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CONTAINER TECHNOLOGY STUDY
Volume I: Text

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16. Abstract

This report describes the results of an initial study to assess the technological and operational constraints on the development of a multimodal domestic freight container system.

Under this program, the critical technological and operating constraints were identified, and the impact on shippers and operators was assessed. Key current investments in the freight transportation system were developed to evaluate the obsolescence of these investments due to the introduction of containers over a period of time.

Also described are areas where further research is required to overcome the critical constraints identified during the study.

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PREFACE

Public Law 95-208 enacted on December 1, 1977 (91 Stat 1477) directs the Secretary of Transportation, "... to the maximum possible extent, encourage the development and use of intermodal transport, using containers constructed to facilitate economical, safe and expeditious handling of containerized cargo without intermediate reloading while such cargo is in transport over land, air and sea areas."

As part of its overall assessment of the potential of a domestic container system, the Office of Facilitation in the Transportation Programs Bureau of the Research and Special Programs Administration, U.S. Department of Transportation (DOT), acting through the Transportation Systems Center (TSC), authorized this study to evaluate the technological constraints, independent of institutional barriers.

On the basis of the contractor's expertise, and in coordination with the TSC Technical Monitor, the study delineates current and potential problems to the unimodal and intermodal acceptance of a domestic container system possessing multimodal characteristics. The report identifies how further research, in combination with industry participation, can remove these constraints without major disturbance to existing investments in the transportation industry.

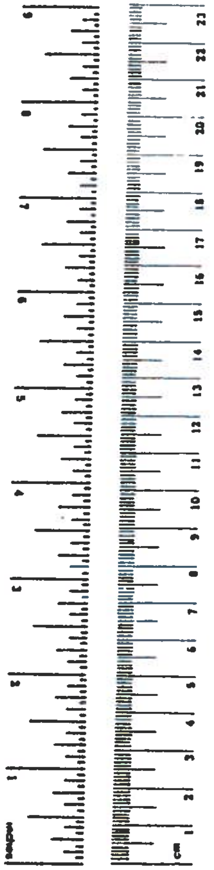
The work reported herein was completed under the direction of the TSC Technical Monitor, William C. Spaeth. The research for this report, and its final preparation, were the responsibility of Bert A. Bodenheimer. Research contributing to portions of the report was performed by Phillip D. Ohl and Robert Nelson.

John T. Norris, of the DOT Research and Special Programs Administration, provided invaluable guidance during the course of the program.

METRIC CONVERSION FACTORS

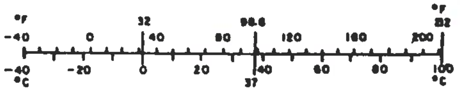
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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EXECUTIVE SUMMARY

In response to Public Law 95-208, the Office of Facilitation in the Transportation Bureau of the Research and Special Programs Administration, Department of Transportation, acting through the Transportation Systems Center, has undertaken this study to make an initial assessment of the technological constraints on the development of a domestic container system.

OBJECTIVES

The main objectives of this study were:

1) To describe the various technologies which can be employed to alleviate major problems in the unimodal and multimodal acceptance of a domestic container freight system.

2) To make an initial assessment of the impact of a domestic container freight system on both the users and operators of the current freight transportation system.

3) To recommend further research into a limited number of the technological areas thought to be critical in the acceptance of a domestic container freight system.

RESULTS

It is an implicit assumption of this study that containers will not replace all other forms of transportation in the United States. However, except for commodities moved in very specialized carrying vehicles, containers can meet nearly all other service demands. Dry Van Containers, Refrigerated and Heated Containers, Dry and Liquid Bulk Containers, Open Top and Flat Bed units are all in existence and are extensively used.

On the basis of the detailed examinations conducted during this study it is concluded that there are no major technological or operational constraints which would preclude the deployment of a domestic container system. Indeed, the use of containers would have substantial benefits for both the users and providers of transportation service.

