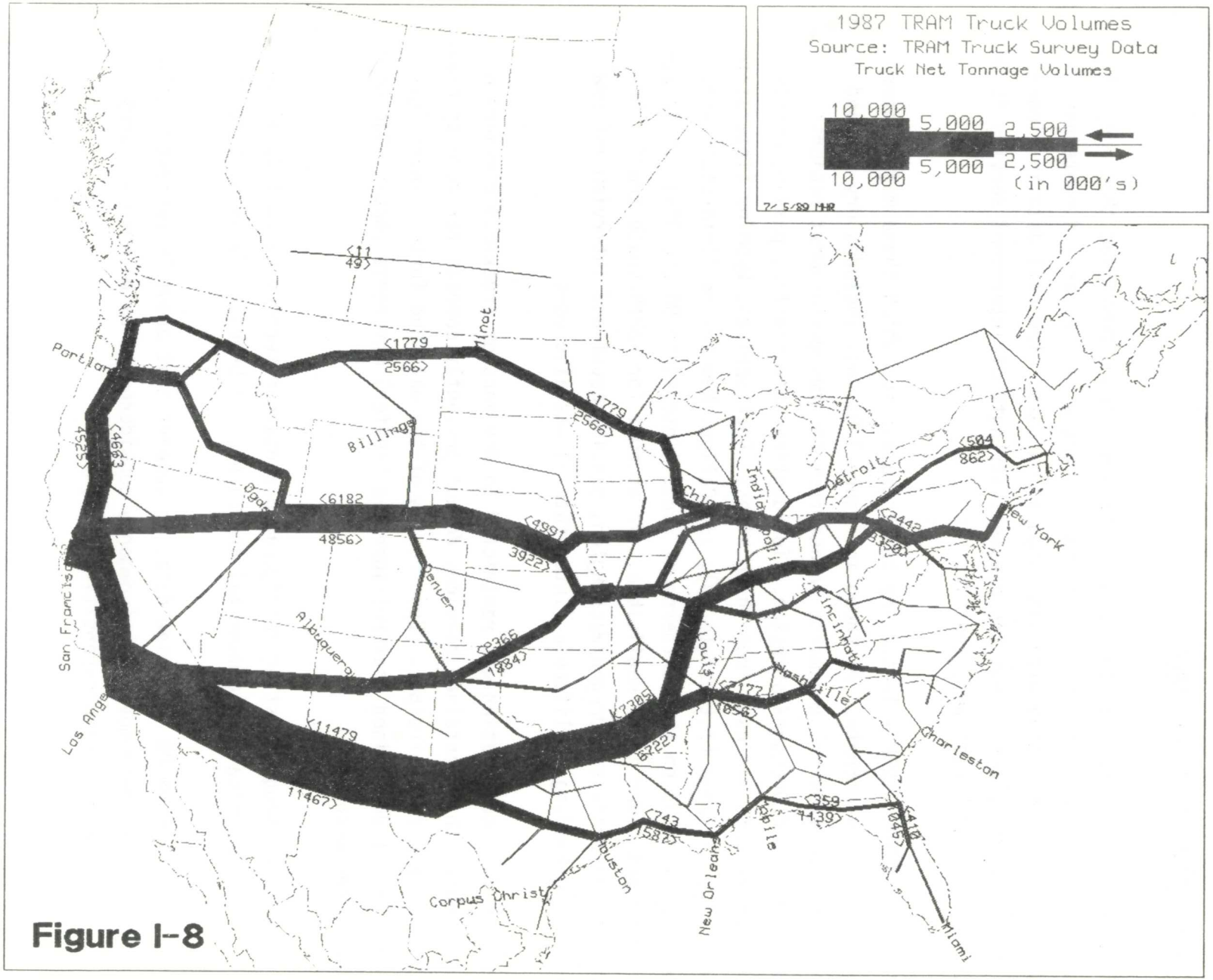

1987 TRAM Truck Volumes
Source: TRAM Truck Survey Data
Truck Net Tonnage Volumes
10,000
5,000
2,500
2,500
5,000
10,000
(in 000's)
Portland
Billings
Minot
Denver
Albuquerque
San Francisco
Los Angeles
Chicago
Indianapolis
Detroit
New York
Cincinnati
Louisville
Nashville
Charleston
Houston
Corpus Christi
New Orleans
Miami
<11
49>
<1779
2566>
<1779
2566>
<6182
4856>
<4991
3922>
<2365
1884>
<11479
11467>
<7385
6222>
<2177
1656>
<2442
1350>
<504
862>
<359
1439>
<743
582>
<410
445>

Figure I-8

Accordingly, passing counts and interviews for reefers from the same sites (Rock Springs, Eloy, Gallup and Redding) were compiled.

California Truck Traffic. Table I-2 shows annualized estimated dry van and reefer truck flows to and from California through each of the four sites. As the tables show, the majority of transcontinental California truck traffic moves over the southern routes, Interstate 10 and Interstate 40. This concentration of truck traffic on the southern routes matches the concentation of rail intermodal traffic on the Southern Corridor. Both traffic concentrations are attributable to the large Southern California population; the large amount of foreign trade through Southern California ports; and the massive agricultural production of the Southern San Joaquin Valley, Kern County, and Imperial Valley growing areas. The role of agriculatural commodities is especially apparent in the greater number of refrigerated rather than dry van trucks. Even within the dry van category, agricultural and food products account for roughly 20 percent of the eastbound loads.

Oregon/Washington Truck Traffic. Table I-2 also shows Oregon/Washington dry van and reefer truck traffic totals through Rock Springs and Redding. As expected, the totals are much smaller than those for California. For Oregon and Washington dry vans exceed reefers.

Balance. The eastbound and westbound (or northbound and southbound) truck traffic totals are very closely balanced, especially compared to rail intermodal traffic. For all practical purposes, truckers do not make empty transcontinental trips.

TRUCK COMMODITIES

Dry Van Commodities. Table I-3 shows the distribution of dry van commodities for California, and Table I-4 for Oregon/Washington. The California commodity mix varies widely by lane, due to differences between eastern origin and destination markets, and to differences between Northern and Southern California. Field crops and food are prominent in all lanes for both regions, but especially eastbound. The Rock Springs and Redding flows include large amounts of

Table I-2

RELEVANT TRANSCONTINENTAL TRUCK TRAFFIC
ANNUAL VOLUME ESTIMATES

TO AND FROM CALIFORNIA:

Via	East/Southbound	West/Northbound	Total
DRY VANS			
Rock Springs	86,472	78,960	165,432
Eloy	212,748	189,396	402,144
Gallup	209,016	286,299	495,315
Redding	173,364	201,156	374,520
Subtotal:	681,600	755,811	1,437,411
REFRIGERATED VANS			
Rock Springs	76,308	95,736	172,044
Eloy	277,704	277,500	555,204
Gallup	197,256	205,716	402,972
Redding	114,420	155,844	270,264
Subtotal:	665,688	734,796	1,400,484
CALIFORNIA TOTAL:	1,347,288	1,490,607	2,837,895

TO AND FROM OREGON AND WASHINGTON:

DRY VANS			
Rock Springs	67,080	79,128	146,208
REFRIGERATED VANS			
Rock Springs	91,572	68,316	159,888
Subtotal:	158,652	147,444	306,096
WEST COAST TOTAL	1,505,940	1,638,051	3,143,991

Source: NMTDB

Table I-3

CALIFORNIA DRY VAN
TRUCK COMMODITIES*

Monthly Counts

Via	East/Northbound		%	West/Southbound		%
Rock Springs	01 - Field Crops	660	9	20 - Foods	1056	16
	20 - Foods	2685	37	26 - Paper	852	13
	26 - Paper	470	7	28 - Chemicals	955	15
	28 - Chemicals	470	7	36 - Electrical	579	9
	34 - Fab. Metal	520	7	47 - Small Frt.	613	9
	47 - Small Frt.	518	7			
	All Other	1883	26	All Other	2525	38
	Total	7206	100	Total	6580	100
Eloy Springs	01 - Field Crops	972	5	20 - Foods	1123	7
	20 - Foods	2824	16	22 - Textiles	936	6
	25 - Furniture	1389	8	25 - Furniture	1311	8
	28 - Chemicals	1389	8	26 - Paper	999	7
	34 - Fab. Metal	1111	6	28 - Chemicals	2372	15
	35 - Machinery	926	5	30 - Rubber/Plastics	1124	7
	36 - Electrical	1759	10	36 - Electrical	1249	8
	47 - Small Frt.	1991	11	47 - Small Frt.	1686	11
	All Other	5368	30	All Other	4993	32
	Total	17,729	100	Total	15,793	100

*Includes commodities accounting for 5% or more of the total.

Source: NMTDB

Table I-3 - Continued

CALIFORNIA DRY VAN
TRUCK COMMODITIES*

Monthly Counts

Via	East/Northbound			West/Southbound		
			%			%
Gallup	20 - Foods	3350	19	20 - Foods	1039	6
	25 - Furniture	1391	8	25 - Furniture	1040	6
	28 - Chemicals	979	6	26 - Paper	1960	11
	36 - Electrical	1443	8	28 - Chemicals	1760	10
	37 - Auto Parts	1186	7	30 - Rubber/Plastics	1040	6
	39 - Misc. Mfg.	1083	6	34 - Fab. Metal	920	5
	47 - Small Frt.	2009	12	35 - Machinery	1400	8
	All Other	5977	34	36 - Electrical	1799	10
				47 - Small Frt.	1200	7
				All Other	5785	32
	Total	17,418	100	Total	17,943	100
Redding	20 - Foods	4795	29	01 - Field Crops	720	5
	25 - Furniture	849	5	20 - Foods	1862	13
	26 - Paper	2080	12	24 - Lumber	1027	7
	28 - Chemicals	1528	9	26 - Paper	5490	38
	47 - Small Frt.	1697	10	All Other	5298	37
	All Other	5814	35			
	Total	16,763	100	Total	14,447	100

*Includes commodities accounting for 5% or more of the total.

Source: NMTDB

Table I-4

OREGON/WASHINGTON DRY VAN
TRUCK COMMODITIES*

Monthly Counts

Via	Eastbound			West/Southbound		
			%			%
Rock Springs	01 - Field Crops	848	13	20 - Foods	681	12
	20 - Foods	942	14	26 - Paper	681	12
	24 - Lumber	1366	21	28 - Chemicals	681	12
	26 - Paper	800	12	34 - Fab. Metal	340	16
	36 - Electrical	564	9	36 - Electrical	579	10
	37 - Auto Parts	329	5	47 - Small Frt.	409	7
	47 - Small Frt.	376	6	All Other	2219	40
	All Other	1369	21			
	Total	6594	100	Total	5590	100

*Includes commodities accounting for 5% or more of the total.

Source: NMTDB

lumber and paper. All the inbound flows include substantial quantities of chemicals (since these are dry vans, these are packaged chemicals or chemicals in sacks and drums.).

Reefer Commodities. As expected, the commodity mix in refrigerated vans is much different than the mix in dry vans. Reefer movements are dominated by fresh perishable field crops, frozen or chilled foods, and dry foods, especially eastbound or northbound from California and eastbound from Oregon and Washington. Westbound (or southbound to California through Redding), the same commodities dominate, but with a shift towards more frozen or chilled foods and a significant amount of perishable or temperature-sensitive chemicals.

Table I-5 shows that field crops (unprocessed agricultural products, chiefly fresh produce) account for 68 percent of the reefer truck traffic leaving California, with frozen/chilled or canned/dry foods together accounting for 24 percent. Produce and frozen/chilled foods require refrigeration, and would require refrigerated containers for double-stack service. Canned/dry foods, such as canned fruits or wine, do not require active refrigeration but do require insulation, particularly in summer and winter extremes. It is possible to move such commodities in insulated containers, and in fact some goods (notably wine from Modesto) move that way at present. The "other" category, which accounts for 8 percent of the eastbound and northbound flow, may include a mix of refrigerated and insulated commodities.

The westbound commodity mix is entirely different. Perishable crops account for only 10 percent, and frozen/chilled foods for another 30 percent. Canned/dry foods account for 15 percent. Chemicals account for 10 percent of the westbound flow. Although there are chemicals that must be refrigerated (such as photographic or medical supplies), much of that category is more likely to be merely temperature sensitive and require insulation. "Other" commodities, many of which are non-refrigerated backhauls, account for 35 percent of the westbound (or southbound) reefer flow.

For California, it thus appears that at least 81 percent of the eastbound reefer truck flow is fresh produce or frozen/chilled foods for which containers would require refrigeration to compete. This category comprises about

Table I-5

CALIFORNIA REFRIGERATED
TRUCK COMMODITIES

Monthly Count

	Westbound/Southbound						Eastbound/Northbound				
	Field Crop	Froz/ Chill	Dry/ Canned	Chem- icals	All Others	Total	Field Crop	Froz/ Chill	Dry/ Canned	All Others	Total
Via											
Rock Springs	239	3111	1436	479	2713	7978	3943	1017	954	445	6359
Eloy	3006	6013	2544	3006	8556	23,125	18,976	1389	1157	1620	23,142
Gallup	514	4800	3086	2057	6686	17,143	11,671	2137	1315	1315	16,438
Redding	2193	3147	1716	95	2384	9535	5455	3117	3117	1298	12,987
Total	5952	17,017	8782	5637	20,339	57,791	40,045	7660	6543	4678	58,926
Percent	10	30	15	10	35	100	68	13	11	8	100

Source: NMTDB

572,460 annual truck loads. The remaining 19 percent of the eastbound truckloads, roughly 134,622 annual truckloads, carry canned/dry foods or other commodities for which insulated or dry van containers might compete. Westbound, 40 percent of the truckloads, about 276,276 annually, are produce or frozen/chilled foods requiring refrigeration. The other 60 percent, 417,096 annual carloads, consist of canned/dry foods, chemicals, and other commodities, many of which do not require active refrigeration and which might be susceptible to double-stack competition.

As Table I-6 shows, the Oregon/Washington reefer commodity mix closely resembles the California pattern. About 89 percent of the eastbound reefer flow is fresh produce or frozen/chilled foods for which refrigeration is required, as is 28 percent of the westbound flow. The remaining 11 percent of the eastbound flow (roughly 10,080 annual truckloads), and 72 percent of the westbound flow (roughly 49,188 annual truckloads) may be subject to competition from insulated and dry containers.

Containers by Truck. The passing count information on truck types shows that very few containers are moved by truck over long-haul routes. The highest volumes on Table I-7 are well below the minimum scale of a single weekly double-stack train.

DETAILED TRUCK DATA

Detailed truck data from the NMTDB is presented in Appendix I-7 (dry van data) and Appendix I-8 (reefer data).

Table I-6

OREGON/WASHINGTON REFRIGERATED
TRUCK COMMODITIES

Monthly Count

	Westbound						Eastbound				
	Field Crop	Froz/ Chill	Dry/ Canned	Chem- icals	All Others	Total	Field Crop	Froz/ Chill	Dry/ Canned	All Others	Total
Via											
Rock Springs	285	1309	1082	683	2334	5693	4044	2747	305	535	763
Percent	5	23	19	12	41	100	53	36	4	7	100

Source: NMTDB

Table I-7

ESTIMATED MONTHLY CONTAINERS BY HIGHWAY
TO AND FROM CALIFORNIA

	Via Rock Springs	Via Eloy	Via Gallup	Via Redding
To California	17	326	60	180
From California	26	223	26	351

Source: NMTDB Passing Counts, 1987

IV. RAIL AND TRUCK MARKET

RAIL AND TRUCK TRAFFIC FLOWS

Looking forward to the description of a potential domestic double-stack network, the study team combined selected rail and truck data on the same geographic basis. By so doing, it is possible to address some of the basic issues in the formation of such a network, even before we have estimated the total potential diversion from truck.

Rail/Truck Comparisons. The rail and truck data are given in Table I-8, each in units and net tons. The rail data include trailers, containers, and selected boxcar movements. The flows originating in the Northwest and in California show more total rail tons than truck tons, largely a consequence of including selected boxcar traffic (namely lumber, paper, and other forest products). Westbound rail flows from the Upper Midwest (which includes Chicago) exceed truck flows, and by a large margin to the Northwest; the other westbound flows are dominated by trucks. Overall domination by trucks is consistent with national market shares and longstanding trends. The much greater rail penetration of the Upper Midwest-to-Northwest market is likely due to the increase in exports through Northwest ports, and the effectiveness of double-stack backhaul solicitation.

Table I-8 also shows clearly that refrigerated truck movements would be a major potential market for double-stack service if a cost-effective and highly reliable system for double-stack refrigeration can be developed.

Traffic Patterns. Figure I-9 shows the rail traffic flows previously identified as being relevant to the study. Figure I-10 shows the long-haul, interregional truck flows, previously identified as likely to be relevant, allocated to the same rail corridors. (Neither map shows the volumes associated with individual railroads or their routes.)

Some features are immediately apparent. First, the major intermodal routes in the western states correspond closely to the major truck flows. Second,

COMPARISON OF TRUCK VERSUS RAIL DATA BY TRAM REGION
TRUCK DATA SOURCE: TRAM MONTHLY SURVEY EXPANDED TO ANNUALIZED VOLUMES
RAIL DATA SOURCE: 1987 ICC CARLOAD WAYBILL SAMPLE INTERMODAL AND BOXCAR EQUIVALENTS

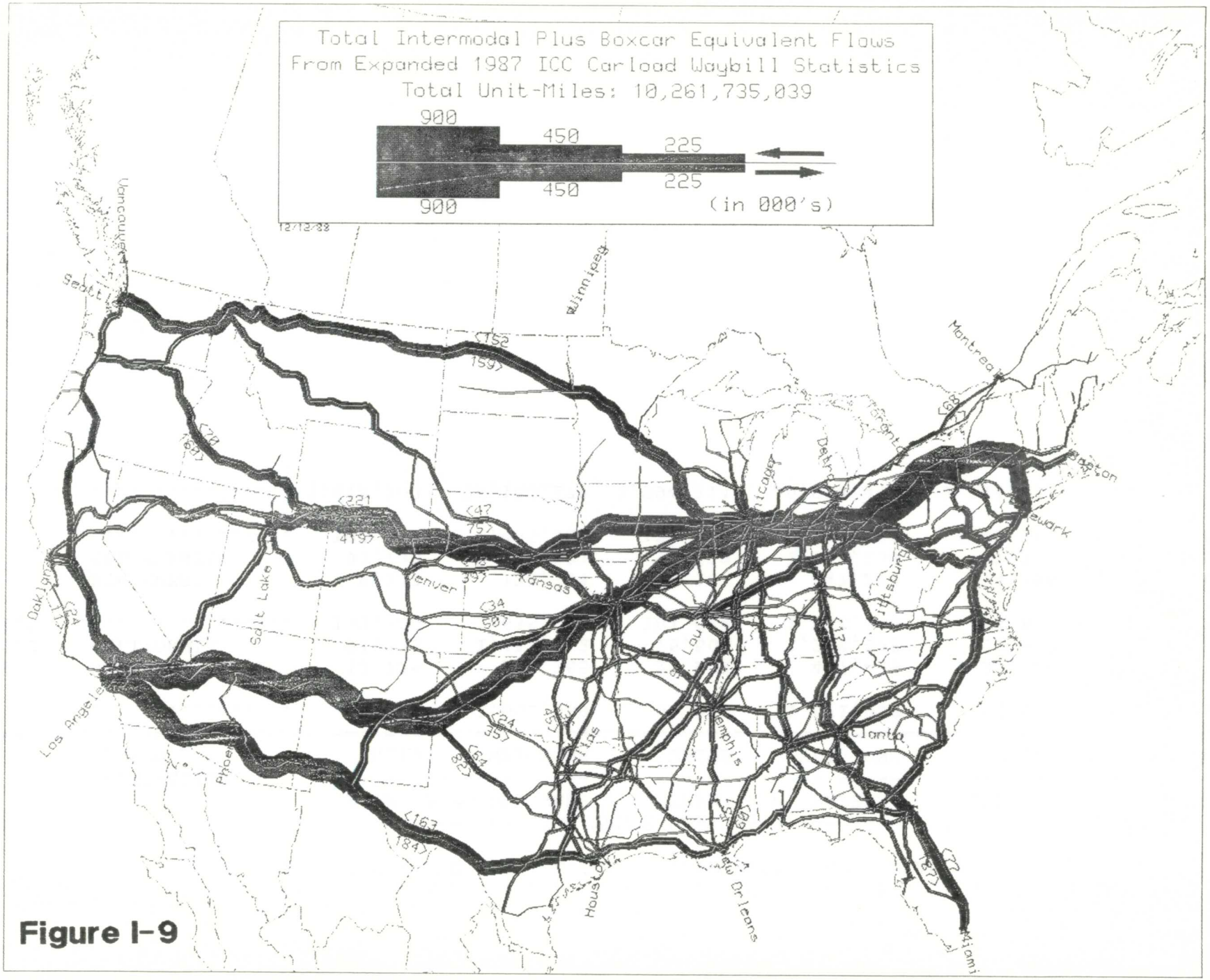
ORIGIN REGION	DESTINATION REGION	TRAM TRUCK DATA: TRAM 12 MO DRY VANS UNITS	TRAM TRUCK DATA: TRAM 12 MO DRY VANS NET TONS	TRAM TRUCK DATA: TRAM 12 MO REFERS UNITS	TRAM TRUCK DATA: TRAM 12 MO REFERS NET TONS	RAIL DATA: EXPANDED 1987 WAYBILL UNITS	RAIL DATA: EXPANDED 1987 WAYBILL NET TONS
NORTHWEST	NORTHWEST	0	0	0	0	68,936	1,210,996
NORTHWEST	CALIFORNIA	135,585	2,420,471	82,240	1,718,670	113,157	2,610,116
NORTHWEST	MOUNTAIN STATES	13,176	245,514	15,956	311,240	38,173	779,504
NORTHWEST	LOWER MIDWEST	17,019	291,443	34,759	727,747	67,343	1,342,680
NORTHWEST	UPPER MIDWEST	23,058	440,471	32,976	665,521	212,520	3,802,870
NORTHWEST	SOUTHEAST	3,294	60,116	15,061	315,455	33,113	697,000
NORTHWEST	MID ATLANTIC	8,784	150,100	22,394	444,393	34,559	662,748
NORTHWEST	NORTHEAST	12,627	231,517	39,785	784,311	57,684	1,202,320
NORTHWEST	.....	213,543	3,839,632	243,171	4,967,337	625,485	12,308,234
CALIFORNIA	NORTHWEST	117,990	1,987,463	96,074	1,948,997	30,084	526,852
CALIFORNIA	CALIFORNIA	15,934	232,745	7,643	140,277	52,573	1,013,436
CALIFORNIA	MOUNTAIN STATES	63,174	910,025	47,458	937,810	69,591	1,265,824
CALIFORNIA	LOWER MIDWEST	194,756	3,008,522	110,758	2,162,383	228,064	3,955,670
CALIFORNIA	UPPER MIDWEST	121,283	1,972,826	98,915	1,964,981	365,737	6,149,001
CALIFORNIA	SOUTHEAST	74,350	1,196,358	59,427	1,206,014	56,719	1,028,384
CALIFORNIA	MID ATLANTIC	55,710	988,916	54,733	1,112,632	67,246	1,175,968
CALIFORNIA	NORTHEAST	95,494	1,441,512	123,383	2,450,214	78,218	1,447,840
CALIFORNIA	.....	738,691	11,738,367	598,391	11,923,308	948,232	16,562,975
MOUNTAIN STATES	NORTHWEST	9,882	175,436	24,589	488,798	38,040	739,228
MOUNTAIN STATES	CALIFORNIA	39,138	674,799	62,607	1,245,586	50,123	928,742
MOUNTAIN STATES	.....	49,020	850,235	87,196	1,734,384	88,163	1,667,970
LOWER MIDWEST	NORTHWEST	29,646	421,526	54,779	1,071,046	45,666	721,920
LOWER MIDWEST	CALIFORNIA	164,085	2,497,525	158,711	3,135,054	240,903	4,391,051
LOWER MIDWEST	.....	193,731	2,919,051	213,490	4,206,100	286,569	5,112,971
UPPER MIDWEST	NORTHWEST	21,960	325,919	36,915	664,213	179,845	2,009,472
UPPER MIDWEST	CALIFORNIA	153,466	2,290,970	131,264	2,455,447	337,463	5,251,848
UPPER MIDWEST	.....	175,426	2,616,889	168,179	3,119,660	517,308	7,261,320
SOUTHEAST	NORTHWEST	5,490	106,919	12,183	218,805	12,608	225,280
SOUTHEAST	CALIFORNIA	61,031	984,150	46,856	852,233	38,968	725,373

Table I-8

COMPARISON OF TRUCK VERSUS RAIL DATA BY TRAM REGION
TRUCK DATA SOURCE: TRAM MONTHLY SURVEY EXPANDED TO ANNUALIZED VOLUMES
RAIL DATA SOURCE: 1987 ICC CARLOAD WAYBILL SAMPLE INTERMODAL AND BOXCAR EQUIVALENTS

ORIGIN REGION	DESTINATION REGION	TRAM TRUCK DATA: TRAM 12 MO DRY VANS UNITS	TRAM TRUCK DATA: TRAM 12 MO DRY VANS NET TONS	TRAM TRUCK DATA: TRAM 12 MO REFERS UNITS	TRAM TRUCK DATA: TRAM 12 MO REFERS NET TONS	RAIL DATA: EXPANDED 1987 WAYBILL UNITS	RAIL DATA: EXPANDED 1987 WAYBILL NET TONS
SOUTHEAST	.....	66,521	1,091,069	59,039	1,071,038	51,576	950,653
MID ATLANTIC	NORTHWEST	13,725	181,365	25,534	427,429	21,586	285,720
MID ATLANTIC	CALIFORNIA	94,375	1,454,312	75,508	1,218,668	63,242	1,015,620
MID ATLANTIC	.....	108,100	1,635,677	101,042	1,646,097	84,828	1,301,340
NORTHEAST	NORTHWEST	9,333	124,734	26,167	447,267	4,798	76,620
NORTHEAST	CALIFORNIA	93,738	1,370,624	97,639	1,719,253	37,112	554,040
NORTHEAST	.....	103,071	1,495,358	123,806	2,166,520	41,910	630,660
.....		1,648,103	26,186,278	1,594,314	30,834,444	2,644,071	45,796,123

Table I-8


Total Intermodal Plus Boxcar Equivalent Flows
From Expanded 1987 ICC Carload Waybill Statistics
Total Unit-Miles: 10,261,735,039
900
450
225
225
450
900
(in 000's)
12/12/88
Vancouver
Seattle
Winnipeg
Montreal
Boston
Newark
Detroit
Toronto
Chicago
Pittsburgh
Kansas
Denver
Salt Lake
Oakland
Los Angeles
Phoenix
Houston
New Orleans
Memphis
Atlanta
Miami
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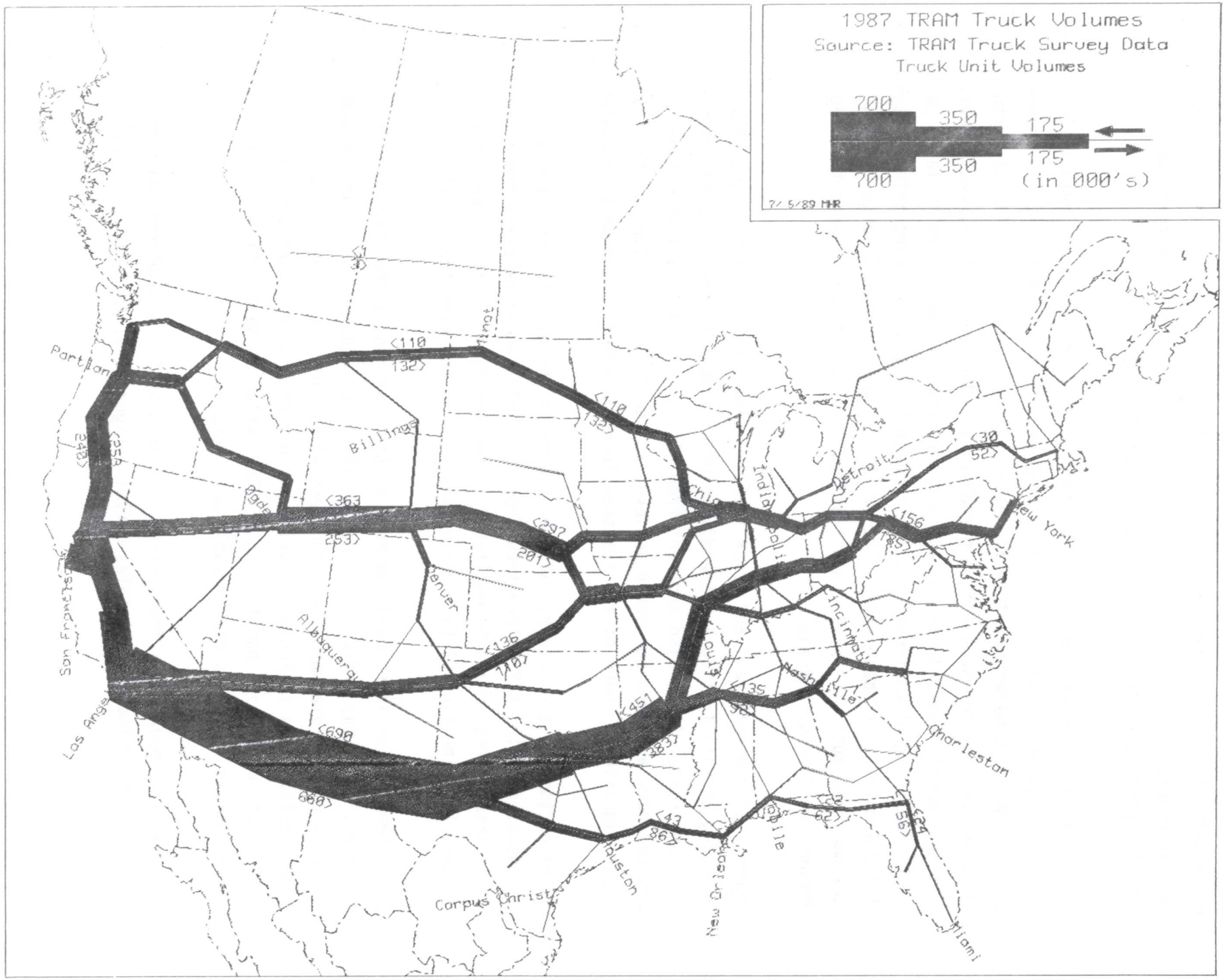
<60
<87

Figure I-9


1987 TRAM Truck Volumes
Source: TRAM Truck Survey Data
Truck Unit Volumes
700
350
175
175
350
700
(in 000's)
7/5/89 MHR
Portland
Billings
Denver
Albuquerque
San Francisco
Los Angeles
Corpus Christi
Houston
New Orleans
Dallas
Detroit
Cincinnati
Nash
Charleston
New York
Miami
<110
132>
<110
132>
<363
253>
<297
201>
<136
100>
<690
660>
<451
<135
<43
86>
<30
52>
<156
185>
<56>

relatively little truck traffic shows up in the eastern rail corridors. Third, rail intermodal traffic is heavily concentrated in a few midwestern hubs, notably Chicago, while truck traffic is more diffuse.