Among the benefits to shippers would be the wide availability of standardized equipment and the ability to easily route cargoes by alternate modes. The operator will benefit by lower total investment cost, reduced line haul costs, and reduced terminal handling costs. These benefits can be achieved without disturbing the great majority of the investment in the present domestic transportation plant, and could be achieved by orderly phase-in of containers in the relatively short period of ten years.

However, hindering the acceptance of containers as transport vehicles is the lack of agreement among the modes as to what the performance requirements of the unit must be and what constitutes an acceptable size of unit. The American National Standards Institute's "Requirements for Freight Containers, MH5.1", which applies only to the marine, highway, and rail modes, is thought to be unduly restrictive when applied to purely domestic service. An all mode transport vehicle, which also meets the requirements of the air mode, must be developed; a container and chassis system appears to have the basic characteristics to be developed into such a vehicle. The present transportation system can easily adapt up to a 45 foot long freight unit, which is the size preferred by highway operators, and can do so without restricting the use of shorter length containers, such as the 40 foot and 20 foot long units.

To date, the available technologies have not been fully exploited. For example, the application of newly developed, high strength to tare weight materials promises to further enhance the suitability of containers for domestic use and to further increase energy savings that are possible by the use of containers in the transportation of goods.

Since it is implicit that containers having multimodal capabilities will be freely interchanged among the modes, containers must be especially suitable to the service needs of the highway and rail carriers, which are the principal domestic transportation modes. In turn, greater efficiency must be achieved at transportation system nodal points, where a transfer is made between modes. Specialized intermodal terminals, geared to serve the rapid movement of containers do not now generally exist; terminals that are designed for Trailer-On-Flat Car (TOFC) service are principally for long haul traffic in which some delay in movement does not adversely affect overall service time. The lack of facilities designed for container service is a second barrier to the use of containers.

A national container system must also have adequate equipment control and inspection procedures, so that empty containers are easily available to potential users. This will result in a reduction of overall empty miles without delays to any one mode. In this area new developments have also not been sufficiently exploited primarily because system performance criteria, agreed to by all modes, have not been adequately defined.

RECOMMENDATIONS FOR FURTHER RESEARCH

The timely resolution of the problems enumerated above are important to preclude independent equipment and investment decisions by major operators which will form an additional barrier to adoption of a domestic container system. To take maximum advantage of the opportunities that now exist, it is recommended that the following programs be implemented through a combination of Government and private sector sponsorship.

1) Develop performance specifications for a domestic container. This effort, guided by an Industry Steering Group, should address the question of domestic container sizes, strengths, handling and transfer methods, and domestic shipper's needs for cargo restraint devices.

2) Develop prototype, light weight containers and chassis, and utilize these in demonstration projects to test service life. It is anticipated that existing members of the container manufacturing industry and others not now in the field, will wish to participate to demonstrate novel and proprietary concepts. Supervised by DOT to avoid duplication, such prototypes can be built and tested concurrently with developing a performance specification for a domestic container.

3) The development of terminals specifically geared to rapid container handling is of great importance to make a domestic system gain wide acceptance. Both rail/highway transfer and rail/rail transfer alternatives must be developed and the operational characteristics of the alternatives defined and evaluated for the guidance of all intermodal operators and for use by shippers and consignees desiring to handle containers without chassis.

4) Equipment Control and Inspection Procedures for intermodal exchange of equipment must be suitable for each of the modes, and must be capable of implementation alongside, and be consistent with, unimodal requirements and legal obligations. A broadly based, representative industry group should be formed by DOT to study and define the needs so that the newly emerging technology can be applied to fill the requirements.

5) Finally, to gain further understanding of alternative operating techniques and procedures for short haul movements, a detailed economic analysis of foreign experience should be conducted.