The second and third features are related. TRAM's initial truck data include long-haul movements with a relatively high probability of diversion to intermodal. Shorter movements within the eastern states could not, without further analysis, be assigned such a high probability. Moreover, the extremely heavy rail intermodal flow between Chicago and New York are occasioned in large part by the funneling of east-west traffic through Chicago, including both through-billed and re-billed movements. The truck corridor between Chicago and New York would be much denser if truck traffic, like rail traffic, were funneled through the Chicago gateway.

Figure I-11 presents rail and truck traffic volumes on the same scale. The funneling of rail traffic and the diffusion of truck traffic are both immediately apparent. It is also apparent from Figure I-11 that rail intermodal services have achieved (or could achieve, in the case of relevant boxcar traffic) a significant share of the transcontinental market in the western states.

In the northernmost corridor, rail has the major share. This interpretation is consistent with TRAM information from the field, where relevant truck traffic on Interstates 90 and 94 was found to be very light. It must be noted, however, that the Central Corridor serves some of the same traffic flows.

In the Central Corridor, rail has more of the eastbound market than of the westbound, which may reflect the rail movements of containerized imports and piggyback refrigerated produce. The Central Corridor branches in Utah (with Union Pacific lines to Southern California and the Pacific Northwest) and in the Midwest (with Union pacific and SP/DRGW routes to Kansas City and St. Louis), making its flows considerably more complex.

There has also been significant market penetration in the Southern Corridor, notably in the Chicago-Los Angeles market. Figure I-11 indicates that rail

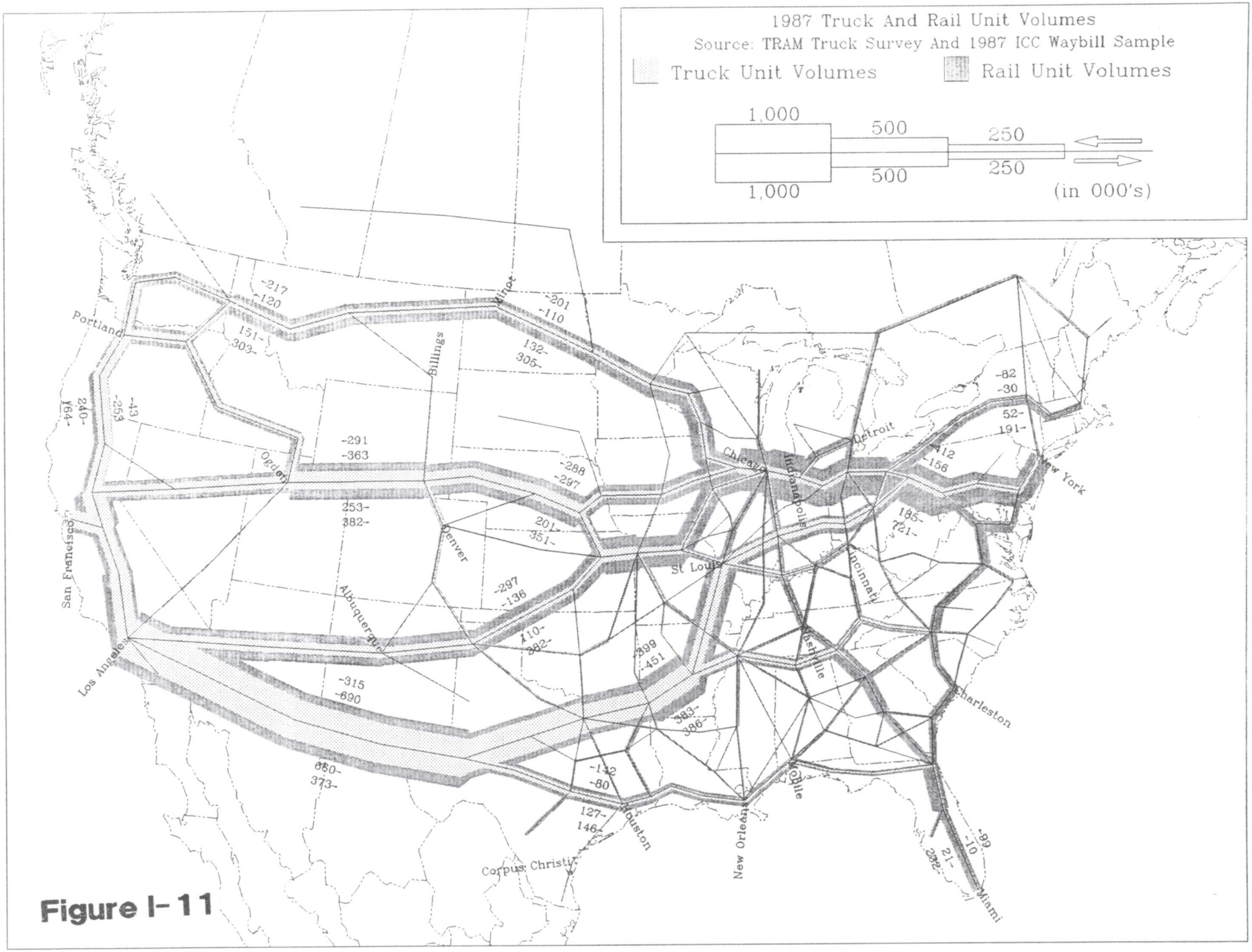

1987 Truck And Rail Unit Volumes
Source: TRAM Truck Survey And 1987 ICC Waybill Sample
Truck Unit Volumes
Rail Unit Volumes
1,000
500
250
250
500
1,000
(in 000's)
Portland
Billings
Minot
Ogden
Denver
Chicago
Detroit
Indianapolis
St Louis
Cincinnati
New York
San Francisco
Los Angeles
Albuquerque
Nashville
Charleston
Mobile
New Orleans
Houston
Corpus Christi
Miami
-217
-120
-201
-110
151-
303-
132-
305-
240-
364-
-43
-253
-291
-363
-288
-297
253-
382-
201-
351-
-297
-136
110-
382-
399
451
-315
-690
383-
386-
650-
373-
-142
-80
127-
146-
-82
-30
52-
191-
112
156
185-
221-
21-
232-
99
10

Figure I-11

now carries the majority of the relevant traffic. Work by the AAR's Intermodal Policy Division has confirmed that double-stack services have indeed diverted substantial truck traffic in the major corridors.

Figure I-11 suggests, however, that there are large truck flows moving over Interstate 10 to and from California (and observed at TRAM's Eloy, Arizona collection point) in which there has been relatively little rail intermodal penetration. Both rail and truck flows branch out from this corridor, with the larger flow serving the Midwest and points east.

The general match between rail and truck flows in Figure I-11 confirms the relevance of the selected truck flows for competition with existing intermodal services.

Traffic Balance. One recurring issue in intermodal transportation of all kinds, especially double-stack movements, is traffic balance. Table I-9 shows the ratios between eastboundf and westbound units for dry vans, reefer vans, and rail. Ratios near 1.0 (ranging perhaps from 0.8 to 1.2) indicate relatively close balance between movements in the two directions. As the ratios move farther from 1.0, balance becomes a serious issue. At a ratio of 1.5, 50 percent more units are moving eastbound that are returning westbound.

The ratios indicate that rail traffic flows often have a worse balance problem than truck flows. Four of the six Northwest flows follow this pattern, as does the Northwest total. The California flows are more evenly balanced for both rail and truck.

The rail flows between California and the Northwest are severely imbalanced, most likely due to the heavy southbound movements of lumber, paper, and other forest products in boxcars, which then return empty.

Several strategies have been tried to overcome imbalances, but none is easy to implement or highly profitable when implemented. One strategy is to seek

Table I-9

1987 Truck and Rail Traffic Balance Ratios
(Units)

Northwest	Dry Vans Units Eastbound	Dry Vans Units Westbound	Ratio	Reefer Vans Units Eastbound	Reefer Vans Units Westbound	Ratio	Rail Units Eastbound	Rail Units Westbound	Ratio
Mountain States	18,176	9,882	1.8	15,956	24,589	0.6	38,173	38,040	1.0
Lower Midwest	17,019	29,646	0.6	34,759	54,779	0.6	67,343	45,666	1.5
Upper Midwest	23,058	21,960	1.1	32,976	36,915	0.9	212,520	179,845	1.2
Southeast	3,294	5,490	0.6	15,061	12,183	1.2	33,113	12,608	2.6
Mid Atlantic	8,784	13,725	0.6	22,394	25,534	0.9	34,559	21,586	1.6
Northeast	12,627	9,333	1.4	39,785	26,167	1.5	57,684	4,798	12.0
Total	77,958	90,036	0.9	160,931	180,167	0.9	443,392	302,543	1.5
California									
Mountain States	63,174	39,138	1.6	47,458	62,607	0.8	69,591	50,123	1.4
Lower Midwest	194,756	164,085	1.2	110,758	158,711	0.7	228,064	240,903	0.9
Upper Midwest	121,283	153,466	0.8	98,915	131,264	0.8	365,737	337,463	1.1
Southwest	71,350	61,031	1.2	59,427	46,856	1.3	56,719	38,968	1.5
Mid Atlantic	55,710	94,375	0.6	54,733	75,508	0.7	67,246	63,242	1.1
Northeast	95,494	93,738	1.0	123,383	97,639	1.3	78,218	37,112	2.1
Total	601,767	605,833	1.0	494,674	572,585	0.9	865,575	767,811	1.1

"backhaul" movements by offering low rates in the light direction. This strategy has been vigorously pursued by intermodal operators, but some observers note a long-term profitability problem once the lower rates become accepted as "standard." A second strategy is "cream skimming," attempting to carry only balanced, high-value freight. Cream-skimming, however, is an open invitation to aggressive competitors, and it is difficult to maintain for extended periods. A third strategy is "triangulation," where the return movement goes to a different destination and a short repositioning movement is accepted to gain an improved overall balance. truck is an inherently more flexible mode and has an advantage in attempting to triangulate movements, accounting for part of the trucking industry's better overall traffic balance. This advantage shows up in Table I-9, where the total truck balance for the Northwest is considerably better than the balances for individual truck flows.

V. BASIS OF RAIL-TRUCK COMPETITION

This section addresses two questions: (1) What is the nature of truck participation in container flows? and (2) To what extent does the truck compete with rail for container movements?

A review of current published material regarding the status quo confirms that out to 500 miles, truck is the dominant mode used in the movement of trailer freight. Temple, Barker, and Sloan (TBS) data show few rail movements of containers under 500 miles. Table I-10 shows that only 13% of the 1983 TOFC/COFC traffic moved less than 500 miles.

CONTAINER FLOWS

When containers are unloaded from oceangoing vessels, they must be placed on chassis for movement on land. These containers-on-chassis are then moved by truck to destination, or moved by truck to a rail facility for further movement. The subsequent rail movement can be a TOFC (trailer-on-flat-car) equivalent with the container moving on the chassis; it can be a COFC (container-on-flat-car) movement without the chassis, or it can be a container in a double-stack train, again without the chassis.

Sea-Land data, Table I-11, shows truck movements predominate out to 300 miles. TRAM field data is also consistent. Table I-12 shows 210 motor carriers moving containers distances from less than 100 miles up to 700 miles. Table I-13 shows an estimated 5500 containers per month moving into and out of the Midwest from Baltimore, Newark, and Philadelphia and over 16,000 containers moving from Norfolk, Wilmington, and Charleston to Atlanta, Winston-Salem, and throughout the Southeast, all by truck.

All of the data are consistent in showing that, at present, truck is the primary transport mode for containers out to 300-500 miles.

Table I-10

TREND IN TOFC/COFC LENGTH OF HAUL
TRUCK INTERMODAL BREAKEVEN MILEAGES

LENGTH OF HAUL

Length of Haul (miles)	TOTAL TRAILER/CONTAINER LOADINGS 1976	Percent	1983	Percent	Average Annual Growth 1976-1983
0 - 500	533,047	21.0%	556,251	13.6%	0.6%
500 - 999	1,104,168	43.5	1,451,978	35.5	4.0
1,000 - 1,199	502,587	18.8	916,177	22.4	9.0
2,000 +	398,516	15.7	1,165,672	28.5	16.6
TOTAL	2,538,318	100.0%	4,090,078	100.0%	7.1%

NOTE: Length of haul statistics and their comparisons can be distorted by rebilling at major gateways. In addition, 1983 data include some flat car movements other than intermodal due to a change in car type.

BREAKEVEN MILEAGES

Truckload (TL)	Conventional TOFC 40'x96"	Conventional TOFC 48'x102"	Lightweight TOFC 48'x102"	Double-Stack Marine ISO 40'	Double-Stack Domestic 48'x102"
TL 45'x96"	675	575	500	775	450
TL 45'x102"	875	650	550	875	500
TL 45'x102"	1,175	725	600	1,000	550
TL TWIN 28'x102"	1,700	950	775	1,275	650
TL TWIN 45'x102"	Intermodal unattractive	2,050	1,400	2,675	1,050

TOFC/COFC economics are favorable at these mileages or greater.
Source: TBS analysis

Table I-11

GEOGRAPHIC DISTRIBUTION OF SEA-LAND CONTAINERS

Miles	Elizabeth, NJ Truck	Elizabeth, NJ Rail	Jacksonville, FL Truck	Jacksonville, FL Rail	New Orleans, LA Truck	New Orleans, LA Rail	TOTAL	%
0-300	2,392	--	386	--	742	--	3,520	71
301-400	68	--	106	69	69	174	486	10
401-500	177	2	15	5	34	24	257	5
501-600	24	2	8	1	37	21	93	2
601-700	6	16	--	6	17	22	67	1
701-800	5	100	22	8	20	15	148	3
801-900	2	13	3	37	38	28	121	2
901-1,000	--	4	3	25	15	36	83	2
1,000 +	3	29	11	22	12	114	191	4
TOTALS	2,677	166	532	173	984	434	4,966	
	94.16%	5.83%	75.46%	24.43%	69.39%	30.61%		

Source: Transportation Research and Marketing

Table I-12

MILEAGE BLOCKS AND ESTIMATED CONTAINER MOVEMENTS
JUNE, 1986

	TO PORT AREA ONLY		TO PORT AREA/ COASTAL STATES		TRAVELLING - 500 MILES		TRAVELLING - 700 MILES		TOTAL	
	# Car-riers	# Con-tainers	# Car-riers	# Con-tainers	# Car-riers	# Con-tainers	# Car-riers	# Con-tainers	# Car-riers	# Con-tainers
Baltimore, MD	4	575	6	136	7	433	10	870	27	2,014
Boston, MA	4	88	4	172	7	355	3	38	18	653
Charleston, SC	1	150	1	13	5	216	6	309	13	688
Galveston, TX	2	400					1	40	3	440
Houston, TX	1	300	3	35	6	456	7	193	17	984
Jacksonville, FL	1	29	4	44	3	105	2	70	10	248
Los Angeles, CA	4	860	1	63	1	25	3	395	9	1,343
Miami, FL	2	18	3	62			2	30	7	110
New Orleans, LA	1	25	4	620	4	110	4	139	13	894
NY-NJ	5	157	2	63	6	319	15	1,607	28	2,146
Norfolk, VA	2	250	2	62	1	1	5	117	10	430
Oakland, CA	6	672	2	60	1	10	1	163	10	905
Philadelphia, PA	4	876	2	45	3	93	3	27	12	1,041
Portland, OR	3	250	4	90	2	13	1	10	10	363
Savannah, GA	2	1,000	2	63	3	40	34	208	11	1,311
Seattle, WA	5	376	5	246	2	16	4	41	16	679
Wilmington, DE	1	50	–	–	–	–	1	85	2	135
TOTALS	48	6,076	45	1,774	51	2,192	72	4,342	216	14,384

*There are 54 carriers contacted who deliver more than 700 miles distance.

Table I-13

OBSERVED TRUCK CONTAINER MOVEMENTS
7-DAY COUNT, ESTIMATED MONTHLY VOLUME

I-80	Clearfield, PA	750
I-76/I-70	Breezewood, PA	5,000
I-95	Ashland, VA	2,500
US 74/76	Wilmington, NC	7,900
I-26	Charleston, NC	24,600
Rt 44/58	Norfolk, VA	15,800
I-85	Manson, NC	2,100

Source: NMTDB, June, 1986

COMPETITION BETWEEN DOUBLE-STACKS AND TRUCKS

Although the short-haul movements of marine containers are currently dominated by trucks, longer hauls of marine containers have always been dominated by the railroads, and particularly so since the advent of minilandbridge service in 1972. Double stack cars have dominated the rail movement of containers in those longer hauls since 1984, when they were put into dedicated service by APL. Domestically, there is general agreement that suitable containers riding those same double-stack cars can capture a substantial share of the long-haul domestic traffic now carried in piggyback trailers. The open question is the extent to which double-stacked domestic containers can succeed where piggyback trailers have largely failed: penetrating the truckload market.

If the double-stack cars can be fully utilized, double-stacked containers have a lower unit linehaul cost than piggyback trailers. Estimates of the linehaul cost advantage range from 25 to 45 percent, depending on a host of factors. A substantial portion of the effort in Task II will be devoted to establishing the relationship between linehaul cost and length of haul, train size, equipment type, and other relevant features. While this cost advantage will unquestionably make double-stacked containers a more effective competitive tool than piggyback trailers, it is only a small part of the answer.

Truckload motor carriers operate in a market for door-to-door distributive transportation. Carriers offering multiple-drop service are not, in that respect, true truckload carriers, and are unlikely to be targeted for double-stack competition. The basis of competition, as in all transportation markets, is cost, convenience and service. The cost, in this case, is the door-to-door cost, of which the rail linehaul cost is only one component. Our analysis will focus on underlying carrier costs, rather than market price, as the basis for comparison, since prices are subject to many transient influences while underlying costs are relatively stable. Service has multiple dimensions, including transit time, reliability, loss and damage experience, and a large number of less quantifiable measures. Double-stack services have shown a highly competitive loss and damage experience, better than trucks in many cases. Convenience, the facility with which the movement can be arranged and

carried out, is difficult to quantify but extremely important. Most of the other factors, such as marketing effectiveness, responsiveness to inquiries, shipment tracing, claims settlement, etc. are institutional and organizational issues that must be addressed, but are fundamentally separate from the choice of technology. Moreover, these factors will be addressed in detail in Task III. Our analysis of service competition, therefore, will focus on transit times, with the caveat that the reliability of those transit times must also be competitive.

Rail/Truck Rate Differential

For an identical movement (same commodity, capacity, and door-to-door transit time), it is generally conceded that rail intermodal service cannot command the same rate as truckload motor carrier service, primarily because of trucking's superior convenience. TRAM's experience in the field indicates that rail intermodal operators must offer a discount of approximately 15 percent to achieve competitive equality with trucks. If the two modes are assumed to require the same contribution towards overhead and profit, rail intermodal service can compete effectively where its underlying costs are 15 percent or more below truck.

Where rail costs are 15 percent below truck costs for the same movement (as they are at present), and transit time is competitive, we would expect each mode to have a market share similar to its present participation (10-15 percent in hauls over 500 miles, none on shorter hauls.). As the rail cost advantage increases beyond 15 percent, the rail market share should grow rapidly. Where the rail cost advantage is less than 15 percent, the rail market share may be negligible.

The 15 percent differential is based on market experience with piggyback trailers. Any reduction in that differential will require fundamental improvements in rail intermodal service (the potential for which will be examined in Tasks II and III). One indication can be drawn from Norfolk Southern's Triple Crown RoadRailer service, which is priced 5-10 percent less than truckload service, and 15-20 percent more than piggyback. Determination of the market-driven discount range for double-stacked containers will be an important part of Task II.

Cost/Service Tradeoffs

A more complex question arises when, for the same movement, rail and truck door-to-door transit times (or other service factors) differ. While it has historically been a safe assumption that rail intermodal service will be slower, it may now be faster (even door-to-door) in some long-haul lanes.

Inventory cost, namely the carrying of interest cost associated with goods in transit, has often been used to assign a dollar value to transit time differences. Where the value of goods can be established, the inventory cost will be useful for distinguishing high-value commodities intolerant of delay from lower-value commodities where the shipper is more likely to trade transit time for lower cost. Inventory cost can also be used to establish a threshold transit time differential for major commodities of interest. Both uses assume that double-stack transit times are reliable, since predictability of transport is a prerequisite for inventory cost calculations. Moreover, reliability is essential to achieve the necessary double-stack car utilization.

Any results obtained from inventory cost estimates, however, must be tempered with marketplace experience and results. Truck transit time information will be compared with rail transit time information to determine what service differences are being offered and accepted in today's market.

Door-to-Door Trucking vs. Drayage

Because truckload motor carriers typically operate door-to-door while double-stack service requires drayage from major intermodal hubs, the geometry of the competing rail and truck movements becomes critical.

Figure I-12 illustrates the problem. A truckload carrier can move directly between points C and D. A double-stack service between A and B may be able to compete with little or no mileage penalty by draying between C and A, and between B and D. For a movement between E and F, however, the double-stack service would require drayage trips against the flow of traffic, placing the intermodal move at a distance and time disadvantage. Lower rail linehaul costs or faster linehaul speeds may not be able to make up the difference.

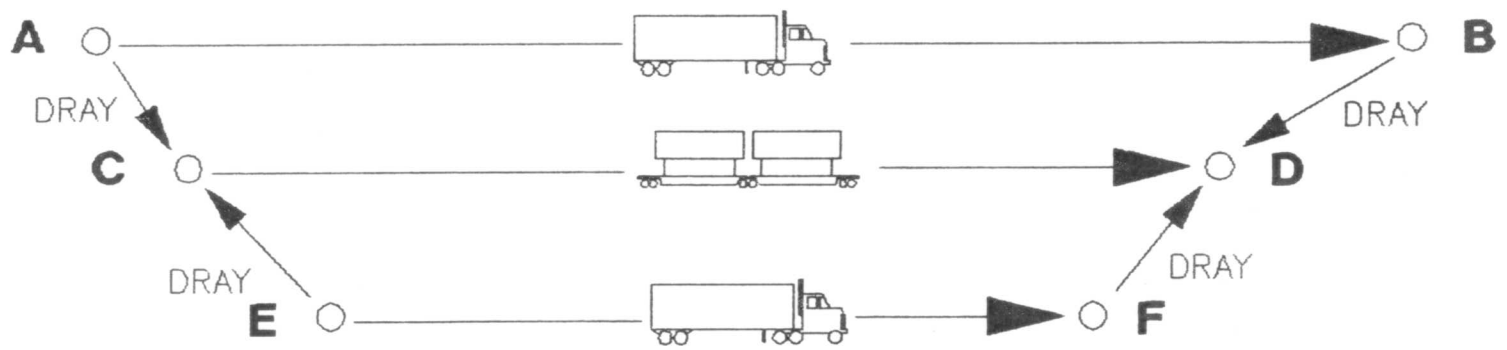


Figure I-12

Competition Between

Double-Stacks and Trucks

The amount of drayage that can be included in the rail movement while remaining competitive with trucks is a function of the total movement distance. The cost advantages of double-stack service are primarily on the linehaul. On short hauls, the costs are increased disproportionately by the higher proportion of the total movement that is devoted to drayage (or stem time). The longer the linehaul, the greater the cost advantage available to offset drayage costs. Therefore, a major intermodal hub will not have a single, fixed draying area for all double-stack movements, but rather a services of overlapping drawing areas for movements in different corridors. For example, the drawing area around Chicago for a Chicago-New York movement would be small relative to the drawing area around Chicago for a Chicago-Los Angeles movement.

While for convenience sake the competitive market area around intermodal hubs is often drawn as a circle of fixed radius, the shape as well as the size of the competitive market area is a function of the linehaul. Competitive market areas are more likely to be ovoid or egg-shaped, deeper in the direction of linehaul travel and shallower against it. (Figure I-13).

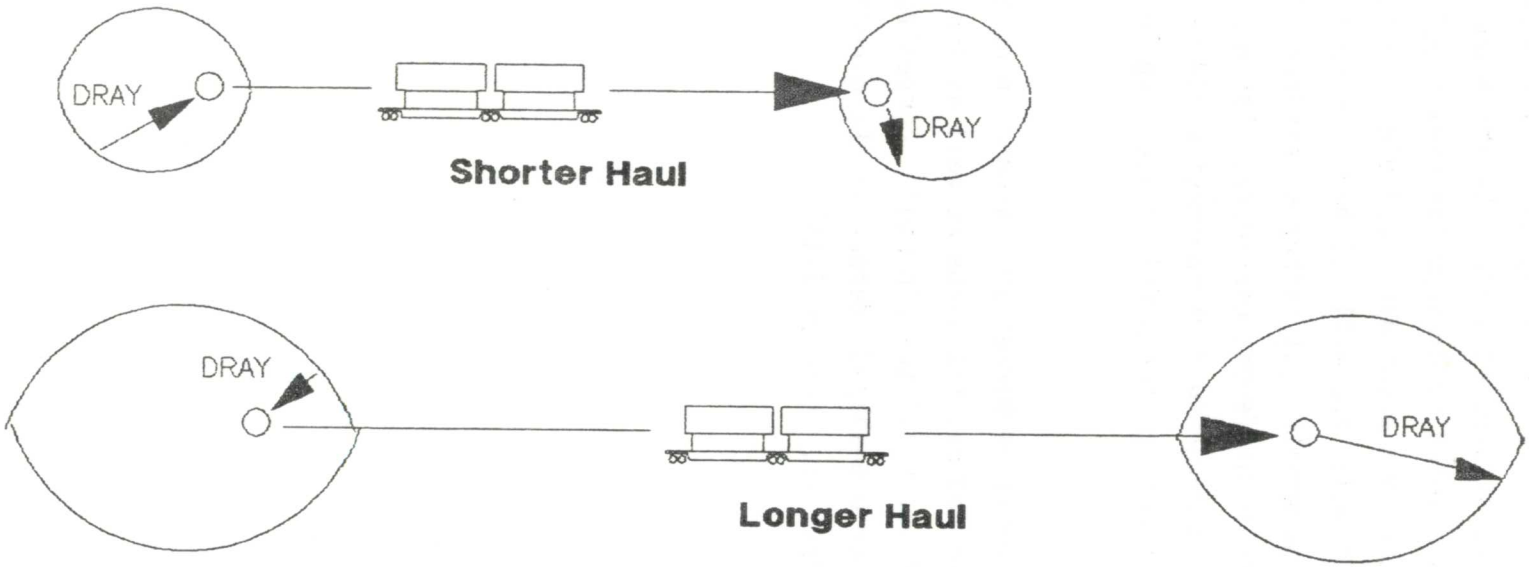


Figure I-13

Double-Stack Linehaul and Drayage Ranges

VI. CURRENT DOUBLE-STACK SERVICES

BEGINNINGS OF RAIL CONTAINER SERVICE

Containers of various kinds are not new to the railroads, or to maritime shipping. Since the nineteenth century, there have been numerous attempts to introduce standardized containers for various commodities. Railroad efforts were focussed mainly on improved methods for handling Less-than-Carload (LCL) freight. Until the late 1950's, however, none of these attempts resulted in widespread or long-lasting use of containers. The present Maritime containerization began in the late 1950's with the efforts of Sea-Land on the East Coast and Matson on the West Coast. Sea-Land used 35-foot containers in U.S. and European trades; Matson introduced 24-foot containers in the Hawaiian trade.

The success of these ventures and the beginnings of containerization by other ocean carriers led to a crucial step: the establishment of the International Standards Organization (ISO). After much debate, the ISO issued standards for container sizes and configurations, and for the exact nature of corner castings to serve as securement and lifting points. With standardized container contact points, mechanized lifting machines and rail cars could be designed and built to handle all standard containers.

The initial ISO standards covered 8-foot high, 8-foot wide containers in 20-foot and 40-foot lengths. Later, standards were issued to cover 8-foot 6-inch, 9-foot, and 9-foot 6-inch (high cube) containers, and 45-foot long containers. Proposed standards for 48-foot long, 9-foot high, 8-foot 6-inch wide containers are now under consideration. ISO-standard configurations for flat, bulkhead, tank, and other specialized containers have also been established.

The next major development was the introduction of regular marine container movements via rail by SeaTrain in 1972. This event began the expansion of landbridge, minilandbridge, and microlandbridge services which continues to this day. These services can be described as follows.

Landbridge. A port-to-port movement of containers replacing the middle portion of an ocean voyage that began before the first port and extends beyond the second. For example, a long voyage between Asia and Europe might be replaced by a shorter voyage between Asia and the U.S. West Coast, a landbridge movement between the West and East Coasts, and a final ocean segment between the East Coast and Europe.

Minilandbridge. A port-to-port movement replacing one end of an ocean voyage. Mini-Landbridge (MLB) service uses a land transportation mode -- sometimes truck, but usually rail -- to serve a second port from a single "load center" port. A good example is an ocean carrier calling at Los Angeles and offering MLB service to and from Houston, rather than calling at Houston directly. Ocean carriers frequently include MLB departures and arrivals in published ship schedules.

Micro-Landbridge. Micro-Landbridge service operates between a U.S. port of call and an inland U.S. intermodal hub (which may or may not also be a port). Service between Charleston and Atlanta is one example. Chicago is the single largest inland hub for microlandbridge service. Despite Chicago being a port, intermodal service to Chicago is not a substitute for a Great Lakes port call.

Inland Points Intermodal. The difference between minilandbridge and microlandbridge has little day-to-day significance. The term "Inland Points Intermodal" (IPI) is used by some to denote all inland intermodal services offered under an ocean carrier bill of lading. IPI services are distinguished from Overland Common Point (OCP) services by this simple bill of lading. OCP services use an ocean carrier bill of lading between ports, and a shipper or third party bill of lading inland.

With few exceptions, initial pickup or final delivery of the container is made by truck. The intermodal system depends initially on motor carriers to transfer or "dray" containers between port terminals and nearby rail terminals (except for some on-dock rail terminals, where the drayage has been internalized). The system again depends on motor carriers to make the link between

intermodal hubs and the ultimate shipper or consignee. In fact, the concentration of rail intermodal operations at a small number of major hubs has been made possible by the ability of motor carriers to feed those hubs efficiently from distances of up to 250 miles, and sometimes more.

ADVENT OF DOUBLE-STACK SERVICE

The first double-stack car, a single-platform version, was completed in 1977 by ACF for Southern Pacific. Subsequent versions produced in 1979 and 1981 grew to three and five articulated units, with five units becoming a standard for all subsequent production. The ACF/SP cars were placed in service carrying Sea-Land containers in the Southern Corridor.

In July of 1983, American President Lines ran its first "experimental" double-stack train from Los Angeles to Chicago. This train was made up of 19 ACF/SP 5-platform cars and one 5-platform BUDD LO-PAC 2000 car. Double-stacking was a technological improvement over the intermodal flatcars used in APL "Liner-trains" since 1979. The APL "experimental" train was a success, and led APL to order several trainsets of BUDD-designed LOPAC-2000 cars built by Thrall. Regular APL double-stack service started in 1984, and was followed by double-stack service for Sea-Land (using Gunderson cars) in 1985. Soon thereafter, other ocean carriers, including Maersk, NYK, K-Line, and others, started dedicated double-stack trains from the West Coast.

The dedicated "unit" trains of APL and Sea-Land set the pattern for early double-stack operations. The introduction of "common-user" service by BN in 1986 led to far greater flexibility in double-stack operations. Today, the actual number of double-stack trains departing in a given week will vary considerably, depending on:

- weekly fluctuations in import and export container traffic;
- the extent to which low-volume trains are combined;
- the extent to which overflow traffic requires additional trains; and
- the portion of common-user and other intermodal trains made up of double-stack cars.

The number of cars and containers on a train will also vary widely week to week. Almost none of the double-stack trains now operating are true unit trains in the sense of having a fixed car consist.

EXISTING DOUBLE-STACK SERVICES

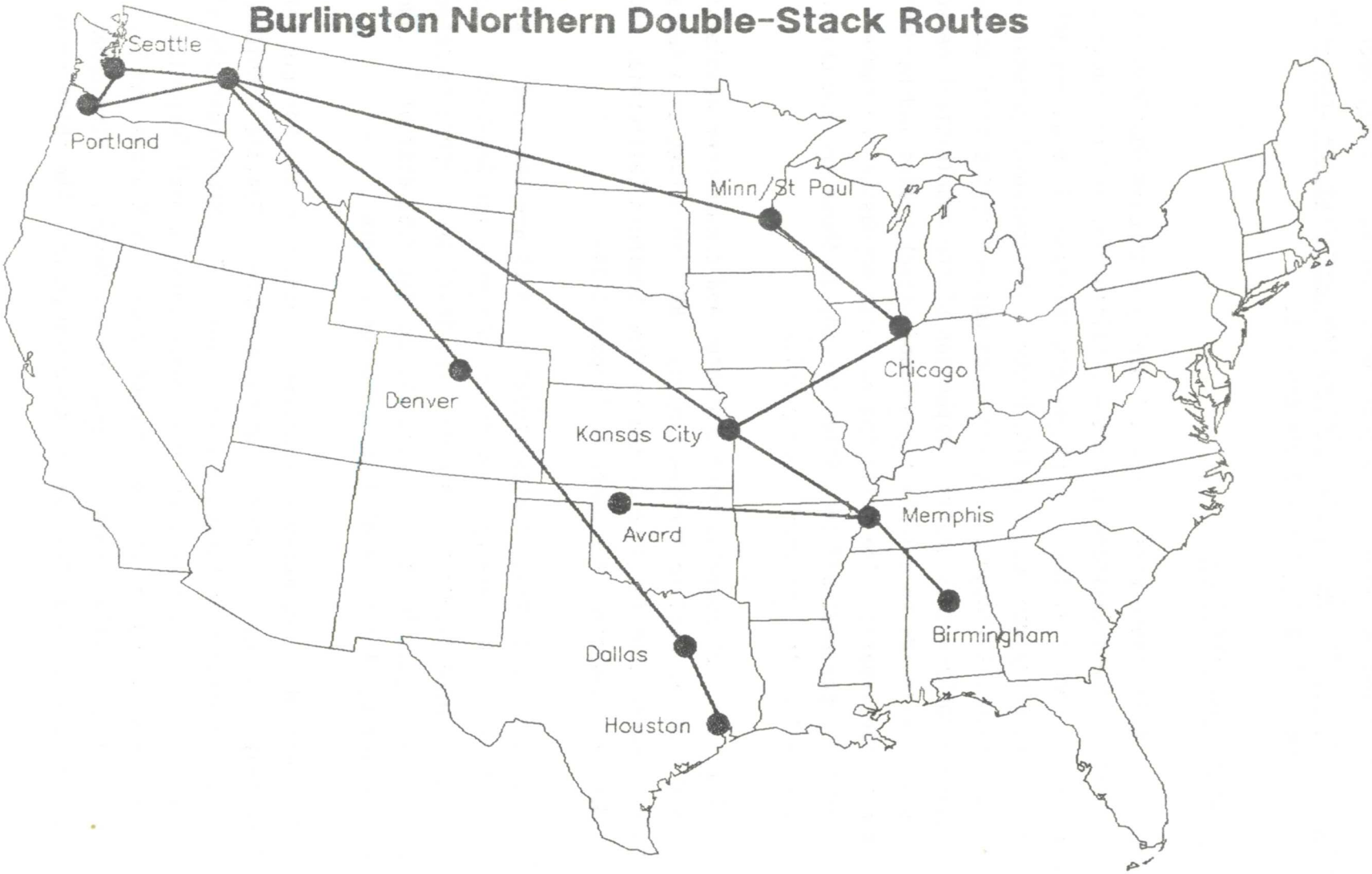
As of December, 1988, there were nearly 100 weekly eastbound double-stack departures from Southern California, Northern California, and the Pacific Northwest. Until recently, the role of eastern railroads in double-stack operations was to carry west coast trains between mid-continent gateways and eastern destinations. Although continuations of western trains still account for most eastern double-stack traffic, expansion of the double-stack network has led eastern railroads to establish new double-stack trains independent of their western counterparts. The following accounts emphasize the number of weekly scheduled departures and the cities served, as those are the critical service features from the customer's perspective.

Burlington Northern. BN operates both dedicated and common-user double-stack trains to and from the Pacific Northwest ports. BN also serves as a Kansas City - Chicago connection for some SP trains from Southern California, and as a Avard - Memphis connection for Santa Fe (Figure I-14).

The only dedicated double-stack trains operating on BN are Sea-Land's, which originate in Tacoma. BN operates three trains per week for Sea-Land. Two trains operate between Tacoma and Chicago. The third train operates between Tacoma and New York (Little Ferry, N.J.), via CSX and NYSW east of Chicago. Overflow Sea-Land traffic is handled on common-user trains.

BN schedules three daily common-user container trains from the Seattle International Gateway, six days per week. The major route is Seattle - Chicago, with intermediate service to Minneapolis/St. Paul. This train consists of about 90% double-stack equipment, the rest being conventional (especially for the relatively high volume of 20' import containers from Seattle and Tacoma). The second route is Seattle - Omaha - Kansas City - Memphis - Birmingham. That train consists of about 40% double-stack equipment. The third route, in

Figure I-14
Burlington Northern Double-Stack Routes



order of volume, is Seattle - Denver - Dallas - Houston, which occasionally uses double-stack equipment but is primarily conventional. BN also operates second sections of any of these trains as required.

Mitsui's advertised service is carried on BN common-user trains eastbound. Westbound, a block of Mitsui export traffic is separated at Spokane and operates to Portland on a BN Expediter train. From Portland the cars return to Seattle with export or empty containers.

BN moves a substantial portion of its export traffic on conventional flat cars because much of it originates away from the main urban hubs served by double-stacks. The double-stacks return westbound with a mix of export, domestic, and empty containers.

Burlington Northern has started a domestic container service under the name "BN America", with service initially provided on the Denver-Dallas route. BN expects to expand domestic container service over the Seattle-Chicago and Portland-Chicago routes in early 1989.

Finally, BN also offers daily trailer intermodal service from Seattle-Tacoma. Trailer and container traffic is sometimes mixed to handle overflows or short trains.

Santa Fe. Santa Fe currently operates one dedicated Southern California double-stack train, for Hyundai. Departures are weekly from Los Angeles, and Santa Fe moves the train to Chicago. A portion of the Hyundai train continues on Conrail to New York.

Santa Fe offers several daily intermodal departures from Los Angeles which can and do carry double-stacked containers on a common-user basis. Santa Fe's major traffic lanes are Los Angeles - Chicago and Los Angeles-Houston/Dallas, with service offered to all major intermediate points, notably Kansas City. (Figure I-15) Santa Fe also operates a Los Angeles-Memphis intermodal service in conjunction with BN. Mitsui is a major user of the Santa Fe common user intermodal operations.

Figure I-15
Santa Fe Double-Stack Routes



In Northern California, Santa Fe operates a weekly dedicated train from Richmond for Maersk. This train operates through the Franklin Canyon and Tehachapi tunnels, and so is limited to two 8'6" containers on each platform.

Santa Fe also operates three or more daily intermodal trains to and from Richmond. Although these trains do not regularly carry double-stack cars, they carry a substantial volume of containers and could support common-user double-stack service (with the tunnel restrictions).

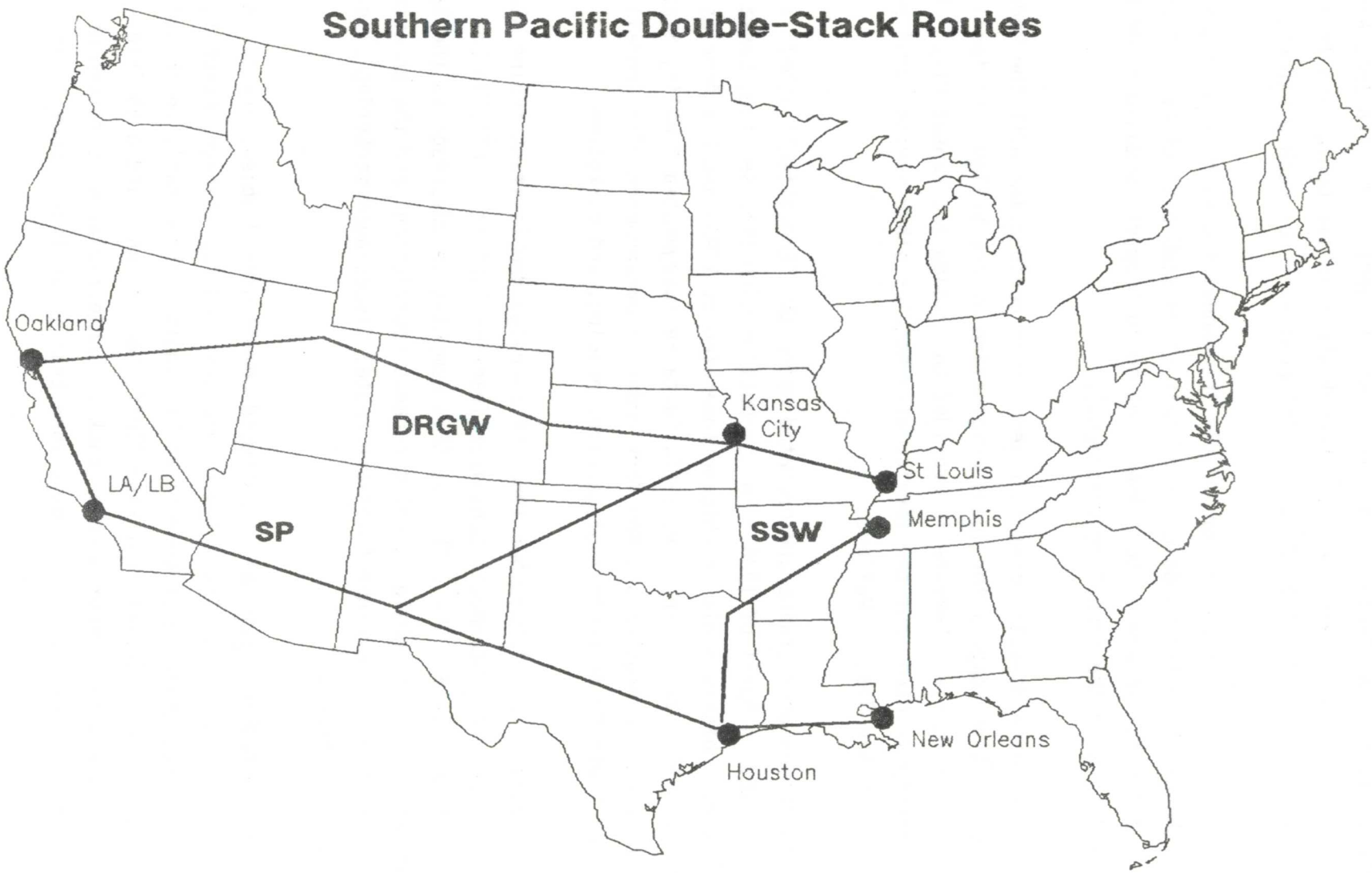
Santa Fe provides a domestic container service in conjunction with the Modesto and Empire Traction company for loads originating at the Valley Lift facility at Modesto, California. Service is provided to Chicago and Kansas City. One major commodity is wine, but the service also handles other agricultural products from the San Joaquin Valley.

Santa Fe's common-user trains are operated under the "EconoStack" label, a program started in April of 1986. In conjunction with this service, Santa Fe set up neutral chassis pools in Chicago (operated by XTRA) and Los Angeles (operated by Flexi-Van). In July, 1988, Santa Fe inaugurated "Quality Stack" service between Los Angeles and New York under an arrangement with Conrail that leaves Santa Fe in control of service, pricing, and marketing.

Southern Pacific. Until December 1988, SP operated double-stack trains almost exclusively from its Intermodal Container Transfer Facility (ICTF) in Los Angeles. (Figure I-16) The ICTF gave SP a competitive advantage in the largest intermodal market, while tunnel clearance restrictions and the uncertain future of the Central Corridor (overland route) discouraged marketing efforts in Northern California.

SP currently schedules four daily eastbound common-user double-stack train departures from the ICTF. These trains are destined for Chicago, Memphis, Houston, and interchange with Conrail at St. Louis. Three daily westbound trains to Los Angeles depart from Pine Bluff, New Orleans, and a BN interchange at Kansas City. Other double-stack or conventional cars return on regular SP intermodal trains. On days when traffic is light, some of the

Figure I-16
Southern Pacific Double-Stack Routes



eastbound trains may be combined as far as El Paso or some other intermediate point.

SP operates a daily dedicated train for Sea-Land to Memphis, and three weekly trains. A Sea-Land train to New Orleans departs on Monday, and Sea-Land Chicago trains depart Monday and Wednesday. A daily Sea-Land train returns westbound from Memphis.

There are two dedicated NYK trains from L.A. on SP. The first departs on Sunday for St. Louis, using SP's original ACF-built double-stack cars. A second NYK train departs Friday and splits to serve Chicago and St. Louis. Two westbound trains return from St. Louis.

Mitsui (MOL) has two dedicated departures on SP, both leaving L.A. on Sunday. The first splits to serve Chicago and St. Louis. The second goes to Memphis. THe Memphis train returns westbound, and the Chicago and St. Louis portions are combined as a single westbound train.

SP operates three weekly dedicated trains from the ICTF for Evergreen. Trains depart Saturday and Tuesday for Chicago, and the third train departs Tuesday and splits to reach New Orleans and Memphis. The two Chicago trains return westbound, and the westbound Memphis and New Orleans trains are combined.

On the Southern Corridor, SP originates six weekly trains for American President Intermodal. Three operate on Sunday, Wednesday, and Friday via Houston to New Orleans for interchange with Norfolk Southern to Atlanta. The other three operate Saturday, Tuesday, and Thursday to Memphis via Dallas. The corresponding westbound Memphis and New Orleans trains are combined. There is one extra westbound train received from Norfolk Southern at New Orleans that apparently triangulates imbalanced Chicago - Atlanta traffic (API operates four Chicago - Atlanta trains, but only two Atlanta - Chicago trains).

SP now has thirteen scheduled weekly eastbound departures for ESI, six of which are actually separate trains, the domestic offshoot of OOCL that solicits traffic from other ocean carriers as well. There is a daily scheduled

service for Memphis, which typically operates as part of another SP train. The six separate trains depart the ICTF on Sunday for Memphis, Monday for Houston and Chicago, Wednesday for Chicago, Thursday for Houston, and Saturday for Chicago. All these trains have westbound counterparts.

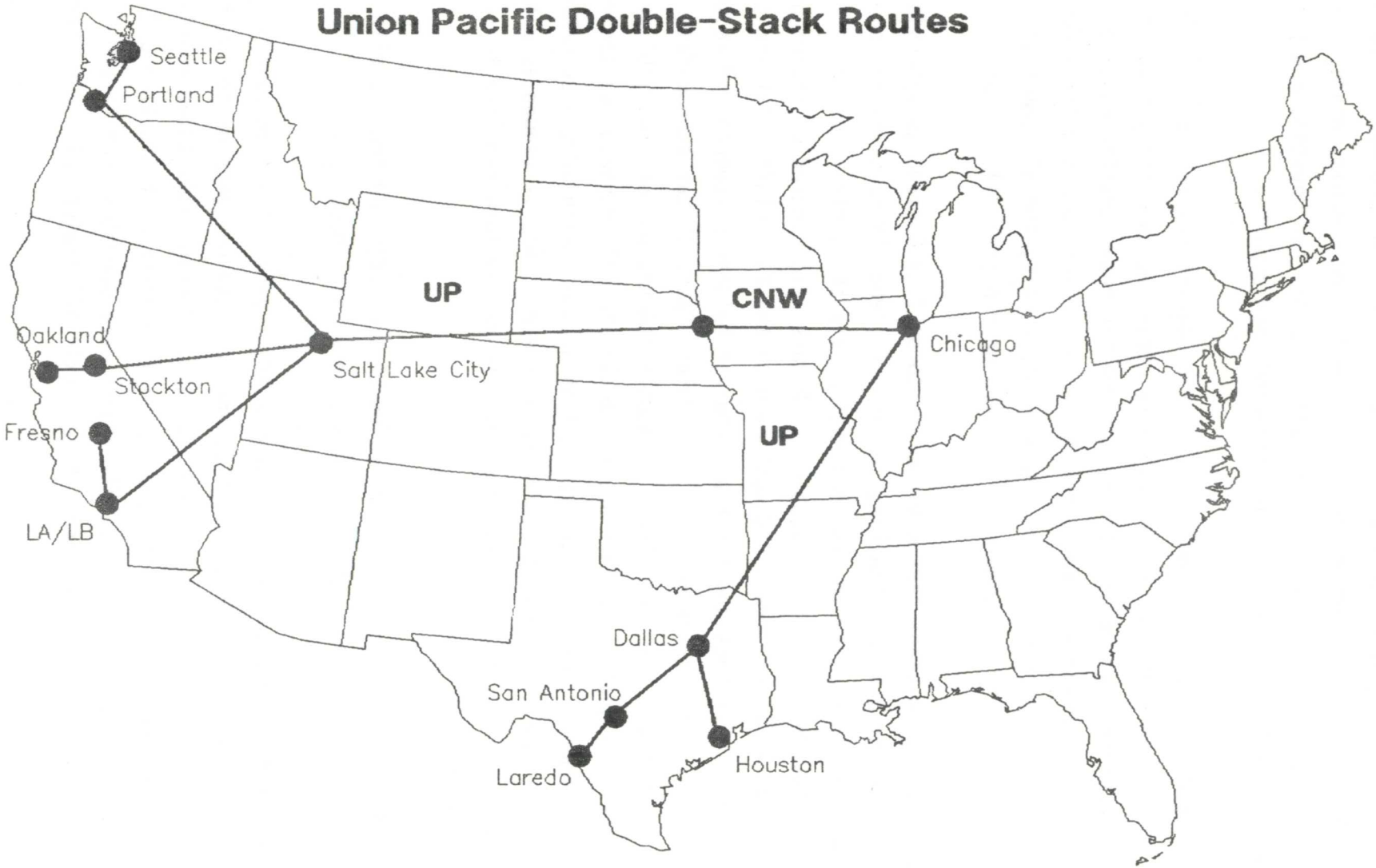
SP thus schedules about 57 weekly double-stack departures from the Los Angeles ICTF. The actual number of trains may vary depending on which scheduled departures are combined as a single train, and whether heavy traffic requires extra trains for some schedules. While the dedicated trains operated for steamship companies generally consist of only double-stack cars, the SP common-user trains may also carry containers or trailers on conventional cars as required.

On occasion, double-stack cars may operate to or from Oakland as extensions of Southern Corridor trains. Starting in December 1988, SP is offering common-user double-stack service to and from Oakland via the Central Corridor over the Sierra Nevada. Initially, double-stack cars were handled eastbound on the daily Oakland - Memphis train and westbound on the Pine Bluff - Oakland train. By switching trains back and forth as required between eastbound and westbound tracks of its double-track mainline over Donner Pass, SP can accommodate combinations of 8'6" and 9'6" containers on double stacks, but not two 9'6" containers together. Signaling is in place to facilitate this maneuver westbound, but not eastbound; for eastbound operations SP uses train orders or schedule authority of some kind to keep other trains clear. This is viewed as a temporary solution until traffic growth warrants the expenditure required to raise tunnel clearances.

Union Pacific. All double-stack trains on UP are dedicated trains, with the major customer being API. UP's routes are shown in Figure I-17.

From Los Angeles, UP operates seven weekly API trains. Six terminate in Chicago (API trains LC1, LC2, LC4, LC5, LC6, and LC7) and one goes on to South Kearny via Conrail (train LK5). From Oakland, UP originates three weekly API trains to Chicago (OC1, OC5, OC7), which include pickups at Stockton and Sacramento. Connecting services, not full trains, are operated from Fresno (FA1, FA6). From Seattle, UP originates three weekly API trains, all to Chicago

Figure I-17
Union Pacific Double-Stack Routes



(SC2, SC4, SC6). Altogether there are thirteen API departures from the West Coast ports on UP.

Westbound, UP operates seven weekly multi-destination API trains originating on CNW at Chicago. These trains (CW1-7) serve different mixes of all the API service points in the West. There are also three short-distance API trains westbound from Salt Lake City to Los Angeles on UP (UL1, UL4, UL6). Four weekly API trains move from Chicago via CNW and UP directly to Los Angeles.