1. BACKGROUND AND OBJECTIVES

1.1 BACKGROUND

Over the past several decades the international transportation sector has witnessed a dramatic increase in the use of containers for the movement of freight. Almost all movement of non-bulk commodities between the developed nations uses containers. The use of container systems has permitted increased terminal throughput, equipment utilization, and labor productivity while minimizing loss and damages and improving service quality. However, these container systems have primarily been limited to international marine transport with interfaces with domestic highway and/or rail systems at either end of the line-haul trip. The development of a container system for domestic movement of goods has been slow and sporadic, even though there would be a significant advantage to the use of containers.

1.1.1 Historical Background

The use of containers in the United States is generally confined to the domestic leg of international cargo movements. A true container system having multimodal capability does not exist for domestic freight movements; the rail/highway Trailer-on-Flat-Car (TOFC) system, which is bimodal in character, exists with only limited success. Whereas, at the end of 1978, there were approximately 2,500,000 trailers of various lengths and other descriptions used for domestic transportation of freight (1), there were only about 120,000 special trailers available for use in TOFC service (2). Marine containers owned by American companies numbered 180,000 with an additional 580,000 units available from American leasing companies, and these are used almost exclusively for international trade (3).

It is useful to summarize briefly the major deployment of cargo containers as an aid to understanding the current advantages of containers in transporting freight. It is not assumed that containers will ever replace all other means of transporting freight, but that because of the demonstrated advantages of containers an increased use of such units has the potential for reducing total transportation costs and improving service.

1.1.1.1 Air Mode - Air cargo containers, 8 ft. x 8 ft. x 20 ft., are currently used on some wide body jet aircraft as an alternative to the pallet and net restraint system. The adoption of containers, with a tare weight of 2,000 lbs. (1000 kg) for a cargo load of 25,000 lbs. (11,340 kg) (4) is by no means universal among the cargo airlines. Where relatively dense cargo is carried, and tare weight becomes an important consideration, carriers prefer the pallet and net combination despite the increased handling cost resulting from the need to shape the cargo to the fuselage and to install the net. The driving force behind consolidation of cargo on either pallets or into containers is the labor and time that would be utilized by manual loading of wide body aircraft. Airlines use cargo containers in airport to airport service to make large unit loads from individual small shipments to achieve rapid aircraft turn time. The earning capacity of the line haul equipment per unit of time is so great that the expenses of consolidation are easily absorbed.

1.1.1.2 Marine Mode - The marine mode is currently the primary user of containers. The adoption of containers by marine operators, world wide, recognizes the benefit of keeping the line haul vehicle moving as much of the time as possible by reducing port time. Again, the earnings capability of modern ships is so great that the huge investment in terminal handling equipment and containers is justified. A by-product of the reduction in vessel turn time is the reduction of manpower required, since cargo is not re-handled at the dock.

The shape of the marine line haul vehicle, which dictated the lift-on/lift-off method of handling containers, the need to move the container to the dock from the shipper, and from the dock to the consignee, resulted in the two part combination of the container and the truck chassis.

It is generally understood that an all chassis terminal system provides the best terminal service time, whereas a system in which containers are grounded provides the least chassis cost. In a chassis system, containers are taken from and to the vessel exclusively by over-the-road chassis, i.e., there is a chassis for every container on land. In a grounded system, containers are taken to and from the vessel by straddle carrier, stevedoring chassis or side loader. Containers in the yard are placed on the ground either singly or in vertical stacks, and are placed on over-the-road chassis only during the time the container moves off the terminal in the highway mode.

1.1.1.3 Rail Mode - The rail mode's use of container shaped boxes, transported on rail cars, dates to the early 1920's; the patent literature describes many units of different constructions, and many of these units were actually used. True container systems were employed by the Southern Railway in the 1960's and by the New York Central Railroad in "Flexi-Van" service. Both systems, now abandoned, were used as an alternative to "Piggyback", or TOFC service, since both railroad companies had bridge and tunnel clearance restrictions that constrained TOFC service.

Today, rails carry steamship company furnished containers as both TOFC and Containers-on-Flat-Car (COFC). The predominant method is as TOFC (container on a chassis), since this avoids the problem of having a chassis available at the destination. COFC is extensively used on dedicated trains in the "landbridge" and "minibridge" services, which are substituted service for marine transport. At the present time, the railroads own no containers or chassis; equipment is furnished exclusively by the ocean carriers.

1.1.1.4 Highway Mode - The motor carrier is the critical link between all other modes; it moves the containers over the road to and from rail terminals, ports and airports. A standardized design of chassis kingpin and tractor fifth wheel allows free interchange of chassis among all motor carriers.

1.1.1.5 Intermodal vs. Intramodal Use - It is clear that the use of containers is intermodal in the sense that containers are physically exchanged among one or more of the marine, rail, highway and air transport systems. It is equally clear that the use of containers is currently only unimodal in the sense that each mode uses the others as an adjunct to its own line haul service. Thus, while trucks are used in airports to deliver containers from the terminal to the plane, the underlying concept is unimodal, airport to airport service.

It is also evident that the highway mode is the only one that is generally self sufficient, i.e., it can provide door to door service without requiring some activity in a second mode. Thus, in addition to the intermodal use of containers, the potential unimodal use in the trucking industry requires careful evaluation.

A domestic container system should have truly multimodal capabilities. That is, the system should offer efficient interchange between any of the modes - air, rail, highway or marine. However, it is important to realize two facts at the outset: (1) Each of the individual modes has its own unique equipment design requirements; and (2) the vast majority of transfers between modes will involve only two modal combinations. Some points are obvious - the air mode technology places a premium on minimizing weight, the width and height of trucks is limited by highway requirements and design, etc. In addition, the major capital investments made by the individual modes have to be recognized and it would be unrealistic to expect the premature scrapping of existing equipment and facilities. This implies that proposed domestic container systems should be as compatible with existing equipment and operational practices as is possible.

Indeed, since virtually all domestic containerizable freight currently moves by highway and/or rail, it is reasonable to expect that the majority of intermodal transferring for a domestic container system will involve the highway and rail modes with trucking also being used as a pickup and delivery system for air and marine containers. Thus, the success of a domestic container system will, in large part, depend on the success of identifying an efficient and profitable highway/rail container system which possesses the ability to efficiently interact with air and marine operations with minimal adverse impacts.

1.1.2 Project Background

The word container, as stipulated by Public Law 95-208 and used herein is limited to that class of transport equipment as defined by the Convention for Safe Containers (5), to wit:

> "For the purpose of the present Convention, unless expressly provided otherwise:
>
> 1. 'Container means an article of transport equipment:
> (a) of a permanent character and accordingly strong enough to be suitable for repeated use;
> (b) specially designed to facilitate the transport of goods, by one or more modes of transport, without intermediate reloading;

(c) designed to be secured and/or readily handled, having corner fittings for these purposes;
(d) of a size such that the area enclosed by the four outer bottom corners is either:
   (i) at least 14 sq.m. (150 sq. ft.) or
   (ii) at least 7 sq.m. (75 sq. ft.) if it is fitted with top corner fittings;
the term 'container' includes neither vehicles nor packaging; however, containers when carried on chassis are included.

2. 'Corner fittings' means an arrangement of apertures and faces at the top and/or bottom of a container for the purposes of handling, stacking and/or securing."

Given the minimum areas of paragraph 1(d) above, and the general maximum allowable truck width of 8 feet, the containers included in this study are limited to units at least 18.75 feet long without top corner fittings, or 9.375 feet long if top corner fittings are employed.

Because of the important role which government plays in terms of transportation research and development, economic and safety regulation, and direct subsidization of transportation modes, it is important to understand both the institutional and technological constraints which so far have hindered the acceptance of containers for purely domestic use, and thus determine where and how the government can encourage containerization when justified.

As part of its overall assessment of the potential of a domestic container system, the Research and Special Programs Administration of the Department of Transportation, acting through the Transportation System Center, in July of 1979, authorized this study to evaluate the technological constraints to a domestic container system, independent of any institutional barriers.