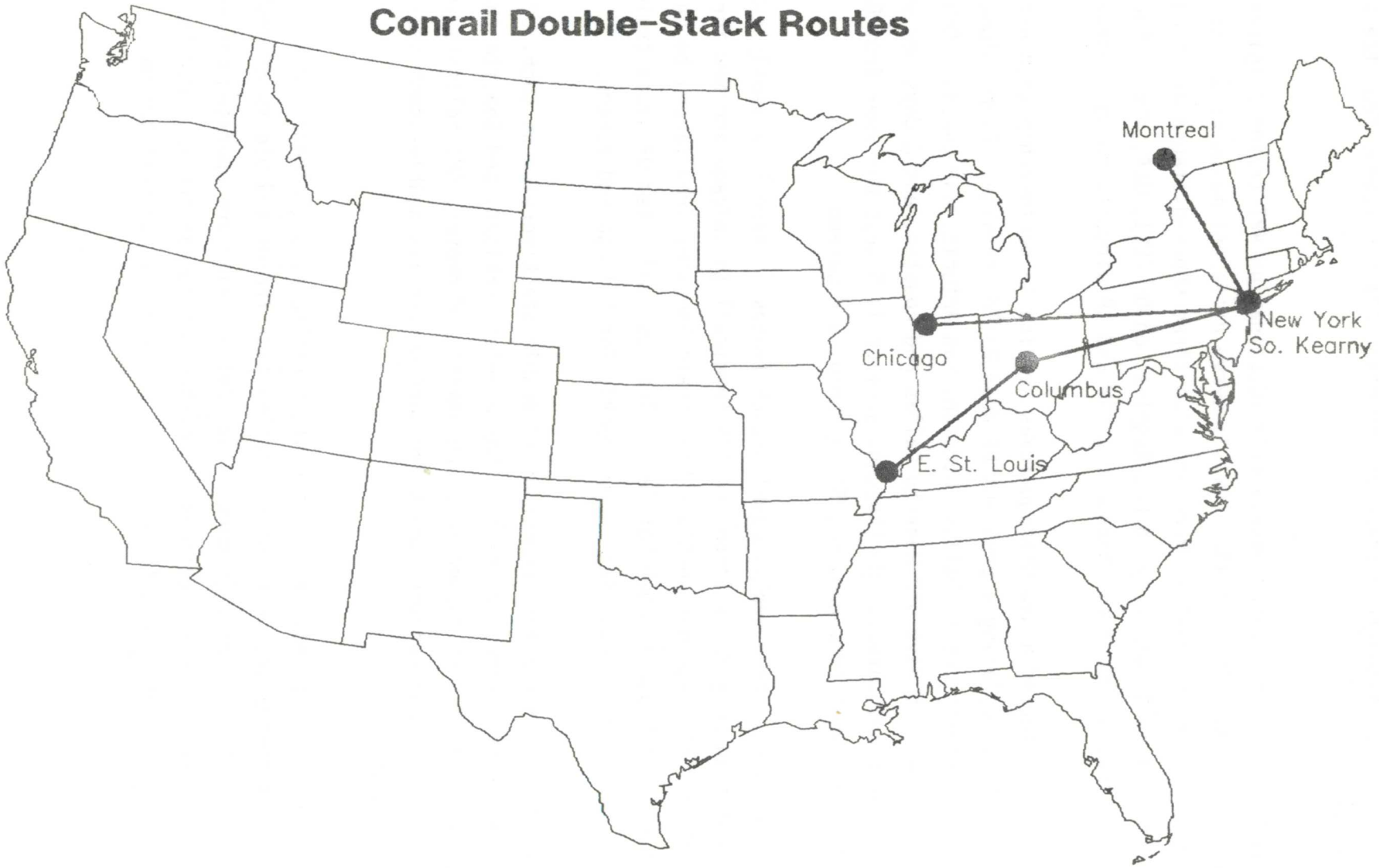
Union Pacific started a new Chicago-Texas service in partnership with API in December, 1988, replacing a previous UP Road Railer service. From Chicago, UP moves API double-stacks to Dallas, Houston, San Antonio, and Laredo. Southbound, service is 5 days per week to Dallas and Houston, and 6 days per week to San Antonio and Laredo. Northbound, service is 5 days per week from Dallas, and 4 days per week from Houston, San Antonio, and Laredo.

UP operates three other weekly double-stack trains. There is a weekly K-Line train departing Long Beach (from the ITS terminal) to Chicago and New York (via CNW and CR). Another weekly K-Line train operates from Tacoma to Chicago and returns westbound through Portland. The last dedicated UP stack train is operated for Maersk, departing Tacoma weekly for Chicago and return.

Although UP does not offer "common-user" double-stack service as such, UP does operate daily intermodal trains from Los Angeles, Oakland, and Seattle that can carry containers on conventional equipment. Moreover, API solicits traffic from other ocean carriers and third parties for its double-stack trains operating over UP.

Conrail. Conrail connects with the western railroads at Chicago and East St. Louis, and interchanges both entire double-stack trains and blocks of double-stack cars at both points. (Figure I-18) Solid trains are operated either on their own schedules or as sections of regular intermodal trains. Blocks of double-stack cars are added to Conrail's "TrailVan" intermodal trains.

Figure I-18
Conrail Double-Stack Routes



Conrail handles API's traffic between eastern cities and the CNW interchange at Chicago. API schedules three weekly departures from South Kearny to Chicago (trains KC1, KC4, and KC5). In Chicago, these trains connect with API's west coast services via UP/CNW. Eastbound, API schedules just one complete weekly train between Los Angeles and South Kearny (train LK5), which travels over Conrail east of Chicago. Conrail, however, handles API double-stack traffic on regular TrailVan trains between Chicago and South Kearny six days per week. API thereby offers South Kearny arrivals every day but Saturday.

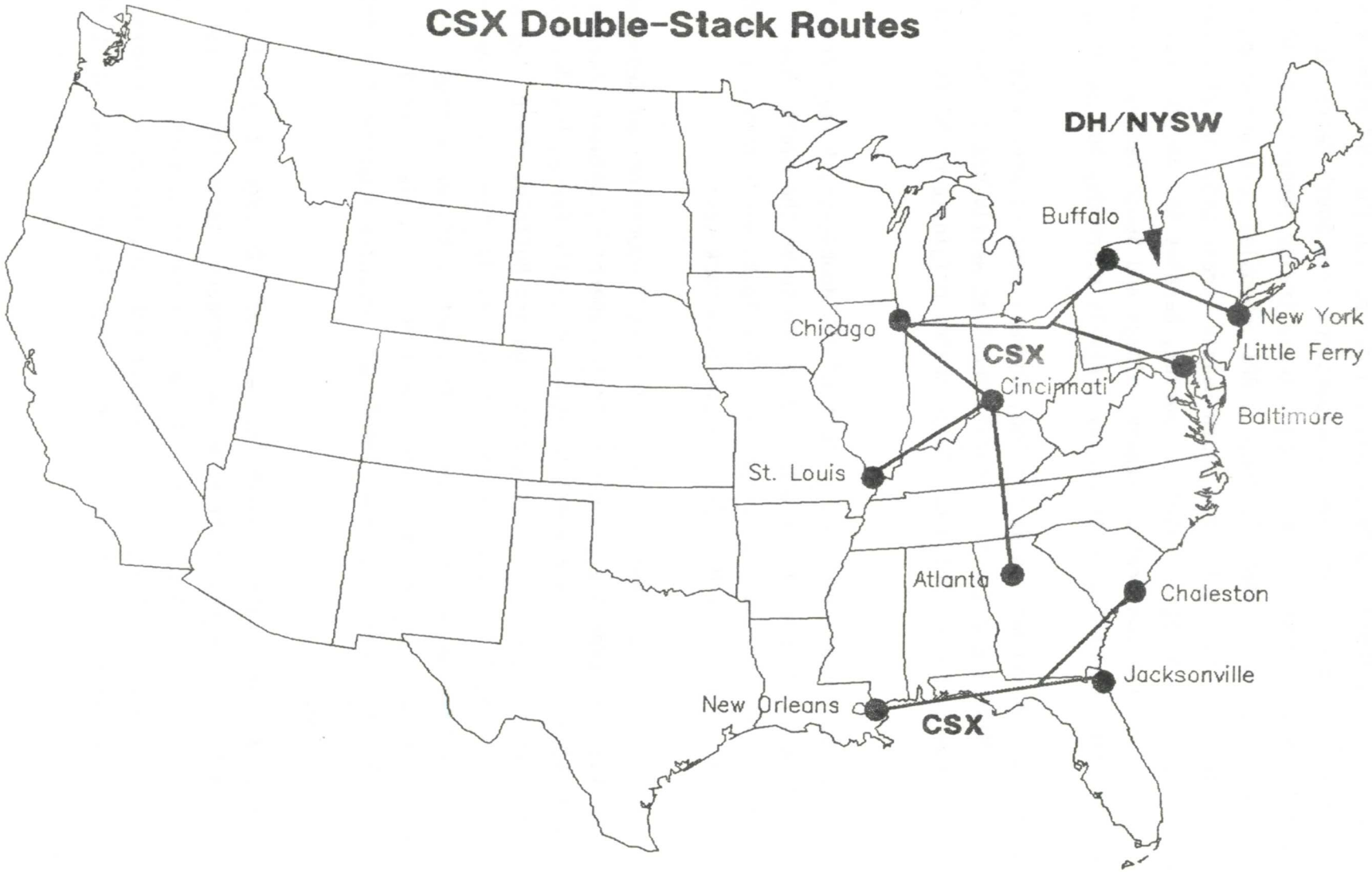
Also from the UP/CNW connection at Chicago, Conrail handles weekly Chicago-New York trains for Maersk and K Line. Conrail receives weekly NYK and MOL double-stack trains from S Line at Chicago. These trains originate on SP in Southern California.

At East St. Louis, Conrail receives a block of MOL double-stack cars from SP (SSW). These cars are moved to Columbus, Ohio, to serve the nearby Honda plant at Marysville. The cars continue on to New York, where they are combined with the Chicago-New York MOL cars for the trip back west.

CSX. Not surprisingly, CSX handles the eastern rail operations of Sea-Land trains. The major movements are 3 weekly trains operating between Chicago (from SP and BN) and CSL's intermodal terminal at Little Ferry, New Jersey. CSX actually operates the trains between Chicago and Buffalo, where they are interchanged with the Delaware & Hudson. (Figure I-19) The D & H (now under operation by the NYSW) moves the trains to Binghamton, NY, where they are interchanged with the New York, Susquehana Western for the last leg into Little Ferry. The Little Ferry terminal itself was recently acquired from the NYSW.

CSX also operates several other routes for Sea-Land: Chicago-Atlanta (2 per week); Chicago-Port Covington (Baltimore); New Orleans-Charleston (as part of CSX's daily Gulfwind); and New Orleans-Jacksonville (with conventional interchange to FEC for Miami). Besides the Sea-Land traffic, CSX moves a portion of NYK's weekly east-west train between the SP interchange in East St. Louis and Cincinnati.

Figure I-19
CSX Double-Stack Routes



CSX's Chicago-Baltimore service was originally begun by the Chessie System under an arrangement with the State of Maryland.

CSX has pursued a somewhat different double-stack strategy, preferring to add double-stack cars to existing "double-stackable" intermodal trains. A case in point is the Gulfwind, which has taken the place of the former United States Lines double-stack train between Savannah and New Orleans, and the former Evergreen double-stack train from Charleston. As of late 1988, CSX counted 27 weekly double-stack departures and 25 daily intermodal trains.

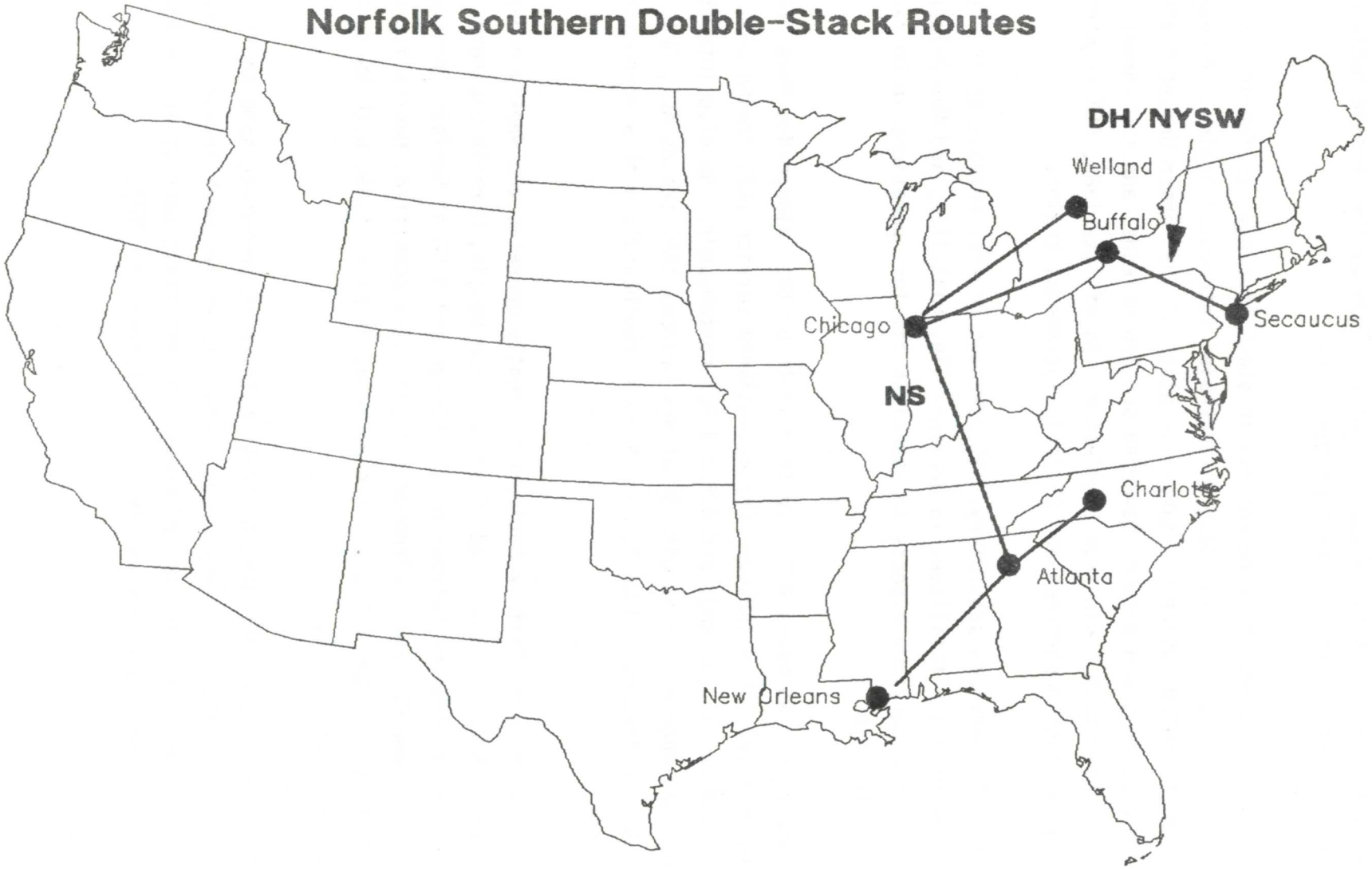
Through its CSX Services subsidiary, CSX operates neutral chassis pools and container maintenance facilities in Jacksonville, Nashville, and New Orleans. By mid-1989, CSX Services expects to establish similar operations in Chicago, Atlanta and Memphis.

Norfolk Southern. NS moves API's traffic south of the Chicago-New York corridor. (Figure I-20) This includes Chicago-Atlanta service (API trains CA1, CA3, CA4, and CA5 southbound, and AC5 and AC7 northbound). NS also interchanges Atlanta-Los Angeles trains with SP at New Orleans (API trains AL1, AL4, AL6, and AL7 westbound, and LA 2, LA5, and LA7 eastbound), with a connection to Charlotte.

For K-Line and Maersk, Norfolk Southern presently operates two weekly round trips between Chicago and Welland, Ontario. For Hanjin, Norfolk Southern handles a weekly movement between BN at Chicago and NYSW at Buffalo (destination Secaucus, New Jersey). Although not yet fully committed, Maersk is expected to add service between Chicago and Montreal in early 1989, with NS to move the trains through Buffalo.

In the Buffalo-Chicago corridor, Norfolk Southern is operating some short double-stack trains with two-man crews. Four trains per week in each direction currently operate with reduced crews. Normal train consist is one locomotive and up to non five-platform cars (45 platforms, 90 FEU).

Figure I-20
Norfolk Southern Double-Stack Routes



Grand Trunk Western. GTW moves API double-stack traffic between Chicago and Detroit (API trains DC5 and DC7). (Figure I-21) The API traffic was originally handled at GTW's intermodal facility, but API has recently opened its own facility at Woodhaven, 18 miles from Detroit on GTW.

CNW. Chicago and North Western provides UP and its customers with a vital connection between Fremont, Nebraska and Chicago. (Figure I-21) All of UP's dedicated trains for API, Maersk, and K-Line use this route.

SOO. SOO Line provides SP with a Kansas City-Chicago connection for those clients not using the BN connection. (Figure I-21)

IAIS. Iowa Interstate (IAIS) operates a domestic double-stack service for Interdom, Inc., for which Maytag Appliance provided the original start-up traffic. Interdom's service is based in Newton, Iowa (approximately 30 miles east of Des Moines) where Maytag has a major plant and Iowa Interstate has recently upgraded its intermodal facility. IAIS operates over a combination of its own trackage and trackage rights between Blue Island, Illinois and Council Bluffs, Iowa, providing daily service in the Chicago-Los Angeles corridor in conjunction with UP and CNW. Interdom operates a fleet of leased double-stack cars and containers (including 150 48-foot-long, 102-inch-wide containers built especially for domestic service), and was moving roughly 200 loads per week in late 1988.

NYSW/D&H. The New York, Susquehana & Western (NYSW) was for several years the only regional railroad involved in double-stack traffic, carrying Sea-Land trains between Binghamton, New York and Little Ferry, New Jersey on a combination of NYSW's own trackage and trackage rights over Conrail. (Figure I-22) In the last year, this operation has changed in two ways. First NYSW sold the Little Ferry terminal to CSL (CSX/Sea-Land Intermodal). Second, NYSW has become the directed service operator of the Delaware & Hudson after that carrier's bankruptcy. D&H previously handled Sea-Land trains between Buffalo and Binghamton; NYSW now effectively has a single-line haul between Buffalo and Little Ferry.

Figure I-21

CNW, GTW, SOO, and IAIS Double Stack Routes

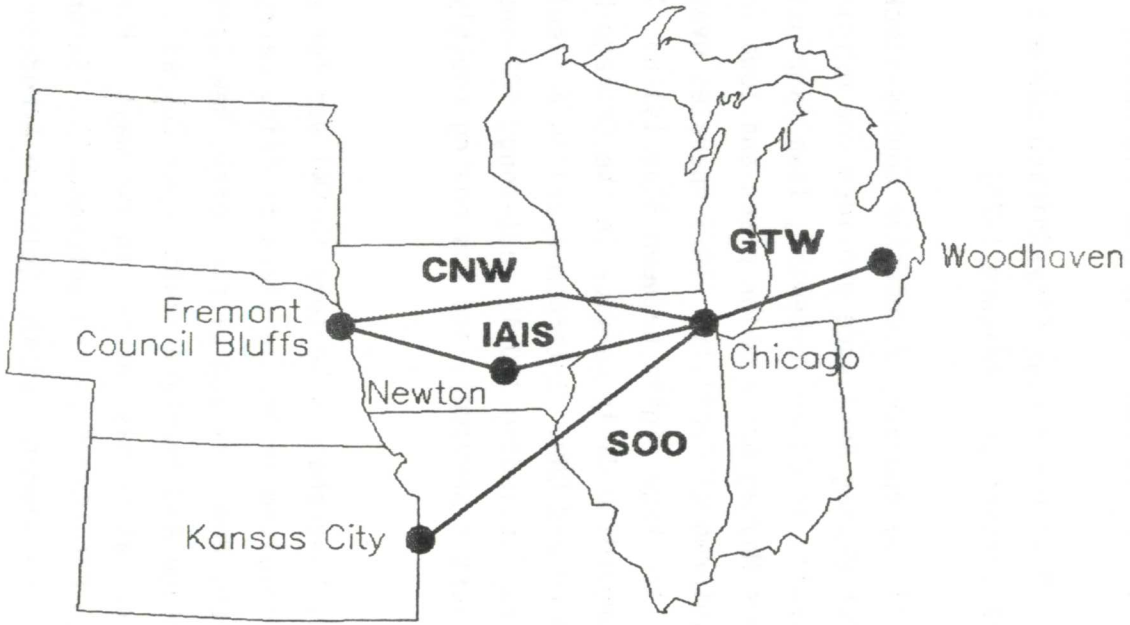


Figure I-22
D&H / NYS&W Double-Stack Route



Canadian National. Canadian National Railway has announced plans to begin weekly Vancouver-Toronto double-stack service by the end of January, 1989. The trains would initially consist of 30 platforms (6 5-platform cars), with the equipment provided by Trailer Train. Because CN still has some clearance restrictions, the service will emphasize 8-ft. and 8-ft. 6-inch high containers with careful matching of equipment.

CURRENT DOUBLE-STACK NETWORK AND MARKETS

The current 1989 double-stack network is shown in Figure I-23. Each of the seven major railroads -- ATSF, BN, CR, CSX, NS, SP/DRGW, UP -- operates numerous double-stack services, including dedicated trains, common-user trains, and blocks of double-stack traffic on other intermodal trains. Of the next smaller group of railroads, Soo Line, CNW, GTW, and D&H/NYSW all offer some double-stack service.

IC, and the remaining portions of the Guilford System (BM, MEC) do not now participate in double-stack movements. IC formerly provided a St. Louis-Chicago link for some SP double-stacks that have since switched to BN or SOO routes.

Other than the Iowa Interstate and the NYSW, none of the "new" regional carriers carries regular double-stack traffic. This is not surprising, since these regional railroads were formed from trackage sold by the Class I carriers, which is unlikely to include major intermodal corridors or hubs. Moreover, double-stack traffic demands high standards of track maintenance and linehaul service that newly formed regional railroads are largely unable to provide.

The combination of routes and hubs shown in Figure I-23 yields very extensive national coverage, enabling double-stack trains to serve all major U.S. markets. Figure I-24 illustrates this point, using a 250 mile drayage radius to show the area accessible from each double-stack hub. The 250 mile radius is a commonly used ballpark figure for maximum intermodal drayage.

Figure I-23

1989 DOUBLE-STACK NETWORK

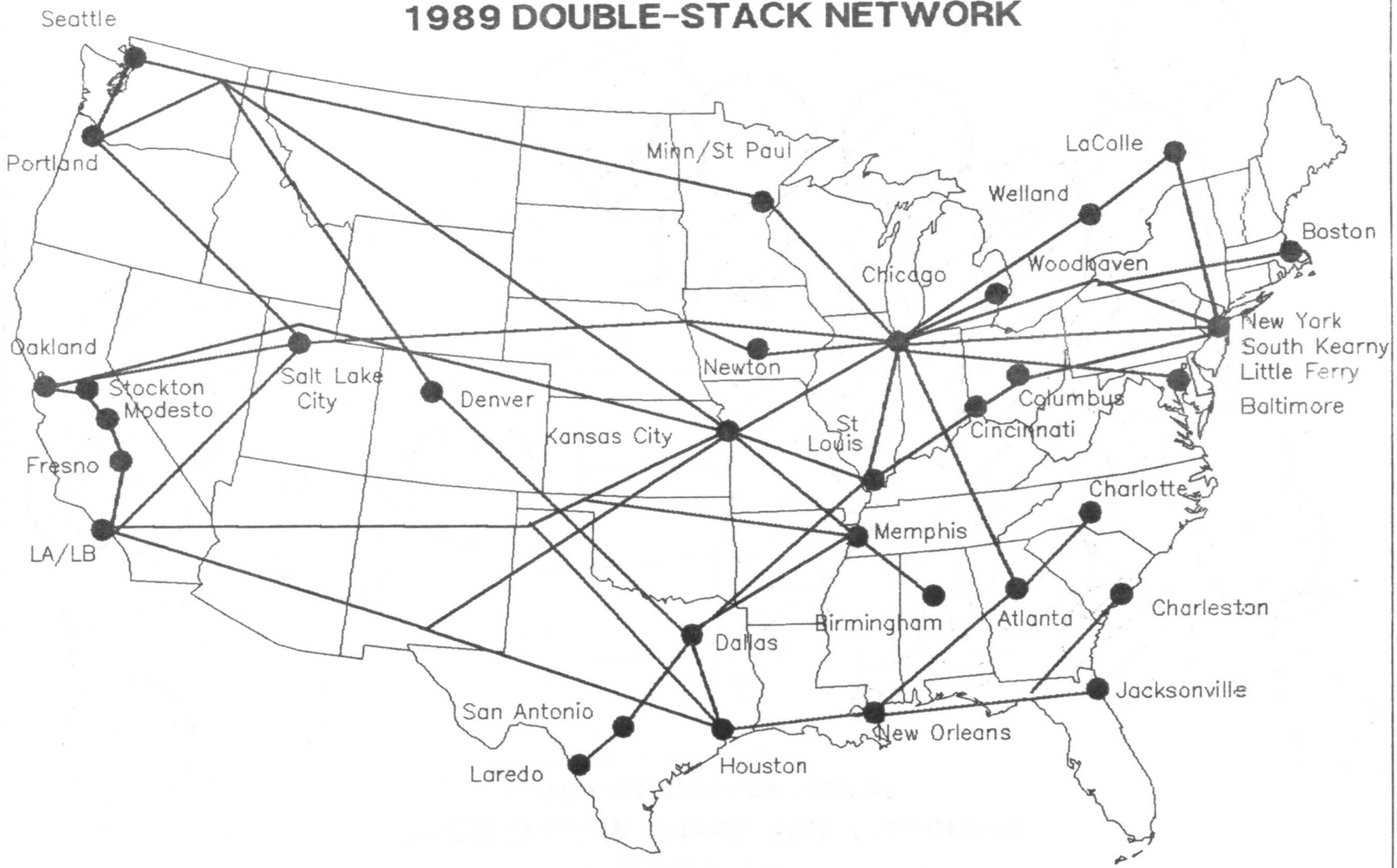
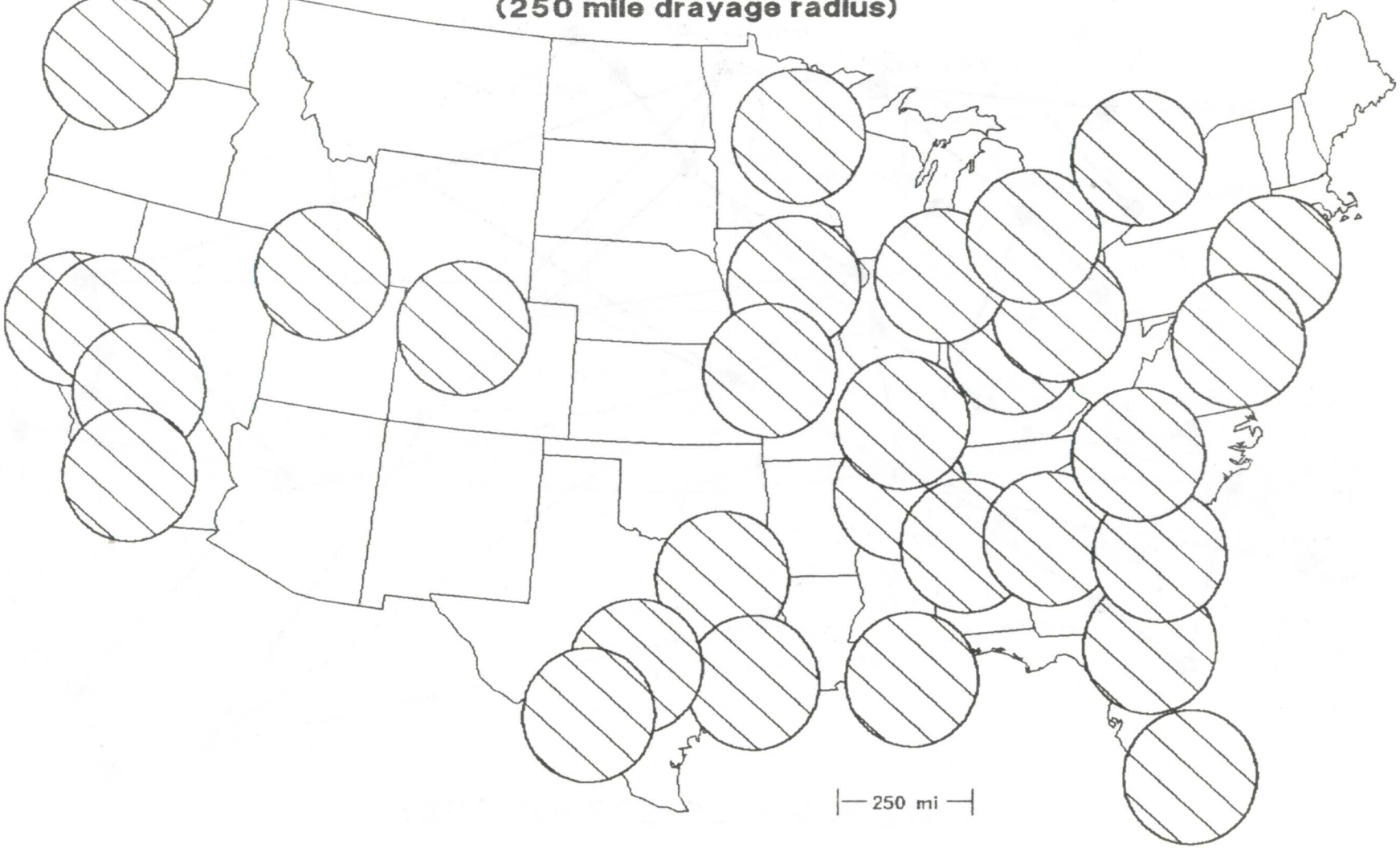


Figure I-24
1988 Double-Stack Hub Coverage
(250 mile drayage radius)



The drayage circles shown in Figure I-24 cover virtually all major U.S. population centers. The significant "gaps" shown include middle Pennsylvania (Altoona), the Tennessee/Kentucky border (Nashville/Knoxville), and central Wisconsin (Oshkosh/Green Bay). It is likely that further traffic development in these areas would lead carriers to establish hubs to serve them.

BACKHAUL ARRANGEMENTS

Double-stack service depends, like all transportation services, on utilization. Utilization in turn depends on the ability to fill equipment with revenue-producing loads in both directions. The introduction and growth of double-stack services was based on international traffic, which has had a strong imbalance of imports over exports. This imbalance placed a premium on the ability of carriers to attract backhaul freight. Although the increase in domestic container movements and the growth of exports has somewhat diminished the importance of backhaul freight, many of the arrangements made to solicit backhauls are still in place and will play a role in the further development of double-stack service.

APL's initial double-stack train of mid-1983 was an experiment in backhaul solicitation as well as an experiment in technology. For that train, and for some subsequent movements, APL arranged for two subsidiaries of Transway International, Western Carloading and Merchant Stor-Dor, to solicit and provide the backhaul freight. APL undertook a permanent solution to the backhaul problem by acquiring National Piggyback, then the nation's largest intermodal shippers' agent. American President subsequently reorganized to place all domestic activities in a subsidiary parallel to APL, namely American President Domestic (APD). APD now oversees American President International (API, which operates the trains) and the activities of National Piggyback and other domestic subsidiaries.

The underlying economies of American President's backhaul program are controlled in part by the terms of API's contract with Union Pacific. Although the actual terms are, of course, proprietary, the key features are:

- o pass-through of equipment costs, giving API the incentive for high utilization;

- o a round-trip rate, obligating API to pay for the movement of containers in both directions; and

- o a relatively low "additive" rate for loads (rather than empties) in the backhaul direction.

It is thus in the interest of both API and UP to fill the containers with backhaul freight. The "additive" rates give a fixed cost to API above which any backhaul revenue is net. Similar contracts have been offered to other potential Union Pacific customers.

A second basic approach has been taken by BN, ATSF, and SP. The ocean carriers from which these railroads were soliciting traffic did not buy domestic shippers' agents or make comparable investments in their ability to solicit backhauls, and were unlikely to do so. BN, ATSF, and SP reached various agreements to "buy back" portions of the westbound capacity of the proposed trains, and to solicit the backhauls themselves.

This arrangement is implemented through a charge for moving empty containers, a charge for moving containers with ocean-carrier loads, and a different "management fee" for returning a container with a railroad-solicited load. The "management fee" is usually significantly less than the charge for moving an empty container, and the railroads typically agree to return the container to the West Coast within 30 days (which is often faster than the ocean carriers can get it back by themselves). Ocean carriers are thus encouraged to solicit exports through their own sales force, and to turn over the remaining empty containers to the railroad. Some ocean carriers do not solicit exports at all, preferring to turn over all westbound containers to the railroad and forego the expense of an inland sales force.

The railroads market this "buyback" capacity either through their own sales force, or, more commonly, through third parties. One important benefit of

this arrangement is the preservation of railroad control over inland intermodal solicitation, an especially important consideration for Santa Fe, which had a large share in the Chicago-Los Angeles piggyback market.

VII. RAIL INTERMODAL TECHNOLOGIES

THE INTERMODAL FLEET

The composition of the rail intermodal car fleet is changing rapidly. As shown in Table I-14, there has been a massive increase in the double-stack fleet but a much smaller increase in the third-generation TOFC car fleet. The existing fleet of first and second generation TOFC and COFC cars is dwindling, and a much larger proportion of total intermodal capacity is devoted to containers. One specific sub-issue is the longevity of railroad piggyback cars (flat cars, articulated skeleton cars, and stand-alone frame cars) compared to piggyback trailers: cars may last 20 years or more, while trailers last 5-7 years. Thus, even if containers upplant piggyback trailers, unconverted piggyback equipment may still be a valuable asset for container-on-chassis or COFC service.

Double-Stack Cars. A dramatic change occurred in intermodal car design with the introduction of double-stack cars. In 1977, American Car and Foundry (ACF) and Southern Pacific cooperated in the design and construction of a single, stand-alone double-stack car. The car was regarded by some as a dead-end experiment or a curiosity, but operated over SP successfully for two years before more double-stack cars were built.

ACF/SP. In 1979, SP and ACF introduced a three-unit version of the single-unit double-stack prototype. In 1981, ACF build 42 5-platform cars for SP, which SP then used for Sea-Land traffic.

The SP/ACF cars use bulkheads to secure the containers. Because these cars were designed with Sea-Land traffic in mind, the bulkheads are equipped with "flippers" to hold either 35-foot or 40-foot containers. They have a relatively high tare weight of 39,400 lbs. per platform.

These cars are still in use, and were most recently assigned to NYK's Los Angeles-St. Louis trains.

Table I-14

INTERMODAL FLEET

			Third Generation Cars		
	Total Spaces*	Conventional Cars	Trailer Cars	Double-Stacks	Road-Railers
1983	110,000	109,000	200	400	300
1984	112,000	109,000	700	2,000	300
1985	119,000	109,000	2,900	7,000	300
1986	118,000	102,000	3,100	13,000	300
1987	116,000	93,000	4,800	18,000	1,400
1988	118,000	88,000	5,800	24,000	2,300
1989	120,000	79,000	9,000	30,000	2,300

* Units are trailer or container spaces or slots.

Source : Greenbrier Intermodal

Budd/Thrall. In 1984, American President Lines placed its first 5-platform double-stack cars in service. They were built by Thrall and designed by Budd. A few cars were built with generator sets to power refrigerated containers. A major feature of these cars was the use of interbox connectors (IBCs) to lock the containers in position. Thrall claimed that IBCs would allow faster loading than the ACF/SP bulkhead system.

The Thrall cars are based on the Budd LoPac-2000 design, which among other things was intended to move piggyback trailers through restricted clearances by placing them in a depressed well. The design was adapted for container use by replacing the well floor with container brackets. The lack of bulkheads had unforeseen importance when domestic containers of 48-feet and 53-feet had to be accommodated. The provision of multiple attachment points on these containers allowed them to be stacked on top of 40-foot and 45-foot containers where they could not fit in 40-foot or 45-foot bulkheads. The original cars had 40-foot wells. Starting in 1985, Thrall produced new well lengths to accommodate 45-foot, 48-foot, and even 53-foot containers, although they could already be carried on the top layer.

FMC/Gunderson. "Twin-Stack" double-stack cars was introduced by FMC in 1984, and subsequently built and marketed by Gunderson. These cars used bulkheads to secure the containers, which entails a higher tare weight. These cars were delivered to BN beginning in 1985 under Greenbrier Leasing's reporting marks. Sea-Land's initial dedicated trains used Gunderson cars with NYSW reporting marks. Nearly 4000 have been delivered thus far. Sea-Land, ATSF, BN, CR, and SP are the main users, with the majority actually owned by Trailer Train.

In 1985, a special, aerodynamically improved version of the Twin-Stack bulkhead car was produced. Wind-tunnel tests have shown that the length of the gap between containers on adjacent platforms is the single most important factor in air resistance. Gunderson designed and built a Twin-Stack version with vertical metal panels ("barn doors") between containers, effectively splitting a long gap that allowed turbulent airflow into two smaller gaps that did not interrupt the airstream. The car was ungainly, but effective. The vertical panels interfered with loading and unloading,

however, and were counter-productive unless the car was full. Subsequent bulkhead cars have not had these features. Moreover, no bulkhead cars have been produced since 1987.

The need to accommodate larger containers and the desire to maximize weight capacity have led Gunderson to re-design recent offerings as IBC cars, eliminating the bulkheads. These new designs are marketed as "Maxi-Stack" cars.

Trinity. Trinity's double-stack cars are derived from a Youngstown "Backpacker" prototype, using an IBC design. Only about 300 cars had been delivered to Trailer Train and BN, making Trinity a minority builder. Most of the Trailer Train cars were used by K-Line.

Double-Stack Comparisons. Table I-15 compares the principal features of six different double-stack models built by Gunderson, Thrall and Trinity, and the comparable specifications of the Trailer Train, "spine car" (as built by Trinity). Several points are immediately apparent:

- bulkhead cars (Gunderson Twin-Stacks) have a higher tare weight and a lower net capacity than IBC cars;
- total length grows with the ability to handle larger containers, up to a point (the ability to place 53-ft. containers on the upper level of IBC cars entails no length penalty); and
- all of the current double-stack designs have substantial tare weight advantages over the spine car.

The specifications also show that the newest double-stack cars from the three active builders are all very much alike. The Gunderson Maxi-Stack II, the Thrall LoPac II 40/48, and the Trinity Backpaker-48, are all about 290 feet long, weight 36,000 - 38,000 lbs. per platform, and can accommodate 48-53 ft. containers.

Table I-15

DOUBLE-STACK CAR COMPARISONS

	Type	Top/Bottom Container Lengths	Tare Pounds Per Platform	Net Pounds Per Platform	Overall Length
LO-PAC 2000	IBC	40/45	30,050	100,000	266-1
LO-PAC II	IBC	40/48	37,000	122,000	267-5
Twin Stack	Bulkhead	40/45	34,000	100,000	265-1
Maxi Stack	IBC	40/48	35,400	124,000	265-1
Maxi Stack II	IBC	48/53	36,800	122,000	289-8
Backpacker-48	IBC	40/48	32,400	102,500	267-2
Spine Car	--	48/--	26,120	67,200	251-7

In 1985, Thrall Car Co. designed a new single unit car (DTTX 110022). It was built and tested as a demonstrator for Trailer Train, but there have been no production deliveries. Although the first ACF/SP double-stack car was a single--unit design, all subsequent production cars have been multi-unit articulated designs.

The notion of a single-unit double-stack car may have been formed in response to the perceived "inflexibility" of the 5-platform double-stack cars. In the early years of double-stack operations, many observers felt that double-stack cars could only move efficiently in unit trains on the busiest corridors. Whether or not unit train operations are required for maximum efficiency, double-stack cars are now commonly mixed with other intermodal cars. Moreover, the threshold volume of 10 40-foot containers to fill a single 5-platform double-stack car no longer seems like a large traffic increment in the current environment of container traffic growth. Finally, the spine car is now being advanced as an alternative for low-volume corridors. For all these reasons. the impetus behind single-unit double-stack development seems to have subsided.

Other Container Cars

Converted Container Cars. Through the 1970's there were examples of container car conversions, which often amounted to turning 50-foot flat cars into container cars. Santa Fe, for example, modified a number of its bulkhead flat cars into container cars. Western Pacific had a series of semi-permanently coupled flatcars in container service through the early 1980's. In the mid-1980's, Southern Pacific and Trailer Train converted a number of TOFC flatcars by removing a part of the deck and adding container pedestals. These cars could then carry either four 20-foot or two 40-foot containers.

Most recently, Trailer Train converted several of their 60-foot bulkhead and standard flat cars into container cars which could carry either three 20-foot containers, or one 20-foot and one 40-foot container. These and other Trailer Train conversions received VTTX or TTCX reporting mark, and are used in either assigned or general service.

These various converted container cars have met different needs at different times. The earliest conversions allowed the railroads to carry containers before specialized or dual-purpose intermodal cars were available. The second round of conversions re-used older, less desirable piggyback cars to accommodate the growing container traffic before the advent of double-stacks. The most recent conversions, the Trailer Train VTTX and TTCX series, are operating as an adjunct to double-stacks. These cars handle containers where double-stacks cannot go (and spine cars are not yet used). Their more enduring role, however, may be in handling the overflow of 20-foot containers. Because double-stacks can ordinarily handle 20-foot containers on the bottom of the end platforms only, corridors with heavy 20-foot container volumes require some supplementary equipment. Burlington Northern's trains between the Pacific Northwest and Texas reportedly handle a large proportion of 20-foot containers, and use a mix of equipment types.

Articulated Single-Stack. The first railroad to build a modern, articulated single-stack "skeleton" car for containers was the Union Pacific, in 1983. The car weighed 45 tons, and consisted of 5 units shaped like capital "I's" to support containers at their corners.

The multi-platform, single-stack container cars now in use are Trailer Train "spine cars." There are currently two designs: one from Trinity (a Pullman design), and the other from Bethlehem Steel Car. They were both introduced in 1987, are capable of carrying up to five 48-foot containers, and can carry 20-foot containers on every other unit.

Trailer Cars

Although sporadic movements of road trailers or even wagons on flatcars can be traced back into the 19th century, large scale trailer-on-flatcar (TOFC) service began in the 1950's. Early services used general purpose 50-foot flatcars that had been fitted with side rails, tie-down chains, and bridge plates to load and secure trailers. Early trailers were typically 20-30 feet long, and two could often be carried on a single flatcar. Trailers grew to 35 and

40 feet long, limiting a 50-foot flatcar to just one trailer. The Pennsylvania Railroad pioneered in the construction of especially designed TOFC flatcars 70 feet or more in length.

After the formation of Trailer Train, a series of semi-standardized 85-foot flatcars were designed and built by several manufacturers to carry two trailers each in regular TOFC service. These cars used collapsible hitches to secure the trailers rather than multiple tie-down chains.

Until the advant of mechanized lift equipment, TOFC trailers were usually "circus loaded." Circus loading is accomplished by positioning TOFC cars end-on to a sloping ramp, lowering bridgeplates to create a continuous driveable surface over the cars, and backing trailers up the ramp and into position one at a time. The name derives from the longstanding practice of loading circus wagons onto flatcars the same way. Without going into more detail, it can be said that circus loading is an inefficient and obsolete technology. While it was still in use, however, TOFC flatcars had to be equipped with collapsible hitches and moveable bridgeplates, both of which create maintenance headaches for the railroads.

Trailer-only TOFC cars, which commonly carried "TTX" initials under Trailer Train ownership, could carry containers on chassis, but not bare containers. Dual-purpose cars, the "TTAX" series, were designed and built with bridgeplates, collapsible hitches, and retractable container pedestals, to accommodate either trailers or containers. Although these cars were useful in being able to accommodate all types of intermodal traffic, the process of changing configurations was time consuming and the greater number and variety of moving parts created maintenance problems.

Converted Trailer Cars. Several railroads and private companies have rebuilt boxcars and flatcars to single-trailer intermodal cars converting numerous boxcars and flatcars into TOFC cars by removing the entire supestructure and part of the floor to leave the center sill and a platform for the trailer wheels. The Southern Railway also began a large-scale conversion in 1983; by the end of 1984, more than 1,500 cars had been rebuilt by the Southern and

Norfolk & Western shops. XTRA also began converting flatcars in 1985 at TG Railway, a contract shop in Fort Worth. Most XTRA cars have been placed in service under CNW reporting marks. MKT also did a number of conversions prior to the UP merger. About 3,000 cars have been converted into single-trailer piggyback cars.

TOFC Conversions. Another group of conversions involved modifying 89-foot flatcars to handle two 45-foot trailers. In 1982, the first cars were modified from former dual-purpose cars. Santa Fe and Southern Pacific both applied fixed hitches and removed bridgeplates on their 89-foot flat cars to carry two 45-foot trailers. TOFC cars with bridgeplates were no longer in demand, as the small circus loading facilities became less important and more expensive to operate. The bridgeplates were removed, making it necessary to load the trailers with mechanical lift equipment. Trailer Train reversed the positions of the trailers so they faced back-to-back on KTTX cars, which had the effect of increasing protection from theft. By the end of 1987, around 2,000 cars had been converted.

In 1985, Trailer Train began converting 89-foot flatcars into its new RTTX cars. Each car was equipped with two fixed hitches on the ends and one collapsible hitch just off-center in the middle, and has the capacity to move either two 45-foot trailers or three 28-foot trailers. Around 5,400 RTTX cars are in service.

In 1987, Trailer Train developed a method of carrying 53-foot trailers by taking two 89-foot flatcars and replacing the two adjoining couplers with a drawbar to create a two-unit flatcar. Hitches were installed on the two units to carry three 53-foot trailers, the middle one bridged between the two units. Approximately 100 of these "Long Runner" conversions have been produced.

Single-unit Trailer Cars. The four-wheel "Front Runner" intermodal flatcar has been built in quantity for Trailer Train. These cars feature two different single-axle trucks. Since 1983, about 2,800 have been built by eight different builders, including some from overseas.

Articulated Trailer Cars. In 1978, Santa Fe developed a multiple-unit articulated trailer-only car. They consisted of ten units, each with one fixed hitch and a platform to support one trailer. They are now known as "Fuel Foilers", originally known as "Ten Packs." ITEL acquired the rights for this design, and after making some modifications called them the "Impack" car. Cotton Belt, ITEL, and Trailer Train have purchased Impack cars and Santa Fe is now purchasing Impack cars rather than building their own.

In 1981, American Car and Foundry built a "4-Runner" prototype, similar to the Santa Fe/Impack model. It features a new single-axle truck instead of the conventional two-axle truck employed on the Santa Fe, ITEL and Thrall cars. Trailer Train received 101 of these cars. In 1983, ACF introduced a more conventional design car with standard trucks. Twelve sets were delivered to BN. A car by Thrall, the "ARC-5", is similar to the Impack cars. Twenty of these were built and delivered to Trailer Train in 1984.

Dual-Purpose Cars. Dual-purpose cars combine container and trailer capability. Trailer Train led the way with a dual-purpose car, the TTAX 89-foot flatcar. By 1988, most former TTAX cars had been improved by removing the bridgeplates and adjusting the hitches to allow two 45-foot trailers, or containers on chassis. These are now called TTWX cars. Santa Fe and Southern Pacific have also modified a number of dual-purpose cars to handle two 45-footers.

The only new dual-purpose car that has gone into limited production was the Pacific Car and Foundry design. These were three-platform cars capable of carrying a variety of different containers on special pedestals, and having fixed hitches forward of the area where the container would sit. PCF is no longer producing intermodal cars.

Trailer Fleet Changes. The effect of construction and conversion programs has been to change the composition of the major trailer car fleet -- Trailer Trains -- over the years. As Table I-16 shows, the TTX and TTAX TOFC and COFC fleets, which peaked in the early 1980's, have been largely retired or converted to more specialized and efficient types.

Table I-16

TRAILER TRAIN
TOFC AND TOFC/COFC CAR FLEETS

	1973	1982	1987
TTX	24,989	28,494	14,406
TTAX	2,916	14,564	39
KTTX	--	--	1,574
TTWX	--	--	14,215
WTTX	--	--	14,191
RTTX	--	--	5,395

Source: The Official Railway Equipment Register

Comparisons. Table I-17 provides weight comparisons between several car types. The double-stack cars offer significant advantages in net/tare ratio and in net tons per coupled length. Simply put, double-stack cars are a more efficient intermodal line haul vehicle. Table I-18 compares representative cars of each type on the basis of two cubic capacity measures: cubic feet per ton of tare weight, and cubic feet per foot of coupled length. It is apparent that double-stack cars provide the greatest cubic capacity per ton. The two other intermodal technologies -- the articulated TOFC cars and the spine container car -- exceed the cu. ft./ton of the 50-foot boxcar. In terms of train length, only the largest double-stack car produces more cubic feet per foot of coupled length than the boxcar.

CARLESS TECHNOLOGIES

Carless technologies seek to maximize rail linehaul efficiency by eliminating, or at least minimizing, the railcar itself. This approach may yield additional benefits in the ease of loading and unloading, and in minimizing the need for facility investment. Like most technologies, carless intermodal technology has a longer history than is usually recognized. In the 1950's, the Chesapeake and Ohio railroad tried carless equipment basically similar to modern RoadRailers to carry mail at the end of passenger and express trains. Similar equipment was tried in Great Britain at about the same time. These early attempts were short-lived, for a variety of reasons. Modern carless technologies have had an uneven record so far, with no operations lasting more than about three years. The Triple Crown service now offered by Norfolk Southern, and the XpressRailer service offered by CSX, however, show the promise of greater durability.

RoadRailers. The RoadRailer, in its various forms, is the most common carless technology and the only one that has seen commercial application. Indeed, "RoadRailer" is sometimes used as a generic term for carless technologies.

After some years of design work and prototype construction, production of RoadRailers began with the Mark IV 45-foot dry van model in 1981. The Mark IV RoadRailer is basically a highway trailer that also carries retractable rail

Table I-17

WEIGHT CAPACITY COMPARISONS

Car Type	Net Weight Capacity (lbs.)	Total Tare Weight (lbs.)	Coupled Length (ft.)	Net/ Tare	Net Lbs. Per Foot
Standard TOFC, 2 45-Foot Vans	104,000	93,600	93-8	1.11	1,110
Front Runner 48-Foot Van	50,000	40,000	53-10	1.25	929
Impack 5 45-Foot Vans	260,000	190,000	263-2	1.37	988
Standard COFC	116,000	83,800	94-8	1.38	1,225
Spine Car 5 48-Foot Containers	295,500	195,000	251-8	1.52	1,174
Double-Stack IBC 5 45-Foot Containers 5 48-Foot Containers	526,800	267,250	289-8	1.97	1,819
Boxcar 70-Ton, 50'6"	154,000	66,000	55-7	2.33	2,775
RoadRailer Mark V	48,800	16,200	48-0	2.01	1,017

Source: Manufacturers and Industry Publications

Table I-18

CUBIC CAPACITY COMPARISONS

Car Type	Cubic Capacity	Cubic Feet per Ton	Cubic Feet per Foot
Standard TOFC 2 45-ft. vans	61,000	130	65
Front Runner 48-ft. van	3,550	178	66
Impack 5 40-ft. vans	15,250	161	58
Standard COFC 2 40-ft. containers	4,800	115	51
Spine Car 5 48-ft. containers	17,250	177	69
Double-Stack IBC 5 45-ft. containers 5 48-ft. containers	32,500	243	112

wheels. The original RoadRailer design placed the rail wheels at the extreme rear, behind the highway wheels. For operational reasons the design was changed to place the rail wheels between the two highway axles. An air suspension system is used to change the highway to rail mode, and the RoadRailer carries both highway and rail compatible air brake systems. Because the RoadRailer is intended to operate in trains of 75 or more units, the frame is strengthened to handle the drawbar pull. On the rails, each RoadRailer is attached to the unit in front, without the benefit of additional wheels. Each unit thus supports a portion of its own weight, and a portion of the unit behind. In order to couple with standard locomotives, the first unit in each train must be a special AdaptaRailer.

Mark IV RoadRailers can be positioned on the tracks by a yard tractor, eliminating the need for ordinary railroad switching.

Early proposals called for eventual production of several types of RoadRailers, including dry bulk, tank, and even passenger versions. Some variations have been built for testing purposes, including two equipped to carry autos, a container chassis version, and prototype refrigerated units.

In 1986, the Mark V RoadRailer was introduced. In the Mark V system, the rail wheels take the form of a detachable bogey (freight car truck) equipped with brackets to hold the trailer body and a rail brake system. Besides reducing cost and mechanical complexity of the RoadRailer trailer, this change also significantly reduced the tare weight and increased the highway payload. Because the rail bogey remains with the railroad, each bogey can serve more than one trailer body. The current accepted ratio is 175 trailers per 100 bogies. Trailer Train has recently begun to participate in the supply of bogies. Current versions of the Mark V have reached 53 feet in length with a 96-inch door width.

The primary advantages of RoadRailers are the reductions in tare weight compared to TOFC technology, the elimination of a separate chassis, the reduction in investment for railcars (although the Mark V requires an investment in bogies), and greatly reduced facility cost. RoadRailers themselves are expensive,

however, relative to trailers: roughly $40,000 rather than $5,000. This greater capital expense creates problems with railroad control over equipment that leaves the property, since utilization becomes critical. RoadRailers are also at a tare weight disadvantage relative to trailers, although the Mark V version narrows the gap.

The corporate history of the RoadRailer is complex. It was originally designed and produced by By-Modal Corporation. Bi-Modal was subsequently acquired by North American Car Company, which was in turn a subsidiary of Tiger International. Following a spin-off from Tiger International, North American Car Company entered bankruptcy and sold Bi-Modal's rights to the RoadRailer design to Thrall Car Company. Thrall had earlier been acquired by Duchossis Industries. RoadRailers are now marketed by Thrall, with the trademark held by the RoadRailer Division of the Chamberlin Group, Inc., a Duchosssis affiliate. Actual manufacturing of recent orders has been done by the Stroghton Trailer Company.

RailMaster. The RailMaster design was basically identical to the Mark V RoadRailer, a trailer body carried on a demountable rail bogey. None were produced. A patent dispute was resolved when RoadRailer purchased the RailMaster rights in 1987.

Railtrailer. The Strick Railtrailer design has much in common with the Mark V RoadRailer. Instead of attaching each unit directly to the unit in front, however, the Strick design carries both ends of the trailer body on bogies via standard ISO container corner castings. This eliminates the need for the heavily reinforced tongue of the RoadRailer, and simplifies rail/road conversions. The Railtrailer is lifted from the bogies with a scissors device, rather than with the RoadRailer's air suspension. Strick is a major domestic trailer manufacturer. The bogies are designed and produced by Sambre et Meuse, a French firm. Prototypes have been built for testing, although there has been no commercial application as yet.

Trailer-Railer. The Trailer-Railer is a hybrid technology produced by the Trailer-Rail Corp. Although commonly included with the carless technologies,

Trailer-Railers are in fact cars, each of which carries the wheels of one highway trailer and the nose of the next (on a standard hitch). The trailer, which can be a standard highway trailer of any length, bridges two Trailer-Railers. The Trailer-Railer resembles the disconnected rail trucks used by logging railroads many years ago. The prototype Trailer-Railers are operating on the Iowa Interstate Railroad, whose president is associated with the design and production of the cars by Trailer-Rail Corp. The Trailer-Railer is explicitly designed for short-haul or feeder service. The simplicity of the system permits low-capital facilities. The cars can be included in any freight train, but the train length is severely limited by the strength of the trailer body: Trailer-Railer trains can reach sixteen units within the 650-ton drawbar load limit.

FLIP. The FLIP technology (FLIP stands for Flexible Length Intermodal Platform) is essentially identical to the Trailer-Railer. It was designed and promoted by Berwick Forge & Fabricating and Intermodal Concepts, Inc. Two protoypes were built for testing in 1982, but there was no further production or commercial application.

Comparisons. Table I-19 compares the Mark V RoadRailer with representative double-stacks and TOFC cars. Carless technologies offer clear advantages over conventional TTX types, and a mixed comparison with double-stacks. The Trailer-Railer is primarily designed for flexibility, rather than linehaul efficiency.

Table I-19

CARLESS TECHNOLOGY COMPARISON

	Net Weight Capacity	Total Tare Weight	Cubic Capacity (cu. ft.)	Coupled Length (ft.)	Net/ Tare	Cubic Foot per Ton	Net Tons per Foot	Cubic Feet per Foot
RoadRailer MK V	47,800*	25,200	3,455	48	1.90	274	996	72
Std. TOFC 2 45/Vans	104,000	93,600	6,100	93-8	1.11	130	1,110	65
Double-Stack IBC 5 45-Ft. containers 5 48-Ft. containers	526,800	267,250	32,500	289-8	1.97	243	1,891	112

*Highway Mode

VIII. OCEANBORNE FREIGHT MOVEMENTS

METHODOLOGY

The Bureau of Census data identifies shipments as being Containerized, Not Containerized, or Unknown (if containerized). For this study, we retained all shipments identified as being containerized, and estimated the containerizable portion of the "unknown" shipments using Manalytics proprietary historical containerizability factors. These factors are commodity-specific and trade-specific, and take into account that the process of containerization is virtually complete in the large European and Asian trades, but not yet complete in the smaller trades, particularly in trades with third-world countries lacking extensive container-handling facilities. Thus, the data presented here consist of those shipments reported by the Bureau of the Census to be containerized, and the portion of unknown shipments estimated by Manalytics to be containerizable.

TEU and FEU Estimates

The Bureau of Census data gives weight information in pounds, which we have converted to short tons (2000 pounds) for easy comparison with rail and truck data. The source data do not, however, include an indication of container size, so the study team estimated the twenty-foot equivalent units (TEUs) and forty-foot equivalent units (FEUs) corresponding to the weights reported in the Census data. The basis for these estimates is Manalytics' database of historical 20-foot and 40-foot container loadings, which gives conversion factors in tons/TEU and tons/FEU for all of the relevant commodities and trades. It must be emphasized that the TEU and FEU estimates were separately derived: as the tables will reveal, the FEU estimate is not half the TEU estimate. For cube-limited commodities, a 40-foot container may very well hold roughly twice as much as a 20-foot container, but for weight-limited commodities, a 40-foot container may hold only 1.2 times as much as a 20-foot container, due to U.S. highway weight restrictions.

The twenty-foot equivalents (TEUs) and forty-foot equivalents (FEUs) shown on the tables should be interpreted as estimates of the number of 20-foot (or 40-foot) containers required to carry the total tonnage. Were the entire movement to be carried in only 20-foot containers (or only 40-foot containers), then the TEUs (or FEUs) would be an estimate of the actual number of containers. Since, the various commodities and trades are carried in a mix of container sizes, neither the TEU estimate nor the FEU estimate can be expected to correspond to the actual container count, which would likely fall somewhere between them. No attempt has been made to account for the variations in size between 35', 40', and 45' containers, or for the difference in 8', 8'6", 9', and 9'6" container heights.

The FEU estimate is of primary concern in this study because it yields the easiest conversion to "double-stack train equivalents." A typical double-stack train of 20 five-platform cars, with two 40-45 foot containers (or two 20-foot containers and one 40-45 foot container) on each platform has a capacity of 200 FEU, which will be defined as a "train-equivalent" where required in this study.

Ports and Countries

Ports and port groups are defined in Appendix I-9 (USPORT.LST and USPORT.MAP). Some of the major ports (such as New York) include adjacent regional ports (such as Newark, NJ) where the region effectively functions as a single part of origin or destination. The four-digit port codes shown in the Appendix are the Bureau of the Census codes; the two-digit codes were generated by Manalytics for this project. Pages 8-10 of the Appendix gives a list of land-locked "ports" which were ignored if encountered.

Appendix I-10 (COUNTRY.MAP) also gives an exhaustive list of the countries and 3-digit Census Bureau country codes combined in the six major foreign trade regions used in the table. The groupings are functional, rather than political, and reflect the typical routing of foreign trade.

FOREIGN TRADE

Table I-20 (nine pages) summarizes the containerized foreign trade data gathered by the Bureau of the Census for 1986 and 1987, in terms of short tons (2000 pounds), Twenty-foot Equivalent Units (TEUs) and Forty-foot Equivalent Units (FEUs).

The first page aggregates data for the four U.S. coasts (Atlantic, Gulf, Pacific, and Great Lakes) and Hawaii/Alaska/Puerto Rico. As expected, it is immediately apparent that very little containerized liner cargo moves through the Great Lakes ports. The movement through Hawaii, Alaska, and Puerto Rico are likewise small, and essentially irrelevant to the study, but are included to account for the total tonnage and verify that our data processing methodology includes all records in the Bureau of Census database.

The remaining eight pages give the traffic volumes at major ports (such as Boston, New York, and Philadelphia) or among major port groups (such as Houston/Galveston and Long Beach/Los Angeles). Minor container ports are grouped into regional categories (such as other Delaware River Ports). The containerized liner trade through the minor port regions is generally negligible, but, like Hawaii, Alaska, and Puerto Rico, they are included to account for all of the traffic in the Bureau of Census database. Traffic for each port or region is broken down by foreign origin (imports) or destination (exports) within the Import and Export categories.

Trade Growth

Generally speaking, the two years of data show continuations of current trends. Import tonnage grew approximately 3% between 1986 and 1987, and export tonnage grew 13.6%. Growth was skewed towards the Pacific Coast, as has been the trend over the past few years:

U.S. LINER CONTAINER TRADES BY MAJOR PORT (SHORT TONS) MANALYTICS, INC. 11/20/88 PAGE 1

U.S. PORT AND FOREIGN REGION	IMPORTS 1986 TONS	IMPORTS 1987 TONS	IMPORTS 1986 TEUS	IMPORTS 1987 TEUS	IMPORTS 1986 FEUS	IMPORTS 1987 FEUS	EXPORTS 1986 TONS	EXPORTS 1987 TONS	EXPORTS 1986 TEUS	EXPORTS 1987 TEUS	EXPORTS 1986 FEUS	EXPORTS 1987 FEUS
---- ATLANTIC COAST												
EUROPE	8,968,812	8,941,634	789,111	775,449	472,595	468,401	4,157,651	4,441,888	330,493	353,891	198,326	212,987
EAST AND SOUTH ASIA	5,024,857	4,778,158	595,764	571,386	315,167	301,840	4,161,670	4,247,346	289,574	297,989	192,300	196,764
AUSTRALIA/OCEANIA	514,537	489,279	47,545	45,625	25,131	23,896	196,514	256,447	15,933	20,529	9,505	12,391
AFRICA/MIDDLE EAST	708,210	613,219	54,752	48,975	35,168	30,850	923,930	1,000,794	82,214	88,440	46,362	50,207
LATIN AMERICA	2,675,158	2,804,489	264,183	272,048	145,301	150,804	1,422,080	1,630,200	115,828	134,107	69,438	79,752
CANADA	31,394	182,846	3,246	10,140	1,798	8,446	6,826	9,394	504	661	321	432
TOTAL	17,922,968	17,809,625	1,754,601	1,723,623	995,160	984,237	10,868,671	11,586,069	834,546	895,617	516,252	552,533
---- GULF COAST												
EUROPE	1,331,056	1,217,265	105,812	98,752	67,443	62,125	1,773,288	2,218,117	127,879	162,212	82,035	102,624
EAST AND SOUTH ASIA	180,916	135,609	13,514	12,204	9,058	7,424	834,932	958,506	57,215	66,566	38,031	43,809
AUSTRALIA/OCEANIA	37,651	43,045	3,410	3,907	1,817	2,084	85,077	130,725	5,954	8,700	3,942	6,026
AFRICA/MIDDLE EAST	174,706	109,551	12,345	8,448	8,349	5,422	776,105	853,102	53,603	59,352	35,819	39,477
LATIN AMERICA	867,662	1,126,849	112,465	136,366	54,406	68,031	1,098,033	1,250,473	73,741	85,365	50,533	57,542
CANADA	1,080	3,124	103	162	60	141	444	257	30	26	19	12
TOTAL	2,593,071	2,635,443	247,649	259,839	141,133	145,227	4,567,879	5,411,180	318,422	382,221	210,379	249,490
---- PACIFIC COAST												
EUROPE	1,365,792	1,529,918	115,499	123,566	71,381	78,503	810,527	900,231	65,351	73,545	38,563	43,244
EAST AND SOUTH ASIA	12,167,257	12,823,405	1,756,967	1,830,435	871,448	911,038	11,131,182	13,404,136	847,152	1,019,848	519,539	626,740
AUSTRALIA/OCEANIA	464,042	558,777	42,113	49,123	22,948	27,259	526,705	604,233	41,561	47,366	25,039	28,757
AFRICA/MIDDLE EAST	107,616	170,078	7,889	11,440	5,370	8,299	124,966	160,617	10,417	12,764	6,006	7,778
LATIN AMERICA	226,985	342,704	18,315	25,971	11,190	16,335	163,872	145,731	11,468	10,865	7,605	6,837
CANADA	25,751	65,545	2,120	3,958	1,285	3,037	21,973	18,036	1,364	1,470	1,022	860
TOTAL	14,357,443	15,490,427	1,942,903	2,044,493	983,622	1,044,471	12,779,225	15,232,984	977,313	1,165,858	597,774	714,216
---- GREAT LAKES												
EUROPE	29,457	27,739	2,199	1,849	1,451	1,316	5,376	2,943	359	230	258	138
EAST AND SOUTH ASIA	4,176	3,421	329	294	216	179	66,920	11,931	4,379	800	3,041	542
AUSTRALIA/OCEANIA	135	1,594	13	79	6	72	26	70	2	6	1	3
AFRICA/MIDDLE EAST	1,312	1,427	71	128	59	74	75,647	43,740	4,663	2,991	3,452	2,002
LATIN AMERICA	1,827	32	171	4	83	2	14,628	299	950	17	685	13
CANADA	1,023	1,117	57	64	47	51	5,834	2,139	337	169	265	97
TOTAL	37,930	35,330	2,840	2,418	1,862	1,694	168,431	61,122	10,690	4,213	7,702	2,795
---- HAWAII/ALASKA/PUERTO RICO												
EUROPE	203,147	184,322	14,429	13,291	9,900	8,974	19,222	33,235	1,606	2,788	925	1,583
EAST AND SOUTH ASIA	99,577	117,439	12,962	14,702	6,617	7,637	77,640	83,878	6,648	6,518	3,726	3,944
AUSTRALIA/OCEANIA	36,653	29,318	2,919	2,460	1,727	1,408	2,367	893	155	103	110	48
AFRICA/MIDDLE EAST	5,590	8,721	451	512	272	402	3,980	7,713	304	661	187	356
LATIN AMERICA	199,145	220,266	20,308	20,829	10,967	11,700	120,369	91,486	9,600	7,243	5,759	4,459
CANADA	15,352	10,928	1,296	911	745	528	1,894	2,359	130	199	92	123
TOTAL	559,464	570,994	52,365	52,705	30,228	30,649	225,472	219,564	18,443	17,512	10,799	10,513

Table I-20

U.S. PORT AND FOREIGN REGION	IMPORTS 1986 TONS	IMPORTS 1987 TONS	IMPORTS 1986 TEUS	IMPORTS 1987 TEUS	IMPORTS 1986 FEUS	IMPORTS 1987 FEUS	EXPORTS 1986 TONS	EXPORTS 1987 TONS	EXPORTS 1986 TEUS	EXPORTS 1987 TEUS	EXPORTS 1986 FEUS	EXPORTS 1987 FEUS
---- BOSTON												
EUROPE	283,172	298,912	25,938	26,729	15,259	15,859	61,775	79,639	5,264	6,687	3,001	3,848
EAST AND SOUTH ASIA	3,626	10,627	437	2,225	217	1,060	1,023	4,800	68	341	46	219
AUSTRALIA/OCEANIA	434	2,960	47	306	22	154	9	431	1	33	0	19
AFRICA/MIDDLE EAST	4,371	3,930	364	307	217	194	1,557	2,268	163	193	78	104
LATIN AMERICA	6,342	7,904	661	621	370	386	938	1,170	53	66	41	52
CANADA	88	20	13	1	6	0	0	1	0	0	0	0
TOTAL	298,033	324,353	27,460	30,189	16,091	17,653	65,302	88,309	5,549	7,320	3,166	4,242
---- NEW YORK												
EUROPE	4,289,429	4,114,158	391,470	372,245	232,188	222,476	872,581	768,464	73,404	65,832	42,716	37,883
EAST AND SOUTH ASIA	2,688,524	2,419,236	329,031	299,412	172,320	156,557	1,211,959	1,168,842	90,458	87,404	56,056	54,094
AUSTRALIA/OCEANIA	26,340	29,306	2,307	2,484	1,328	1,460	38,560	47,326	3,284	3,991	1,907	2,333
AFRICA/MIDDLE EAST	302,452	232,979	24,391	20,765	15,402	12,312	283,577	273,849	26,272	24,892	14,331	13,704
LATIN AMERICA	785,523	740,932	73,093	69,035	41,825	39,517	320,755	287,270	26,425	23,504	15,705	14,062
CANADA	13,037	54,891	1,303	3,425	705	2,574	376	63	25	4	18	2
TOTAL	8,105,305	7,591,502	821,595	767,366	463,768	434,896	2,727,808	2,545,814	219,868	205,627	130,733	122,078
---- PHILADELPHIA												
EUROPE	234,332	152,933	19,660	12,914	12,019	7,806	54,635	43,913	3,973	3,177	2,588	2,062
EAST AND SOUTH ASIA	29,242	12,866	2,516	1,098	1,502	660	30,462	3,713	2,116	219	1,416	167
AUSTRALIA/OCEANIA	14,728	8,227	1,460	785	718	396	875	1,300	81	146	45	76
AFRICA/MIDDLE EAST	63,593	53,307	4,511	3,998	2,904	2,487	3,358	1,915	235	137	152	88
LATIN AMERICA	171,856	301,278	13,827	24,865	8,703	15,137	26,177	90,928	1,773	6,930	1,239	4,346
CANADA	1,171	91	76	8	54	4	662	157	44	10	32	7
TOTAL	514,922	528,702	42,050	43,668	25,900	26,490	116,169	141,926	8,222	10,619	5,472	6,746
---- OTHER DELAWARE RIVER PORTS												
EUROPE	86,066	177,133	6,848	14,742	4,356	9,193	27,368	42,768	2,172	3,233	1,319	2,046
EAST AND SOUTH ASIA	1,102	49,320	83	4,966	51	2,815	1,214	20,775	68	1,577	54	946
AUSTRALIA/OCEANIA	330,479	327,743	31,904	30,844	16,151	15,900	35,601	32,185	2,765	2,350	1,757	1,573
AFRICA/MIDDLE EAST	4,264	64,034	329	3,341	224	2,925	854	1,622	59	194	38	100
LATIN AMERICA	219,642	258,044	33,548	35,575	15,201	16,811	8,440	16,735	672	1,367	402	812
CANADA	7	1,117	1	55	0	50	0	3	0	0	0	0
TOTAL	641,560	877,391	72,713	89,523	35,983	47,694	73,477	114,088	5,736	8,721	3,570	5,477
---- BALTIMORE												
EUROPE	1,052,544	1,084,212	91,522	92,135	54,698	56,162	624,589	695,733	47,428	52,990	29,858	33,395
EAST AND SOUTH ASIA	539,077	450,349	56,324	49,327	31,521	27,031	396,842	325,511	26,674	22,615	18,308	15,117
AUSTRALIA/OCEANIA	20,858	9,095	1,075	461	948	413	2,743	5,252	210	441	131	266
AFRICA/MIDDLE EAST	115,067	96,708	8,032	6,797	5,603	4,708	163,631	205,520	14,089	18,585	8,288	10,591
LATIN AMERICA	286,164	218,638	24,994	18,132	14,553	10,957	133,429	128,972	10,173	9,295	6,507	6,133
CANADA	10,314	1,398	928	102	580	72	114	534	7	51	4	24
TOTAL	2,024,024	1,860,400	182,875	166,954	107,903	99,343	1,321,348	1,361,522	98,581	103,977	63,096	65,526

Table I-20

U.S. PORT AND FOREIGN REGION	IMPORTS 1986 TONS	IMPORTS 1987 TONS	IMPORTS 1986 TEUS	IMPORTS 1987 TEUS	IMPORTS 1986 FEUS	IMPORTS 1987 FEUS	EXPORTS 1986 TONS	EXPORTS 1987 TONS	EXPORTS 1986 TEUS	EXPORTS 1987 TEUS	EXPORTS 1986 FEUS	EXPORTS 1987 FEUS
---- LAKE MICHIGAN PORTS												
EUROPE	8,710	10,976	601	638	413	504	3,521	1,115	192	72	159	50
EAST AND SOUTH ASIA	3,580	2,736	249	228	178	144	26,140	6,621	1,805	422	1,187	300
AUSTRALIA/OCEANIA	0	0	0	0	0	0	26	68	2	5	1	3
AFRICA/MIDDLE EAST	76	232	5	30	3	13	63,416	43,589	3,870	2,979	2,897	1,995
LATIN AMERICA	456	10	36	2	21	1	14,165	274	919	13	664	12
CANADA	909	35	46	2	41	1	0	0	0	0	0	0
TOTAL	13,731	13,989	937	900	656	663	107,268	51,667	6,788	3,491	4,908	2,360
---- LAKE ERIE PORTS												
EUROPE	20,140	16,183	1,551	1,176	1,009	785	1,670	1,691	151	149	90	82
EAST AND SOUTH ASIA	586	685	78	66	37	35	1,062	6	53	0	48	0
AUSTRALIA/OCEANIA	135	1,594	13	79	6	72	0	0	0	0	0	0
AFRICA/MIDDLE EAST	1,236	1,195	66	97	55	60	1,002	31	80	1	44	1
LATIN AMERICA	2	22	0	1	0	0	64	25	4	3	2	1
CANADA	1	918	0	46	0	41	3	13	0	1	0	0
TOTAL	22,100	20,597	1,708	1,465	1,107	993	3,801	1,766	288	154	184	84
---- OTHER GREAT LAKES PORTS												
EUROPE	607	580	46	33	28	26	185	137	14	7	8	5
EAST AND SOUTH ASIA	10	0	1	0	0	0	39,718	5,304	2,520	377	1,805	241
AUSTRALIA/OCEANIA	0	0	0	0	0	0	0	2	0	0	0	0
AFRICA/MIDDLE EAST	0	0	0	0	0	0	11,229	120	712	9	510	5
LATIN AMERICA	1,369	0	134	0	62	0	399	0	27	0	18	0
CANADA	113	164	11	15	5	8	5,831	2,126	336	168	265	97
TOTAL	2,099	744	192	48	95	34	57,362	7,689	3,609	561	2,606	348
---- LONG BEACH/LOS ANGELES												
EUROPE	798,083	919,472	67,682	72,524	41,843	46,959	232,943	288,987	19,191	24,289	11,411	14,385
EAST AND SOUTH ASIA	7,656,621	8,203,997	1,130,645	1,195,085	556,738	591,099	4,299,805	5,406,536	330,034	413,082	201,057	253,976
AUSTRALIA/OCEANIA	202,915	255,662	18,164	22,335	10,012	12,481	239,187	262,318	18,921	21,113	11,515	12,724
AFRICA/MIDDLE EAST	65,914	134,330	5,087	8,635	3,371	6,531	69,190	82,105	5,651	6,700	3,290	4,008
LATIN AMERICA	99,241	151,636	8,617	11,749	5,141	7,395	49,896	41,139	3,493	3,225	2,335	1,977
CANADA	15,387	11,389	1,178	747	750	527	1,544	1,220	113	87	72	56
TOTAL	8,838,161	9,676,486	1,231,373	1,311,075	617,855	664,992	4,892,565	6,082,305	377,403	468,496	229,680	287,126
---- OTHER SOUTHERN CALIFORNIA PORTS												
EUROPE	66,650	85,585	3,424	4,691	3,029	3,920	0	0	0	0	0	0
EAST AND SOUTH ASIA	816	497	173	68	80	35	1,551	4,467	156	442	75	218
AFRICA/MIDDLE EAST	0	3,233	0	222	0	146	0	19	0	1	0	0
LATIN AMERICA	598	5,225	56	303	29	240	0	0	0	0	0	0
CANADA	691	0	34	0	31	0	0	0	0	0	0	0
TOTAL	68,755	94,540	3,687	5,284	3,169	4,341	1,551	4,486	156	443	75	218

Table I-20

U.S. PORT AND FOREIGN REGION	IMPORTS 1986 TONS	IMPORTS 1987 TONS	IMPORTS 1986 TEUS	IMPORTS 1987 TEUS	IMPORTS 1986 FEUS	IMPORTS 1987 FEUS	EXPORTS 1986 TONS	EXPORTS 1987 TONS	EXPORTS 1986 TEUS	EXPORTS 1987 TEUS	EXPORTS 1986 FEUS	EXPORTS 1987 FEUS
---- OAKLAND/SAN FRANCISCO												
EUROPE	342,974	372,572	30,287	32,921	18,083	19,592	306,162	358,194	24,740	29,949	14,444	16,972
EAST AND SOUTH ASIA	1,385,326	1,272,830	179,820	162,460	91,348	83,512	2,238,746	2,763,148	170,943	211,010	105,043	129,218
AUSTRALIA/OCEANIA	208,397	219,180	18,943	19,750	10,175	10,622	141,455	139,413	11,290	10,713	6,680	6,558
AFRICA/MIDDLE EAST	24,888	23,372	1,626	1,710	1,161	1,100	26,733	36,379	2,170	3,097	1,281	1,772
LATIN AMERICA	100,140	155,687	7,518	11,596	4,689	7,255	34,432	33,216	2,454	2,551	1,606	1,575
CANADA	6,373	4,067	574	295	334	189	2,567	2,332	168	164	116	106
TOTAL	2,068,098	2,047,708	238,768	228,732	125,790	122,270	2,750,095	3,332,682	211,765	257,484	129,170	156,201
---- OTHER SAN FRANCISCO BAY/SACRAMENTO												
EUROPE	677	15,177	74	955	40	702	1,452	5,848	114	342	67	266
EAST AND SOUTH ASIA	53	681	9	104	3	48	17,889	6,210	1,227	405	812	281
AUSTRALIA/OCEANIA	1,098	38	67	3	49	1	82	7,020	16	500	7	318
AFRICA/MIDDLE EAST	1,781	10	89	0	80	0	26	501	2	38	1	22
LATIN AMERICA	73	1,016	5	72	3	46	20	1,607	2	115	0	72
TOTAL	3,682	16,922	244	1,134	175	797	19,469	21,186	1,361	1,400	887	959
---- OTHER NORTHERN CALIFORNIA PORTS												
EUROPE	2,832	581	252	59	148	31	5,409	2,066	383	160	245	93
EAST AND SOUTH ASIA	609	281	39	29	28	14	6,032	10,332	415	711	274	469
LATIN AMERICA	0	19	0	1	0	0	0	0	0	0	0	0
TOTAL	3,441	881	291	89	176	45	11,441	12,398	798	871	519	562
---- HONOLULU/HAWAII PORTS												
EUROPE	1,658	1,816	136	236	83	122	2	325	0	23	0	14
EAST AND SOUTH ASIA	53,591	60,959	6,471	7,011	3,372	3,754	46,436	46,101	3,425	3,435	2,148	2,149
AUSTRALIA/OCEANIA	36,346	28,568	2,891	2,389	1,712	1,371	2,360	638	154	78	109	37
AFRICA/MIDDLE EAST	132	0	7	0	5	0	90	0	9	0	4	0
LATIN AMERICA	125	66	14	6	7	3	45	14	3	1	1	0
CANADA	533	843	49	77	24	38	1,832	1,578	125	110	89	77
TOTAL	92,385	92,252	9,568	9,719	5,203	5,288	50,765	48,656	3,716	3,647	2,351	2,277
---- PORTLAND, OR												
EUROPE	24,396	29,340	2,065	2,574	1,230	1,510	66,884	76,691	4,488	5,364	3,109	3,575
EAST AND SOUTH ASIA	148,610	161,474	16,524	18,579	8,991	9,975	880,137	928,188	65,431	70,055	40,555	42,917
AUSTRALIA/OCEANIA	1,842	2,137	126	150	87	99	3,754	3,144	294	247	175	143
AFRICA/MIDDLE EAST	151	140	16	14	8	7	1,977	2,617	170	215	96	122
LATIN AMERICA	583	2,906	42	208	26	134	2,961	215	207	15	146	9
CANADA	16	25,140	1	1,258	0	1,142	0	0	0	0	0	0
TOTAL	175,598	221,137	18,774	22,783	10,342	12,867	955,713	1,010,855	70,590	75,896	44,081	46,766
---- OTHER COLUMBIA RIVER PORTS												
EUROPE	795	12	71	1	40	0	14,992	30,466	886	1,865	682	1,384
EAST AND SOUTH ASIA	4,484	4,273	381	321	231	210	18,700	27,679	1,396	2,097	850	1,260
AUSTRALIA/OCEANIA	210	1,725	15	89	10	78	11,401	12,617	687	1,007	519	582
AFRICA/MIDDLE EAST	1,590	300	96	16	73	13	5,718	1,692	429	128	260	77
LATIN AMERICA	900	2,878	66	212	40	132	14,837	15,026	981	982	678	687
TOTAL	7,979	9,188	629	639	394	433	65,648	87,480	4,379	6,079	2,989	3,990

Table I-20

U.S. PORT AND FOREIGN REGION	IMPORTS 1986 TONS	IMPORTS 1987 TONS	IMPORTS 1986 TEUS	IMPORTS 1987 TEUS	IMPORTS 1986 FEUS	IMPORTS 1987 FEUS	EXPORTS 1986 TONS	EXPORTS 1987 TONS	EXPORTS 1986 TEUS	EXPORTS 1987 TEUS	EXPORTS 1986 FEUS	EXPORTS 1987 FEUS
---- SEATTLE/TACOMA												
EUROPE	127,680	105,962	11,505	9,711	6,876	5,716	168,892	122,643	14,437	10,419	7,973	5,862
EAST AND SOUTH ASIA	2,965,578	3,170,045	428,907	452,943	213,733	225,613	3,645,172	4,213,129	275,837	319,282	169,816	196,376
AUSTRALIA/OCEANIA	49,486	79,584	4,787	6,757	2,608	3,954	108,263	147,373	8,580	11,246	5,116	6,960
AFRICA/MIDDLE EAST	13,172	8,063	968	809	669	469	21,216	35,432	1,984	2,436	1,071	1,689
LATIN AMERICA	24,907	23,225	1,971	1,820	1,235	1,126	57,984	46,198	4,071	3,402	2,667	2,136
CANADA	951	20,950	56	1,185	44	964	1,791	2,011	93	114	81	91
TOTAL	3,181,774	3,407,829	448,194	473,225	225,165	237,842	4,003,318	4,566,786	305,002	346,899	186,724	213,114
---- OTHER PUGET SOUND PORTS												
EUROPE	1,397	758	111	83	71	43	7,574	9,339	604	694	344	431
EAST AND SOUTH ASIA	2,739	8,852	321	809	176	507	23,150	43,723	1,709	2,706	1,055	1,988
AUSTRALIA/OCEANIA	0	0	0	0	0	0	977	670	76	46	44	30
AFRICA/MIDDLE EAST	44	2	3	0	1	0	0	0	0	0	0	0
LATIN AMERICA	543	112	37	7	24	5	3,740	8,325	257	573	169	378
CANADA	2,333	3,999	275	471	124	212	16,071	12,473	989	1,104	751	605
TOTAL	7,056	13,723	747	1,370	396	767	51,512	74,530	3,635	5,123	2,363	3,432
---- OTHER PACIFIC NORTHWEST PORTS												
EUROPE	308	459	25	43	16	25	6,219	5,997	506	459	285	272
EAST AND SOUTH ASIA	2,421	475	145	33	115	22	0	724	0	53	0	32
AUSTRALIA/OCEANIA	94	451	8	37	4	21	21,586	31,678	1,693	2,491	980	1,438
AFRICA/MIDDLE EAST	76	628	3	31	3	28	106	1,872	8	146	4	84
LATIN AMERICA	0	0	0	0	0	0	2	5	0	0	0	0
TOTAL	2,899	2,013	181	144	138	96	27,913	40,276	2,207	3,149	1,269	1,826
---- ALASKA PORTS												
EUROPE	123	527	6	62	5	28	341	1,658	31	126	17	77
EAST AND SOUTH ASIA	345	2	39	0	21	0	26,999	22,629	2,985	2,101	1,386	1,105
AUSTRALIA/OCEANIA	0	0	0	0	0	0	0	112	0	9	0	5
AFRICA/MIDDLE EAST	8	0	0	0	0	0	175	4,385	18	435	8	200
LATIN AMERICA	0	0	0	0	0	0	1,597	47	157	5	72	2
CANADA	499	1,136	30	71	23	53	15	621	1	79	0	39
TOTAL	975	1,665	75	133	49	81	29,127	29,452	3,192	2,755	1,483	1,428

Table I-20

1986 - 87 Trade Growth

	Import Short Tons	Export Short Tons
Atlantic	-0.6%	+6.6%
Gulf	+1.6%	+18.5%
Pacific	+7.9%	+19.2%

Trade with East and South Asia accounted for most of the Pacific Coast growth, while Atlantic Coast imports from those regions were down and Atlantic Coast exports up only slightly. Gulf Coast imports from East and South Asia declined sharply, reflecting further reductions in all-water liner service to those ports (a service that was totally discontinued in 1988).

Alternative Measures of Port Cargo Volumes

The American Association of Port Authorities (AAPA) collects and publishes throughput statistics from its member ports. As shown below, these statistics can differ significantly from the Census Bureau figures.

Container Throughput, 1987
(In TEUs)

	Census Bureau Data	AAPA Port Survey
Long Beach/Los Angeles	1,779,571	3,039,845
New York/New Jersey	972,993	2,100,000
Seattle/Tacoma	820,124	1,722,800
Oakland/San Francisco	486,216	1,057,861
Charleston	342,779	581,760
Houston/Galveston	292,745	541,822
Hampton Roads	266,174	481,150
New Orleans	178,072	427,165
Savannah	255,214	362,350
Boston	37,509	136,825

DISCREPANCIES

DOMESTIC EMPTIES TRANSBORDER

In order to understand the apparent discrepancies between the 1987 TEU and tonnage statistics reported by the American Association of Port Authorities, and international containerizable cargo statistics developed from Census Bureau data, the study team contacted key managers at selected ports. The results of these interviews are summarized below.

Ports of Seattle and Tacoma The AAPA reported 1,722,800 TEUs for the two ports; MI reported 820,124 TEUs. The 900,000 TEU differential includes nearly 300,000 TEUs of empty containers, approximately 400,000 TEUs of domestic cargoes to and from Alaska and Hawaii, and around 100,000 TEUs of Canadian transborder cargo. Much of the remaining differential is due to the conversion of 40-foot actual containers into theoretical twenty-foot equivalent units: 40-foot containers that cannot be fully loaded because weight constraints were represented as two TEUs, even though two 20-foot units would carry more cargo than the weight-limited 40-foot container. Thus, port statistics produced in this manner -- particularly for the 40-foot transpacific trades -- tend to overstate TEU statistics.

Port of Los Angeles The AAPA reported 1,579,657 TEU for Los Angeles, and 1,460,188 for Long Beach, for a total of 3,039,817 TEU. Manalytics estimated 1,722,800. The difference is 1.3 million TEU. This difference includes approximately 700,000 TEU of empty containers, and 250,000 TEU or more of domestic movements -- including domestic containers received from rail cars at the Long Beach on-dock ITS facility and drayed from the port (approximately 500 units per month). The remaining difference is due in part to the 40-foot container to TEU conversion discrepancy explained above, as well as to in-transit containers to and from Ensenada, Mexico, which would not be included in SA 305/705 statistics for the ports of San Pedro Bay.

Boston Statistics for MassPort, as published by the AAPA, are 933,464 short tons and 136,825 TEU. Manalytics estimated 402,392 short tons and 36,462 TEU. Port management at MassPort reports that 58 percent of Boston's cargo is feeder service cargo to and from New York (and Nova Scotia), where it is reported to Customs and thus included on SA 305/705 statistics. These cargoes are therefore reported to the AAPA by both Boston and New York ports, while the

Census data show them only at New York. In addition, about one third of the containers reported are empty. If we apply the 58 percent ratio and the one-third empty factor to the AAPA-reported statistics, the adjusted tonnage and TEU statistics are 392,054 short tons and 38,312 TEU, which compare favorably with Manalytics' estimates.

Port of Baltimore Baltimore reported only short tons to the AAPA: 4,554,428 short tons. Manalytics estimated the tonnage to be 3,199,401 short tons. About one million of the 1.36 million ton difference is domestic traffic, particularly that of barge feeder services (see Boston).

In general, AAPA statistics are intended to portray total port activity. While that information may be useful to other studies, it does not depict the underlying base cargo flows of international containerizable cargoes that drive double-stack services.

COASTAL TRADE SHARES

Container trade is overwhelmingly dominated by the Atlantic and Pacific coasts, as Table I-20 clearly shows. Atlantic coast ports handled 43 percent of U.S. containerized tonnage, and Pacific ports handled 44 percent. In 1987, the Gulf Coast still received major all-water service from Asia, and handled roughly 12 percent of U.S. containerized tonnage. Withdrawal of those services in late 1988 means that the Gulf Coast container ports will handle primarily South American and Caribbean traffic, with a small flow of European and African cargo. The Great Lakes ports have never participated heavily in container movements, and handled just 0.1 percent of the U.S. total. The Canadian ports of Halifax, Montreal and St. Johns handle significant container traffic, some of which is U.S. foreign trade in transit. The Hawaiian and Alaskan and Puerto Rican ports handled only traffic imported or exported from those states, and do not participate in long-distance intermodal traffic. Together, they handled 1 percent of U.S. containerized tonnage in 1987.

On the import side, different average container weights on the Atlantic and Pacific Coasts yield different coastal trade shares, depending on whether tons

or TEUs are considered. Average weights, in short tons, on the Atlantic Coast are 10.3 tons/TEU and 18.1 tons/FEU, while Pacific Coast movements are generally lighter at 7.6 tons/TEU and 14.8 tons/FEU. The difference is attributed to differences in commodity mix, with European commodities being typically more dense than the commodities imported from Asia. The result is that the Atlantic Coast ports handle 49 percent of the tonnage, but only 42 percent of the TEUs. The Pacific Coast shares are just opposite: 42 percent of the tonnage and 50 percent of the TEUs. The Gulf handled 6 percent of the 1987 import TEUs, the Great Lakes 0.1 percent, and Hawaii/Alaska/Puerto Rico 1 percent. The Great Lakes showed an average of 14.6 tons/TEU and 20.9 tons/FEU, while the Gulf had 10.1 tons/TEU and 18.1 tons/FEU.

Export shares are more consistent since average export container weights, in short tons, are nearly the same on both major coasts: 12.9 tons/TEU and 21.0 tons/FEU on the Atlantic, and 13.1 tons/TEU and 21.3 tons/FEU on the Pacific. Accordingly, the Atlantic Coast has 36 percent of both tonnage and TEUs, and the Pacific has 47 percent of both. The Gulf handled 16 percent of the 1987 export TEUs, the Great Lakes 0.2 percent, and Hawaii/Alaska/Puerto Rico 1 percent. The Great Lakes averaged 14.5 tons/TEU and 21.9 tons/FEU, while the Gulf had 14.1 tons/TEU and 21.7 tons/FEU.

IMPORT CONTAINER IMBALANCES

The average weight of exports means that U.S. trade as a whole is more strongly imbalanced in containers than in tons:

1987 U.S. Trade

	Import	Export	Ratio
Tons	36,541,819	32,510,919	1.12:1
TEUs	4,083,078	2,465,421	1.66:1
FEUs	2,206,278	1,539,547	1.43:1

Although the relatively faster growth of exports will eventually balance the container flow, the historic imbalances will persist in the short term.

The major drive for double-stack system expansion has come from Pacific Coast container operators in the Far East and Southeast Asia trades which have traditionally been imbalanced in favor of imports. In 1987, for example, Pacific Coast ports handled an estimated 911,038 FEUs of imports in these trades (described in the table as "East and South Asia," and, in fact dominated by forty-foot equipment) but only 626,740 FEUs of exports, a ratio of 1.45:1. The initial impetus for domestic containerization came from the resultant westbound backhand capacity.

The European trades on the Pacific Coast had much smaller volumes, but even more marked imbalances: 78,503 FEUs of imports, and 43,244 FEUs of exports, for a ratio of 1.82:1 In comparison, the Australia/Oceania container flows on the Pacific Coast were nearly balanced in this trade dominated by twenty-foot containers.

The Atlantic Coast has a more equal mix of European and Asian trades, but strong container imbalances in both. There were 468,401 FEUs of European Atlantic Coast imports in 1987, but only 212,987 FEUs of exports, a 2.2:1 ratio. There were 301,840 FEUs of East and South Asian imports, and 196,764 FEUs of exports for a ratio of 1.53:1.

European cargo accounted for 43 percent of Gulf Coast import FEUs and 41 percent of export FEUs. Latin American trade was the other major segment with 47 percent of the import FEUs and 23 percent of the exports. Asian cargoes accounted for 18 percent of the Gulf Coast export FEUs in 1987, but as explained earlier that cargo is likely to decline sharply. African and Middle East cargoes accounted for 16 percent of the Gulf Coast export FEUs, a somewhat stronger showing than on the Atlantic Coast.

As Table I-20 shows, Great Lakes import trade is almost entirely European, while export trade is over 70 percent African.

Hawaiian, Alaskan, and Puerto Rican ports together show a large amount of Latin American import and export cargo (through Puerto Rico), with the remaining cargo split between Europe and Asia.

The overall Coastal FEU balances were as follows:

1987 FEUs

	Imports	Exports	Excess Imports
Atlantic	984,237	552,533	431,704
Gulf	145,227	249,490	(104,263)
Pacific	1,044,471	714,216	330,255
Great Lakes	1,694	2,795	(1,101)
Hawaii, etc.	30,649	10,513	20,136

The direction of the imbalance depends on the coast. The Pacific Coast experiences an eastbound import excess while the Atlantic has a westbound import excess. The result, as is widely known, is fierce competition for both exports and coastal-bound domestic freight at inland points.

Although the data in the attached table is consistent with well-known, large scale trends, the experience of individual ports may vary widely. For example, New York handles 3.6 times as many import FEUs as it does export FEUs, while the flows through Charleston and Savannah run 1:1.1 and 1:1.2 in favor of exports. The ports of New Orleans and Houston/Galveston both handle roughly twice as many export FEUs as imports. On the Pacific Coast, flows through Long Beach/Los Angeles are 2.3:1 in favor of imports. Seattle/Tacoma flows are nearly balanced at 1.1:1, while Oakland/San Francisco FEU flows are 1:1.3 in favor of exports.

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One data issue that must be addressed is the completeness of origin/destination state information within the Census data. Preliminary processing identified roughly 150 different "state" abbreviations in the field for origin or destination state, only a little over 50 of which can be valid (allowing for the District of Columbia, Virgin Islands, Puerto Rico, Guam, etc.). The invalid state codes accounted for no more than about one percent of the tonnage. There were, however, many more records with no origin or destination state information at all. The invalid and blank state information are combined in an unknown ("??") category in the Appendix Tables.

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Pacific	1,044,471	714,216	330,255
Great Lakes	1,694	2,795	(1,101)
Hawaii, etc.	30,649	10,513	20,136

The direction of the imbalance depends on the coast. The Pacific Coast experiences an eastbound import excess while the Atlantic has a westbound import excess. The result, as is widely known, is fierce competition for both exports and coastal-bound domestic freight at inland points.

Although the data in the attached table is consistent with well-known, large scale trends, the experience of individual ports may vary widely. For example, New York handles 3.6 times as many import FEUs as it does export FEUs, while the flows through Charleston and Savannah run 1:1.1 and 1:1.2 in favor of exports. The ports of New Orleans and Houston/Galveston both handle roughly twice as many export FEUs as imports. On the Pacific Coast, flows through Long Beach/Los Angeles are 2.3:1 in favor of imports. Seattle/Tacoma flows are nearly balanced at 1.1:1, while Oakland/San Francisco FEU flows are 1:1.3 in favor of exports.

ORIGIN/DESTINATION STATE DATA COVERAGE

One data issue that must be addressed is the completeness of origin/destination state information within the Census data. Preliminary processing identified roughly 150 different "state" abbreviations in the field for origin or destination state, only a little over 50 of which can be valid (allowing for the District of Columbia, Virgin Islands, Puerto Rico, Guam, etc.). The invalid state codes accounted for no more than about one percent of the tonnage. There were, however, many more records with no origin or destination state information at all. The invalid and blank state information are combined in an unknown ("??") category in the Appendix Tables.

As Table I-21 shows, records with unknown origin or destination states accounted for 22 percent of total U.S. import and export tonnage. The problem is far more serious for exports: records comprising more than a third of U.S. export tonnage have no valid origin state.

Tables I-22 to I-24 show the O/D state information coverage by foreign region, by U.S. coast, and by major port. Each table gives the percentages of containerized or containerizable import and export liner tonnage from records with valid O/D state abbreviations.

Table I-22 shows that data on European and Latin American trades are most complete, and that data Australia/Oceania exports have the worst coverage. The biggest problem is exports to East and South Asia, one of the largest and fastest growing U.S. trades, in which more than 40 percent of the tonnage has records with no valid states of origin.

Table I-23 shows that movements via both the Atlantic and Pacific Coasts have similar coverage rates: about 90 percent for imports but only 61-64 percent for exports.

Table I-24 shows that the problem of identifying the origin state for export tonnage is most serious at the largest ports: New York (47% coverage); Baltimore (66% coverage); Charleston (56% coverage); New Orleans (63% coverage); Houston/Galveston (69% coverage); Long Beach/Los Angeles (59% coverage); Oakland/San Francisco (66% coverage); and Seattle/Tacoma (60% coverage). In other words, we have no information on the origin state of one-third to one-half the export tonnage at major ports.

The difference between import and export data coverage may reflect the greater scrutiny of import documentation by the Customs Service and other parties. As Tables I-22 to I-24 show, the disparity is apparent across the entire database.

STATE-BY-STATE FINDINGS

Appendix I-11 gives a breakdown of 1987 import and export tonnage, TEUs, and FEUs for each state. This review of the data focuses on the FEU figures.

Table I-21

1987 BUREAU OF THE CENSUS DATA
MISSING OR INVALID O/D STATE INFORMATION

	Total Tonnage	Tonnage With Missing or Invalid O/D State	Percent Unknown
Imports	36,208,241	3,236,177	9%
Exports	32,341,736	11,944,306	37%
TOTAL	68,549,977	15,180,483	22%

Table I-22

1987 BUREAU OF THE CENSUS DATA
O/D STATE COVERAGE BY FOREIGN REGION*

Foreign Region	Imports	Exports
Europe	92%	71%
East and South Asia	92%	59%
Australia/Oceania	92%	23%
Africa/Middle East	87%	55%
Latin America	90%	69%
Canada	59%	57%

*Percent of import or export liner container or containerizable tonnage with origin or destination state codes.

Table I-23

1987 BUREAU OF THE CENSUS DATA
O/D STATE COVERAGE BY COAST*

Coast	Imports	Exports
Atlantic	92%	64%
Gulf	85%	64%
Pacific	91%	61%
Great Lakes	74%	72%
Hawaii/Alaska/Puerto Rico	97%	83%

*Percent of import or export liner container or containerizable tonnage with origin or destination state codes.

Table I-24

1987 BUREAU OF THE CENSUS DATA
O/D STATE COVERAGE BY MAJOR PORT*

Port	Imports	Exports
Boston	93%	53%
New York	93%	47%
Philadelphia	87%	73%
Baltimore	91%	66%
Norfolk	89%	75%
Wilmington, NC	95%	83%
Charleston	92%	56%
Savannah	91%	75%
Jacksonville	89%	79%
Miami	90%	68%
Mobile	93%	54%
New Orleans	90%	63%
Houston/Galveston	89%	69%
Long Beach/Los Angeles	92%	59%
Oakland/San Francisco	92%	66%
Portland, OR	80%	65%
Seattle/Tacoma	89%	60%

*Percent of import or export liner container or containerizable tonnage with origin or destination state codes.

To put the numbers in perspective, it is useful to compare them with the volume required to fill regular double-stack trains. A weekly train of twenty, five-platform cars would carry roughly 10,000 FEU annually. A daily train would raise that figure to 70,000 annual FEUs.

In Table I-25, it quickly becomes apparent that in 1987 only a very few specific port-state combinations separated by 500 miles or more have the required volume to support a weekly train, even without accounting for the headquarters bias. Imports to California through the Port of New York is one example, at 14,565 annual FEU. Imports to Illinois via Long Beach/Los Angeles or via Seattle/Tacoma had the required volume at 46,547 annual FEU and 20,621 FEU respectively. The data also show 21,442 FEU of imports moving to Massachusetts through Long Beach/Los Angeles and 9,525 FEU through Seattle/Tacoma, and 11,252 FEU of imports through Long Beach/Los Angeles to Missouri.

Table I-25 shows these and other examples of large import or export movements between specific states and ports. There is reason to believe that many of these figures are exaggerated by the headquarters bias (such as the Massachusetts imports). Yet all of the state-port pairs shown in Table I-24 are served by existing double-stack operations. The exceptions may be Michigan-Norfolk (which may include large movements of coil steel for the auto industry), and New Jersey-Charleston or New York-Charleston (which may be trucked, or reflect a headquarters bias).

A second observation is that the FEU totals in Table I-25 would not justify the actual number of double-stack trains serving some of those state-port pairs if all those trains actually carried 200 FEU each. The obvious examples are Illinois - LA/LB, Illinois - Sea/Tac, and Texas - LA/LB, all of which have more than one daily train. Clearly, the double-stack trains are serving the multi-state areas surrounding each major city.

Finally, almost all of the flows shown have strong import imbalances, even allowing for a bias towards the headquarters of major importers (such as the Sears Roebuck headquarters in Chicago, which is incorrectly shown as the inland destination of most Sears imports). The only international flow that is

Table I-25

1987 BUREAU OF THE CENSUS DATA
HIGH VOLUME STATE-PORT PAIRS

State	Port	1987 Import FEU	1987 Export FEU
California	New York	14,565	493
Illinois	LB/LA	46,547	5,501
Illinois	Sea/Tac	20,621	4,185
Massachusetts	LB/LA	21,442	448
Massachusetts	Sea/Tac	9,525	534
Michigan	Norfolk	8,698	705
Michigan	LB/LA	14,427	2,754
Michigan	Sea/Tac	7,174	1,828
Missouri	LB/LA	11,252	964
New Jersey	Charleston	8,113	462
New Jersey	LB/LA	53,152	1,070
New Jersey	Sea/Tac	28,720	567
New York	Charleston	18,411	436
New York	Houston/Galveston	8,111	706
New York	LB/LA	66,890	1,822
New York	Oak/SF	16,925	359
New York	Sea/Tac	38,925	1,574
Ohio	LB/LA	16,118	3,967
Ohio	Sea/Tac	10,525	1,325
Pennsylvania	LB/LA	15,353	868
Tennessee	LB/LA	8,608	2,257
Texas	LB/LA	27,333	25,471
Texas	Oak/SF	1,412	12,212

even roughly balanced is Texas - LB/LA, and the only flow with a large export imbalance is Texas - Oak/SF.

REGIONAL AND COASTAL SUMMARIES

The observations above suggest that a regional, rather than state approach to inland origins and destinations may be useful in understanding the existing pattern and future potential of double-stack service. The major intermodal hubs in Chicago, Kansas City, St. Louis, Memphis, Atlanta, Dallas, Houston, New Orleans, New York, and elsewhere are clearly serving origins and destinations beyond the boundaries of their states. Conventional wisdom suggests drayage ranges of up to 250 miles from major hubs, which in many cases would include parts of several states. (The headquarters bias may also artificially concentrate what should be regional data into just a few states.)

Accordingly, the study team used the regions shown in Figure I-25, which are identical to the truck regions shown in Figure I-1. Each region, with the exception of California, includes two or more states and is grouped around major urban clusters with intermodal hubs. There are also good reasons to look at coastal aggregations of ports, in addition to individual ports. Intermodal cargo bound to or from distant inland points is by nature discretionary, and can be routed with comparable efficiency through any one of several major ports on the appropriate coast. For example, intermodal cargo moving between Asia and the Upper Midwest can be routed through Seattle/Tacoma, Oakland/San Francisco, or Long Beach/Los Angeles with comparable costs and transit times. Indeed, many intermodal shippers are relatively indifferent about port selection, and the routing of their cargo may ultimately depend on their choice of ocean carrier, and on that carrier's choice of itinerary and rail connections.

The port and state information is condensed in the Appendix tables, and summarized in Tables I-26 and I-27. These tables use FEUs and "Weekly Train Equivalents" of 10,000 annual FEUs (200 FEU per train, 50 trains per year) to display the underlying pattern of regional and coastal container movements.

Figure I-25
Multi-State Inland Regions



Table I-26

1987 IMPORT/EXPORT SUMMARY
By Coast and Inland Region

	Import FEUs	Weekly Train Equivalents	Export FEUs	Weekly Train Equivalents
** Atlantic				
California	37929	3.8	2657	0.3
Lower Midwest	17836	1.8	7729	0.8
Mid Atlantic	81992	8.2	115575	11.6
Mountain	4258	0.4	2284	0.2
Northeast	571910	57.2	86542	8.7
Northwest	4994	0.5	1180	0.1
Southeast	89750	9.0	103014	10.3
Upper Midwest	87355	8.7	34095	3.4
** Subtotal **	896024	89.6	353076	35.3
** Great Lakes				
California	10	0.0	18	0.0
Lower Midwest	69	0.0	150	0.0
Mid Atlantic	29	0.0	8	0.0
Mountain	1	0.0	137	0.0
Northeast	275	0.0	26	0.0
Northwest	4	0.0	35	0.0
Southeast	17	0.0	17	0.0
Upper Midwest	885	0.1	1735	0.2
** Subtotal **	1290	0.1	2126	0.2

Source: Bureau of the Census

Table I-26

1987 IMPORT/EXPORT SUMMARY
By Coast and Inland Region

	Import FEUs	Weekly Train Equivalents	Export FEUs	Weekly Train Equivalents
** Gulf				
California	6741	0.7	6190	0.6
Lower Midwest	23824	2.4	92649	9.3
Mid Atlantic	2428	0.2	5607	0.6
Mountain	2725	0.3	4904	0.5
Northeast	30969	3.1	4193	0.4
Northwest	801	0.1	519	0.1
Southeast	43133	4.3	44156	4.4
Upper Midwest	9815	1.0	4991	0.5
** Subtotal **	120436	12.0	163209	16.3
** Pacific				
California	328976	32.9	161752	16.2
Lower Midwest	67382	6.7	53192	5.3
Mid Atlantic	34143	3.4	14604	1.5
Mountain	14975	1.5	21793	2.2
Northeast	294413	29.4	9936	1.0
Northwest	34594	3.5	116182	11.6
Southeast	24308	2.4	15564	1.6
Upper Midwest	153375	15.3	37972	3.8
** Subtotal **	952166	95.2	430995	43.1
*** Total ***	1969916	197.0	949406	94.9

Source: Bureau of the Census

Table I-27

1987 IMPORT/EXPORT SUMMARY
By Inland Region and Coast

	Import FEUs	Weekly Train Equivalents	Export FEUs	Weekly Train Equivalents
** California				
Atlantic	37929	3.8	2657	0.3
Great Lakes	10	0.0	18	0.0
Gulf	6741	0.7	6190	0.6
Pacific	328976	32.9	161752	16.2
** Subtotal **	373656	37.4	170617	17.1
** Lower Midwest				
Atlantic	17836	1.8	7729	0.8
Great Lakes	69	0.0	150	0.0
Gulf	23824	2.4	92649	9.3
Pacific	67382	6.7	53192	5.3
** Subtotal **	109111	10.9	153720	15.4
** Mid Atlantic				
Atlantic	81992	8.2	115575	11.6
Great Lakes	29	0.0	8	0.0
Gulf	2428	0.2	5607	0.6
Pacific	34143	3.4	14604	1.5
** Subtotal **	118592	11.9	135794	13.6
** Mountain				
Atlantic	4258	0.4	2284	0.2
Great Lakes	1	0.0	137	0.0
Gulf	2725	0.3	4904	0.5
Pacific	14975	1.5	21793	2.2
** Subtotal **	21959	2.2	29118	2.9

Source: Bureau of the Census

Table I-27

1987 IMPORT/EXPORT SUMMARY
By Inland Region and Coast

	Import FEUs	Weekly Train Equivalents	Export FEUs	Weekly Train Equivalents
** Northeast				
Atlantic	571910	57.2	86542	8.7
Great Lakes	275	0.0	26	0.0
Gulf	30969	3.1	4193	0.4
Pacific	294413	29.4	9936	1.0
** Subtotal **	897567	89.8	100697	10.1
** Northwest				
Atlantic	4994	0.5	1180	0.1
Great Lakes	4	0.0	35	0.0
Gulf	801	0.1	519	0.1
Pacific	34594	3.5	116182	11.6
** Subtotal **	40393	4.0	117916	11.8
** Southeast				
Atlantic	89750	9.0	103014	10.3
Great Lakes	17	0.0	17	0.0
Gulf	43133	4.3	44156	4.4
Pacific	24308	2.4	15564	1.6
** Subtotal **	157208	15.7	162751	16.3
** Upper Midwest				
Atlantic	87355	8.7	34095	3.4
Great Lakes	885	0.1	1735	0.2
Gulf	9815	1.0	4991	0.5
Pacific	153375	15.3	37972	3.8
** Subtotal **	251430	25.1	78793	7.9
*** Total ***	1969916	197.0	949406	94.9

Source: Bureau of the Census

Table I-26 organizes the data by inland region, displaying the 1987 import and export traffic routed through each coast. For example, the first line of Table I-26 shows that imports equivalent to 3.8 weekly double-stack trains were routed to California through Atlantic Coast ports in 1987, and just 0.3 train equivalents of California exports (as reported) moved the opposite way. In almost every case, the largest volume of imports and exports is routed through the nearest coast. Such movements would ordinarily be a short-haul truck market, rather than a double-stack rail market. The major candidate double-stack flows are California traffic through the Atlantic Coast; Lower Midwest traffic through the Pacific Coast; Mid-Atlantic traffic through the Pacific Coast; Northeast traffic through the Gulf and Pacific Coasts; Southeast traffic through the Pacific Coast; and Upper Midwest traffic through both the Atlantic and Pacific Coasts. This is essentially a description of the major current double-stack movements, with the vast majority moving between the Pacific Coast ports and points in the Midwest or beyond.

This pattern is made still clearer in Table I-27, which organizes the same data by coast. Table I-27 shows that, in 1987, the equivalent of about 95 weekly double-stack trains of containerized imports moved through Pacific Coast ports, and that the equivalent of about 57 weekly trains moved to the Midwest states and beyond. By way of comparison, an earlier section identified roughly 100 weekly Pacific Coast departures in late 1988. Allowing for trade growth, the shorter length of some trains, and the prevalence of domestic freight on American President Intermodal trains, the two perspectives on double-stack movement patterns seem consistent.

DETAILED RESULTS

Detailed results of our processing of the 1987 Bureau of the Census data are given in Appendices 1-12 through 1-17, each with different aggregations.

IX. THE RELATIONSHIP BETWEEN PORTS, OCEAN CARRIERS, AND RAILROADS

THE EMERGING NEED FOR COOPERATION

Until the recent growth in intermodalism, there was little need for close, three-way cooperation between ports, ocean carriers, and railroads. Until ocean carrier services were extended inland via landbridge and mini-landbridge, direct contact between ocean carriers and railroads was largely incidental. Until the growth in inland services made port choice discretionary for large volumes of containerized cargo, ports had little incentive to involve themselves in transportation beyond their terminal boundaries.

The advent of large-scale inland intermodal services has changed traditional relationships. Even before double stacking, ports, ocean carriers, and railroads began to see large volumes of high-priority traffic that required cooperation among them. APL began operation of regular Linertrains with conventional flatcars in 1979, and did not convert them to double-stacks until 1984. Railroads began making specific arrangements to accommodate container traffic, beginning with basic issues such as car supply, mechanical lift equipment, and chassis parking at terminals. In fact, SP's original design for a double-stack car was conceived as a means to handle existing ocean carrier business more efficiently.

The growth of double-stack trains has increased the traffic affected by port, ocean carrier, and railroad relationships. The higher standard of service and opportunity for cost savings through double-stack service has made close cooperation more critical to success.

Three factors have intensified the need for cooperation between ports, ocean carriers, and railroads. The first factor is the discretionary nature of inland container cargo, which has increased competition between ports and between railroads. The second factor is deregulation, specifically the increased use of multi-year contracts that enable ocean carriers and railroads to make long-term commitments to container services. The third factor is

increased competition within the intermodal industry, which has increased the pressure on all three parties.

Discretionary Cargo. The routing of container cargo bound to or from rail-served inland destinations has become discretionary because intermodal operations can move cargo efficiently to major inland points from more than one competing port, and because extension of ocean carrier services inland has shifted routing responsibility from ocean shipper to ocean carrier. Ocean carriers in the transpacific trade can reach mid-continent gateways and hubs such as Chicago, Kansas City, St. Louis, or Memphis with competitive cost and service from any major West Coast port. Ocean carriers in the Atlantic trades can do the same from several East Coast ports. This ability gives ocean carriers the flexibility to shift between competing ports to take advantage of better intermodal facilities, lower transfer costs, or a better price/service offer from a different railroad. This flexibility in turn places the ports, and the railroads that serve them, in more intense competition than ever before.

Until ocean carriers began using mini-landbridge tariffs for container cargo, shippers, receivers, or their agents typically controlled both port choice and inland routing. Ocean carrier and port services ended at the marine terminal gate. Both ports and ocean carriers advertised to inland customers, but the railroads were not heavily involved in long-distance ocean transport except to move bulk export cargoes such as grain or coal. Under mini-landbridge tariffs, however, the ocean carrier has the responsibility for selecting the port and the inland carrier.

Deregulation. Deregulation and regulatory exemption of intermodal traffic have had numerous effects, but perhaps the most relevant change is the shift from published tariffs to negotiated contracts. The use of contracts rather than tariffs allows ocean carriers and railroads to enter into multi-year commitments regarding volume, rates, and service. Once such a commitment is in place, both parties can make plans and investments to handle a specific minimum volume of traffic tendered at a specific port. Conversely, competitive contract offers may depend on plans for cost-saving operations or invest-

ments. In either case, the contract commitment directs traffic through a specific port for a period of up to five years, and may require the cooperation of that port for success.

Competition. The factors described above, and others as well, have intensified competition on land, at sea, and between ports. Low railroad rates of return and market pressure from deregulated truckers have added to the railroad competition encouraged by the Staggers Act and the intermodal exemption. Rail mergers have created large intermodal systems, offering multiple competing routes between major origins and destinations. Unlike carload shippers, who are usually tied to one originating railroad, intermodal shippers can often dray their freight to two or more different intermodal yards. Third-party intermodal participation has also tended to intensify competition, because third parties themselves are highly competitive and often have sufficient traffic volume to negotiate favorable contracts. In the container trades, recent large increases in capacity have given ocean carriers incentives for aggressive pricing. Changes in the conference system, notably the increased latitude for "independent action", have brought much the same competitive pressure on the sea as deregulation has on land. Load centering, the practice of funnelling vast local and inland traffic through a small number of container ports, has raised the stakes in port competition. Increasingly, ports are competing for the large inland flows on an "all or nothing" basis. Mergers, joint services, and deployment changes have reduced the number of major port clients, again intensifying competition.

THE OCEAN CARRIER-RAILROAD RELATIONSHIP

The major interchanges of traffic between ocean carriers and railroads are confined to contractual relationships. Some inland traffic is still handled under tariffs, tendered either by ocean carriers or third parties, but the major traffic flows of interest in this study -- current and potential double-stack operations -- move under contract.

Dedicated Train Contracts. Ocean carrier-railroad contracts can take several forms, the first of which is a dedicated double-stack train operation, the

form in which double-stack operations were popularized. In such a contract, the railroad operates a double-stack train on a fixed route for the exclusive use of the ocean carrier. This is often a "take or pay" contract: the ocean carrier pays for the round-trip railcar movement, whether or not there are any containers aboard. Cars can come from different sources:

- purchased or leased by the ocean carrier;
- purchased or leased by the railroad, and assigned to the ocean carrier;
- purchased or leased by Trailer Train, assigned to the railroad, and assigned by the railroad to the ocean carrier; or
- drawn by the railroad from a pool of Trailer Train or railroad-owned cars.

Only APC and Sea-Land have purchased or leased cars directly (APC's cars use APLX initials, Sea-Land's cars use the Susquehana NYSW initials). As of late 1988, railroads themselves actually own or lease only a small number of double-stack cars (ATSF/SFLC has 92, BN has 95, CR has 15, SP has 64 including the prototype ACF cars). Approximately 32 cars carry Greenbrier Leasing initials (GBRX). The majority of double-stack cars, and the principal source for ocean carriers other than APL or Sea-Land, are those purchased or leased by Trailer Train (DTTX initials) and assigned to railroads or operated in pools. One common type of dedicated-train contract passes through the Trailer Train per diem and mileage charges to the ocean carrier, essentially a "train for hire" or "haulage" arrangement.

Dedicated Car Contracts. A second contract type dedicates a number of cars for use of the ocean carrier, but they operate as part of a regularly scheduled train rather than as a dedicated train by themselves. This type of contract is relatively uncommon, as it has been largely superceded by "common user" volume contracts.

Common-User Contracts. The third and perhaps most numerous type of contract is the "common user" volume agreement. In such a contract, the ocean carrier agrees to ship a minimum annual volume of containers over the railroad in

exchange for favorable rates. The low rates are typically offered in corridors where common-user double-stack trains are operated, although in some cases the commitment is system-wide. It is critical to note that the low rates are based on the expected use of double-stack cars, but in lesser corridors or where double-stack cars are in short supply, the containers may actually move on conventional equipment. The rates applied to common-user volume contracts depend on the traffic volume in question. Some railroads negotiate each volume discount separately. Others, notably BN, have put a "tier" system in place, tying rates to volume thresholds. Such contracts are usually open to large third parties, or to ports acting as shipper's agents.

Because the larger ocean carriers have multiple cargo flows in multiple corridors, it is common for such carriers to have more than one rail contract in place. Such a combination may include dedicated-train contracts for the largest corridors (such as Los Angeles-Chicago), and one or more common-user contracts to cover smaller flows from various ports over two or more railroads.

THE RAILROAD-PORT RELATIONSHIP

The railroad-port relationship centers around facilities and infrastructure. Some ports own and operate switching or terminal railroads, and to that extent are involved in rail operations. Some ports have authority to operate as shippers' agents, and to that extent may be railroad customers. These aspects, however, are incidental to the serious issues raised regarding port and port-area rail intermodal facilities.

The issue of rail transfer facilities became germane for intermodal business as competitive pressures led ocean carriers and railroads to seek transfer cost savings. Historically, the link between ship and rail has been over-the-road drayage. The elimination of over-the-road drayage through the provision of so-called "on-dock" transfer facilities can confer a competitive advantage to the railroad-port-ocean carrier combination -- and force competing carrier and port combinations to seek comparable improvements.

The issue, however, is not as simple as "on-dock" versus "off-dock." Each major container port has a unique configuration of terminals and rail facilities. While there is a trend toward more on-dock facilities, several ports have examined alternatives designed to reduce transfer costs between existing facilities. The Virginia Port Authority has taken an entirely different approach, establishing the Virginia Inland Port (VIP) well inland of the ports in the Norfolk area, and within the Port of Baltimore hinterland, with the intention of capturing traffic from a larger region. The issues surrounding on-dock, off-dock, and other rail transfer facilities will be addressed in depth in Tasks IV and V.

Ports would prefer to be served directly by several railroads, in order to offer their clients the benefits of rail competition. Each port, however, would prefer that the railroads serving it would not also serve other ports or solicit traffic at other ports. The railroads have opposing preferences: to serve as many ports as possible, and to be the only railroad at each. It is therefore to be expected that proposals to provide competitive port access to additional railroads would be supported by the port and the new railroad, and opposed by other ports and the existing railroad. This situation has occurred at at least one major port, and is likely to occur elsewhere as ports seek to improve rail access and encourage rail competition.

THE OCEAN CARRIER-PORT RELATIONSHIP

The ocean carrier-port relationship has many features, some of which have been markedly affected by the growth of intermodal and double-stack service. As explained above, inland intermodal cargo is fundamentally discretionary, giving ocean carriers substantial freedom in the choice of a principal intermodal port. This freedom has fueled greater competition between ports in different regions, as well as between ports in the same region. Ocean carriers with great volumes of intermodal cargo have equally great bargaining leverage in negotiations with ports over terminal size and equipment, port charges, intermodal transfer facilities, and ancillary port services. As the number of large ocean carriers is reduced by merger, service rationalizations, and joint ventures, each remaining carrier acquires greater importance. Moreover, the

nature of discretionary cargo and the competitive efforts of neighboring ports make a carrier's threat to switch ports very credible. To remain competitive, ports are compelled to invest in container cranes, terminal improvements, electronic gates and information systems, and on-dock or near-dock rail transfer facilities. Ports seek multi-year ocean carrier commitments to secure these investments.

Ports can be roughly classified as "landlord" ports (those that build and equip terminals but leave the actual operation to tenants) or "operating" ports (those that operate terminals with port employees). The dominant pattern in container trades has been for landlord ports to lease terminals to either stevedore companies (who then operate the terminal for one or more steamship line clients) or steamship lines (who then contract with an outside or subsidiary stevedore company to operate the terminal). Ports more often concentrated on their own operational activities in bulk, break-bulk, or neo-bulk terminals. The distinction between landlord and operating ports, never sharp, is now breaking down further as ports take on additional service functions. Several major ports have shipper's agent authority, and can consolidate ocean carrier volumes under a rail contract rate. Virtually all major container ports are operating or developing automated cargo clearance systems in conjunction with the expansion of the Customs Service AMS system. Several container ports also operate or lease port-area consolidation or distribution facilities to attract major importers, exporters, and their cargo. Finally, major intermodal projects underway or in development are typically multi-user facilities designed to capture economies of scale, and typically anticipate a higher level of port operating involvement than the historical pattern of single-user terminals.

The relationship expands to include the railroads when the ports take an active part in reducing rail transfer costs, or consolidating intermodal traffic under shipper's agent authority to offer lower rates to smaller carriers.

RAILROAD CLEARANCES

One current issue that unites all three parties is the issue of railroad line clearances. Double-stack cars require greater overhead clearances than other

types of railroad freight cars, and there are many rail routes where tunnels, bridges, overpasses, or other structures do not have sufficient clearance. The problem is more common in the eastern states, where the older rail and road infrastructure has for many years limited the use of conventional piggyback cars and tri-level autoracks. Ironically, the well-type Budd Lo-Pac 2000 double-stack car was originally designed as a means of moving piggyback trailers through low eastern clearances. When double-stack cars are loaded with two high-cube, 9'6" high containers, the problem is exacerbated. The problem reaches its greatest dimensions when 53-feet long, 102-inch-wide domestic containers are placed on top, increasing the lateral clearance requirements at the greatest height. The largest combination requires nearly 10 feet of width at 20 feet above the rail. Few railroad tunnels were built with such clearances, and potential clearance problems with the largest domestic containers are common throughout the rail system.

Ocean carriers, railroads, and ports have a common interest in improved clearances and unrestricted double-stack access. The situation, however, is often described as a chicken-and-egg problem: railroads are generally willing to invest in clearance improvements if traffic to justify that investment is committed, but ocean carriers are unwilling to commit traffic unless clearances are improved. In at least one case, a railroad, an ocean carrier, and a port have jointly funded tunnel clearance improvements: Union Pacific, American President, and the Port of Oakland are jointly funding tunnel-clearance improvements in the Feather River Canyon. This cooperative action has encouraged other railroads and ports to explore the possibilities of joint endeavors, and at least two similar projects are currently under consideration.

X. CURRENT AND PLANNED CAPITAL INVESTMENTS

THE SCOPE OF DOUBLE-STACK INVESTMENTS

At this point in the development of double-stack services, it is safe to say that a double-stack network is emerging piecemeal from the actions of individual railroads and ocean-carriers. Many of those actions entail capital investments in the form of construction, renovation, acquisition, or long-term leasing. The scope of these investments encompasses railcars, locomotives, containers, lift-equipment, intermodal facilities, and right-of-way improvements.

Early investments in double-stack systems were focused on the double-stack cars themselves. Locomotives were drawn from existing fleets, containers were provided by ocean carriers, loading and unloading was handled at existing intermodal yards, and double-stack trains moved only where clearances were adequate. Indeed, only Southern Pacific had invested in double-stack cars until APL and Sea-Land bought or leased their own to start dedicated trains.

The second round of investment was occasioned by the growing volume of double-stack traffic and its importance to the railroads. CNW invested in "Global One," probably the first intermodal facility designed for double-stacks. SP, with the Ports of Los Angeles and Long Beach, began development of its Southern California Intermodal Container Transfer Facility (ICTF). The initial ICTF planning actually predated the major growth in double-stack traffic. In the Pacific Northwest, Burlington Northern developed its Seattle International Gateway (SIG) specifically to handle container traffic, and the Port of Tacoma constructed its southern rail transfer facility to accommodate Sea-Land double-stacks.

A third round of capital investment is now underway, reflecting the permanent importance of double-stack traffic and the growth of domestic containerization. These investments, which are discussed below, include numerous facilities, right-of-way improvements, locomotives for intermodal service, and domestic containers.

This section concentrates on the investments made by railroads and others in 1988, or planned for 1989, to accommodate international and domestic container traffic. The information was compiled from published announcements, and is therefore limited to the detail given in those announcements.

INTERMODAL EQUIPMENT

ATSF. Santa Fe has announced a five-year program of capital investment in intermodal equipment with the goal of minimizing conventional, non-articulated cars. The plan calls for the addition of 400 articulated cars (double-stack, Impack, or spine cars) each year. Acquisitions announced for 1988 and 1989 already exceed that number. In 1988, Santa Fe expects to have acquired 100 5-platform double-stack cars; 120 5-platform spine cars; and 200 5-platform Impack cars; for a total of 420 cars and 2100 platforms. For 1989, Santa Fe has ordered 200 5-platform Impack cars and expects to announce an order for 280 more, a total of 480 cars and 2400 platforms.

Santa Fe has also announced substantial investments in piggyback trailers and domestic containers. To its piggyback fleet, Santa Fe will add 600 45-foot trailers, 400 48-foot trailers, and 1700 40-foot insulated trailers, a total of 2700 units. Santa Fe is one of few railroads to invest in domestic containers, with plans to acquire 1000 45-foot containers, 300 48-foot containers, and 500 40-foot containers.

Finally, in 1988 Santa Fe ordered 40 high-horsepower, 4-axle locomotives for intermodal service (20 GP60's from EMD and 20 B40-8's from GE). Santa Fe has purchased only high-horsepower, 4-axle units since 1982.

Burlington Northern. For 1989, Burlington Northern has announced plans to acquire 120 5-platform double-stack cars and 1000 48-foot containers for domestic use.

Conrail. Conrail acquired 30 high-horsepower, 4-axle B40-8 locomotives suitable for intermodal service in 1988, and will acquire another 25 in early 1989.

CSX/Sea-Land. CSX's CSL subsidiary has announced a $40 million capital investment plan for intermodal facilities and equipment in 1989. Half (roughly $20 million) will be devoted to, among other things, expanding the fleet of domestic containers. CSL has been placing 45-foot domestic containers in service between Southern California and Atlanta, and 48-foot domestic containers in service between Southern California and both Atlanta and Jacksonville.

Sea-Land has, historically, been the only major intermodal operator using 35-foot containers. The original SP/ACF double-stack cars had adjustable "flippers" designed specifically to accommodate Sea-Land's still sizeable fleet of 35-foot containers which, as recently as 1986, made up 45 percent of Sea-Land's fleet. Sea-Land's management has made replacement of the 35-foot containers a major priority, and they should be completely gone by the end of 1989.

CSX Intermodal has also announced that it expects to purchase 4,250 45-foot piggyback trailers in 1989.

Norfolk Southern. Norfolk Southern is heavily committed to promotion of its Triple-Crown Road Railer Service. For 1989, NS plans to purchase 600 Mark V (demountable truck) 48-foot-long, 102-inch-wide Road Railers, bringing the total Road Railer fleet to 1600 units. NS also plans on investing some $75 million for 66 new locomotives, at least half of which will be high-horsepower, 4-axle units (EMD GP59's) suitable for intermodal traffic.

New York, Susquehana & Western. The NYSW has announced an order for 20 high-horsepower, 4-axle locomotives (GE model B40-8) specifically for assignment to Sea-Land double-stack trains.

Southern Pacific. SP/DRGW has announced plans to acquire 80 double-stack cars (400 platforms) in 1989. In 1988, SP acquired 50 high-horsepower, 4-axle locomotives, presumably for intermodal service, at a cost of $60 million (the order was split between 35 B40-8's from GE and 15 GP60's from EMD). For 1989, the combined system plans to add another 50 locomotives: 20 B40-8's and 30

GP60's. SP has purchased only 4-axle units since 1980. Finally, SP has also announced plans to purchase 30 piggyback trailers in 1989.

Union Pacific. UP's intermodal focus (other than its contractual relationship with API) has been its Tanktainer service, which offers about 93 tank-type containers to domestic shippers. In the first quarter of 1989, UP expects to add about 90 more tank-type containers, effectively doubling the fleet. Union Pacific has ordered 212 new locomotives, all six-axle, high-horsepower units that UP uses for general service, including intermodal.

Trailer Train. For the first quarter of 1989, Trailer Train has announced a $52.2 million equipment purchase plan, almost entirely devoted to intermodal cars. Trailer Train will purchase 150 125-ton double-stack cars (750 platforms) at a cost of $29 million; 70 spine cars (350 platforms) for $7.2 million; and 500 TOFC platform units for $16 million. Trailer Train has also invested in Road Railer technology, buying 400 rail bogies (demountable trucks) for use with Mark IV RoadRailers. In 1988, Trailer Train retired roughly 2500 older TOFC flatcars and converted another 1500 flatcars to auto racks. Total Trailer Train capital investment for 1988 is expected to total roughly $170 million.

Monon Corporation. Monon Corporation has emerged as a major builder of domestic containers. As of late 1988, Monon had a backlog of orders for roughly 6800 domestic containers in 45-foot, 48-foot, and 53-foot sizes. The major purchaser is XTRA Corp., who in turn will lease the containers to Santa Fe, BN, CSL, API, and others. These orders are reflected in the carrier-by-carrier accounts given earlier. Monon also produces container chassis, and had orders for roughly 4600 in late 1988.

XTRA Corp. XTRA has emerged as a major less or of intermodal equipment. In 1988, XTRA purchased 1200 trailers, 4000 domestic containers, and 3800 chassis. For 1989, the emphasis will shift back to piggyback: XTRA plans to purchase 4380 trailers, 1500 containers, and 1700 chassis, a total expenditure of roughly $100 million.

Transamerica Interway. Transamerica has not announced detailed investment plans. Several thousand vehicles will be purchased, with the emphasis apparently on domestic containers.

FACILITIES

American President Intermodal. In 1988, API opened a facility in Woodhaven, Michigan to support its Detroit-Chicago-Texas service. API also ordered three rubber-tired Transtainer gantry cranes for its South Kearny yard.

Trailer Train. Trailer Train announced the acquisition of a railcar repair facility in Drayton, Michigan which will presumably service Trailer Train's intermodal car fleet. Total cost, with improvements, is expected to be roughly $4.5 million.

Conrail. To accommodate double-stacked high-cube containers on its Chicago-Columbus main line, Conrail is spending $3.5 million to obtain 20-foot, 6-inch clearances under 12 bridges between Chicago and Toledo. Conrail is seeking funding participation from the State of Pennsylvania for a $38 million clearance improvement project on its east-west mainline between Philadelphia and Pittsburgh. The railroad hopes to raise some bridges, lower the tracks under others, and improve tunnel clearances to obtain at least 22 feet of clearance over the whole route (enough for double-stacked high-cube containers).

ATSF. Santa Fe has announced a program of improvements at its Chicago and Kansas City intermodal terminals. Both terminals will receive additional trackage. The Chicago terminal will be expanded by 10 acres, at a cost of $1.1 million. The Kansas City Terminal will receive a third Travelift gantry crane. Santa Fe also opened a new mechanized terminal called "Illini Lift" in Galesburg, IL. For its Albuquerque, New Mexico, facility, Santa Fe leased a Mi-Jack gantry crane to provide lift-on, lift-off service. The Barstow, El Paso, Galesburg, Stockton and San Bernadino facilities have likewise been mechanized. ATSF is also replacing older lift equipment at Los Angeles and Chicago, and adding additional sideloaders in Los Angeles. Both Los Angeles and Chicago facilities will be further upgraded with vertical chassis storage

systems. Finally, Santa Fe is in the process of opening a new Intermodal Market Extension (IMX) facility in Nogales, Arizona, to serve the Mexican market.

CSX. CSL Intermodal plans to spend about $20 million to expand and modernize its facilities in Chicago, New Orleans, and Little Ferry.

Wiscorsin Central. Wisconsin Central has announced plans for a new intermodal facility in Neenah, Wisonsin with mechanical lift capability.

Iowa Interstate. This regional carrier provides domestic intermodal and double-stack service. In late 1988, Iowa Interstate purchased a PC90 side-loader to mechanize its Newton, Iowa intermodal facility (30 miles east of Des Moines). IAIS also added 1500 feet of track, new lighting, and other improvements to the Newton facility.

Union Pacific. In 1988, Union Pacific made capital improvements to its Los Angeles intermodal facility, and constructed a new intermodal facility in Memphis. UP's ongoing $15 million effort to improve tunnel clearances in the Feather River Canyon is scheduled for completion in mid-1989. This project was jointly funded by UP, API, and the Port of Oakland.

SP/DRGW. The DRGW has been pursuing a program of tunnel clearances improvements to accommodate double-stacks. This program was apparently completed in 1988, as test trains were successfully operated in October of that year.

In an effort to keep abreast of rapidly growing traffic, SP added 87 acres of land to its Los Angeles ICTF and designated another 55 acres of land for further expansion. Improvements there are expected to cost $1.8 million. SP also plans to purchase 36 ramp tractors for its intermodal facilities.

CNW. Chicago & North Western is proceeding with the construction of "Global Two," a second double-stack yard in Chicago. Global Two is scheduled for completion in 1992, but portions are expected to be in operation earlier. CNW is investigating possible sites for "Global Three."

Rail-Bridge Corp. Rail-Bridge Corp. is a subsidiary of International Transportation Services (ITS) of Long Beach, which is in turn a subsidiary of K-Line. Rail-Bridge has opened two new double-stack hubs. The first, called "E-Rail," is a 60-acre facility in Elizabeth, New Jersey. The second is a facility in Welland, Ontario, 50 miles south of Toronto.

Canadian National. CN plans to build a $19 million (Canadian) intermodal facility at Port Mann, near Vancouver, British Columbia. This facility will replace two existing Vancouver yards and will enable CN to handle the newly announced Vancouver-Toronto double-stack trains more efficiently. Completion is scheduled for late 1991.

Norfolk Southern. NS has budgeted $17.2 million for intermodal facilities and improvements in 1989. Container facilities at Columbus, Ohio, and Welland, Ontario will receive improvements. Much of the planned expenditure will go for additional terminals and terminal improvements for NS's Triple Crown Road-Railer service.

Stockton Terminal & Eastern. The ST&E is certainly the smallest railroad to report container-related investments. The ST&E has reached an agreement to act as an inland Container Freight Station for the Port of San Francisco, and in that capacity has acquired a side-lift crane to handle containers without chassis.

PORTS

Port of Baltimore. One of the largest single facility investments is Baltimore's new Seagirt terminal, which is scheduled to open in mid-1989 at a cost of $240 million. It will provide what is effectively on-dock transfer to an adjacent rail yard that is already in operation (although the subject of a labor dispute).

Virginia Port Authority. The Virginia Port Authority Expects to open its $10 million "Virginia Inland Port" (VIP) in 1989. VIP was built at Front Royal, VIrginia, over a hundred miles from the Hampton Roads ports it will serve.

This inland development is placed squarely in the traditional hinterlands for the Port of Baltimore, and may signal a new ear in port competition. VIP is expected to handle 20,000 containers the first year, and 40,000 in the second year. Initial plans call for Norfolk Southern to carry containers between VIP and Hampton Roads on three trains per week.

Port of Tacoma. The Port of Tacoma expects to open its new Terminal 3 container facility in April of 1989. Development of this $30 million facility was somewhat delayed by difficulties in resolving tribal claims to adjacent fishing grounds.

Port of Charleston. The Port of Charleston plans to spend $60-65 million to expand its Wando Container Terminal. The project will add 1373 feet of marginal wharf and 62 acres of paved backland for container storage. This project will coincide with the completion of Interstate 526, which will feature a direct freeway interchange at the Wando terminal. The Port established a neutral chassis pool in November, 1988, to serve more than 33 steamship lines. Finally, the Port of Charleston is pursuing the development of an entirely new container terminal, and expects to choose a final site in 1989.

Port of Seattle. The Port of Seattle has approved construction of a $3.2 million on-dock rail facility to serve its Harbor Island container terminals. The project also involves expenditures of $3-4.5 million for a new gatehouse and additional paving.

Port of Oakland. The Port of Oakland has announced a $10-12 million intermodal demonstration project involving the first phase of a multi-user on-dock rail transfer facility and improvements to port-area drayage roads and traffic circulation. Oakland also expects to finalize a lease on portions of the Naval Supply Center, which will be used to expand adjacent intermodal facilities. In 1989, Union Pacific expects to complete the $15 million tunnel clearance improvement project, in which the Port of Oakland has participated. Development of the Port's two-berth Carnation container terminal is being pursued, but construction is still a year or more away.

Port of San Francisco. The Port of San Francisco expects to spend $2 million to upgrade and modernize two container cranes to handle jumbo ships. The Port also plans to invest $5-8 million in improving clearances in rail tunnels serving the Port with construction to be completed in 1990.

Port of Portland. To serve its recently expanded container terminal and on-dock rail facility, the Port of Portland has established a neutral chassis pool to be managed by Strick Leasing Intermodal.

Port of Houston. The Port of Houston is expanding its Barbours Cut terminal complex. The project includes two new berths of 1,000 feet each, an additional 95 acres of backland, and expansion of the adjacent intermodal rail facility. Total project cost (including a berth for import auto traffic) is $80 million.

Port of New Orleans. At its France Road terminal, the Port of New Orleans has a $17 million improvement project scheduled for completion in 1989. The project includes 17 acres of paving and one or more new container cranes.

Port of Galveston. The Port of Galveston expects to complete a $8 million terminal expansion project by mid-1990. The project encompasses a new 730-foot berth, and 20 acres of backlands.

Gulfport. Gulfport is operated by the Mississippi State Port Authority. Investment plans include adding 18 acres to the public container terminal, and additional dredging.

Port of Long Beach. In 1988, the Port of Long Beach approved a controversial proposal to expand on-dock rail trasfer facilities at the International Transportation Services (ITS) terminal (which serves K-Line). The approval, however, is contingent on resolving complex rail access issues.

ANALYSIS

Some of the capital investment plans described above are noteworthy for specific reasons. Yet, taken as a whole, the industry intermodal investment plans

for 1988 and 1989 do not signal any significant departure from current trends. As Table I-28 shows, overall railroad and third party investment will be over $500 million for intermodal equipment.

Railroad capital investment is ordinarily cyclical: a period of prosperity and traffic growth will spur large capital investments which must then carry the railroad through leaner times. The intermodal segment has had the steadiest and strongest growth of any business segment, and has accordingly attracted a steadier stream of investments. The widespread purchases of high-horsepower, 4-axle locomotives reflect this history of growth and the railroads' conviction that growth will continue. (CSX and UP have not joined this trend, as they are investing in six-axle power which they use across all business segments.)

The railroads themselves have taken a conservative approach to freight car purchases over the last decade. Improvements in utilization have enabled the railroads to handle moderate traffic growth without significant equipment purchases. In the intermodal field, two additional factors have held down direct investment by the railroads: provision of cars by Trailer Train, and provision of trailers, containers, and chassis by ships, third parties, or leasing companies. Among railroads, only Santa Fe appears to be acquiring cars directly to any great extent, and those plans are driven by Santa Fe's commitment to the TOFC market. Practically speaking, railroads can participate fully in the growth of intermodal traffic without investing in cars. In addition to Trailer Train as a source of cars, Greebrier Leasing has had some success in leasing double-stack cars to railroads and steamship companies, and Itel has had a limited presence with its Impack articulated trailer car. As the account of corporate plans indicates, major leasing companies such as XTRA and Transamerica Interway continue to provide virtually all the non-steamship containers and chassis, and many of the intermodal trailers.

Heavy recent investment in containers has left the piggy back trailer fleet lagging. Wiht plans for over 8,000 trailers in 1989, the railroads and the leasing companies have clearly not abandoned the trailer yet. Santa Fe has added 480 five-unit Impack cars for trailers, and Trailer Train is adding 500 Front Runners for trailers.

Table I-28

ANNOUNCED 1989
RAILROAD AND THIRD PARTY
DOMESTIC INTERMODAL EQUIPMENT INVESTMENTS*

Type	Quantity	Approximate Price	Total
Double-Stack Cars	380	$ 200,000	$ 76 million
Impack Cars	480	140,000	67 million
Front-Runner Cars	500	32,000	16 million
Spine Cars	70	110,000	8 million
Mark V RoadRailers	600	50,000	30 million
Domestic Containers	5,600	10,000	56 million
Piggyback Trailers	8,280	14,500	120 million
Domestic Chassis	3,800	7,500	29 million
High Horsepower, 4-Axle Locomotives	128	1,200,000	154 million
TOTAL			$556 million

*Excludes investments not broken down by equipment type, or investment made in containers or chassis by ocean carriers.

Ports are keeping pace. Because port capital investments come in large increments (a single conatiner crane is $6-7 million) and have long development times (5-7 years are typically required for a new terminal), development may appear sporadic. A larger view suggests (and Task IV and V are likely to confirm) that there has been and will be a continuous stream of port intermodal development efforts.