1.2 OBJECTIVES

The specific objectives of this study were:

1) To describe the critical technologies which can be employed to allievate major problems in the unimodal and multimodal acceptance of a domestic container freight system.

2) To make an initial assessment of the impact of a domestic container freight system on both the users and operators of the current transportation systems.

3) To recommend further research into a limited number of the technological areas thought to be critical in the acceptance of a domestic container freight system.

1.3 METHODOLOGY

The perspective of this study is to benefit the entire freight transportation system rather than one specific mode. It recognizes that a viable domestic container system will only emerge if:

1) It is compatible with existing means of transporting freight and uses a substantial part of the assets represented by the existing plant.

2) Containers have demonstrable benefits to the shippers and operators of the system, or, as a minimum, are no less desirable than present options.

3) Operational problems, either real or perceived, can be economically solved.

This study was performed by first reviewing recent studies on the impact of highway size and weight laws, energy efficiencies of various modes, and systems studies pertaining to individual modes, as well as by review of trade journals and periodicals. This was done to assure that the study team's own extensive background and expertise was sufficiently current to allow identification of the critical technological factors involved.

Further, to reflect the most recent developments, and to gain insight into the perceptions and attitudes of key firms and individuals to domestic containerization, the technology review was supplemented by interviews with representatives of selected manufacturers, operators, shippers, and representatives of various governmental and trade association groups. The criteria for selection of individuals and firms, as well as the summaries of the interviews, are contained in the Appendixes of this report, which also includes the drawings examined, calculations performed, and other reference material used during the study.

2. CURRENT TRANSPORTATION SYSTEM AND ASSET BASE

2.1 INTRODUCTION

Existing freight systems have been extensively explored by many investigators. (6, 7, 8, 9) These studies generally attempt to establish a baseline, and then evaluate the degree of improvement that can be made in the transportation system. Three factors argue for a different approach:

a) The work done in this manner in the past is so extensive that duplication of effort, and no refinement of data, is a likely result.

b) The technology is not static, but is constantly changing. For example, in recent years the motor carrier industry has been able to make significant improvements in fuel efficiency by the introduction of such innovations as radial tires, fan clutches and air foil designs, and this technology has been introduced rapidly enough to have an almost immediate impact on operating costs. Thus, much of the data on which current judgements are often made are obsolete by the time they are published.

c) There is a clear danger in isolating the various elements of a system, and attempting to optimize each of these elements individually; the resulting system may not, in fact, be optimized by individual component improvements.

A preferable approach to determine where the efforts to change the technology should be placed is to first obtain a picture of the current transportation system and its asset base. Quite obviously, a domestic container system, as an alternate to present methods of transportation, will have the greatest chance of acceptance if the disruption to the current system and its assets is minimal, and if the phase-in of alternate equipment takes place over a sufficient length of time for current equipment to be replaced in an orderly manner. This principle is important everywhere, but it is paramount in the railroad industry, which, in general, is starved for capital funds because of its current low return on investment.

2.2 TRANSPORTATION SYSTEM ELEMENTS

In discussion of the present transportation system and its asset base we have purposely eliminated reference to the rail and road guideway systems because we believe that containers would be transported over the systems as part of a much larger flow of other traffic, and that the physical rail and road network will not be materially altered due to the use of containers. For the same reason airways and waterways are not covered. We have similarly excluded discussion of highway tractors and rail locomotives as well as ships and aircraft. Because the present land system must accommodate so much more traffic than that susceptible to intermodal carriage by container, any intermodal system must, therefore, conform to the overall system requirements. Water transport vessels and aircraft generally are also fixed in design for the forseeable future, but newly constructed equipment is less constrained by existing designs. For example, although the present cargo aircraft, principally the Boeing 747, are limited to eight foot high, 40 foot long containers, loaded through the nose, there is no reason why future aircraft could not accept greater heights. The Boeing 747 can presently carry 8½ foot high 20 foot long containers loaded through side doors, and the C5A military cargo aircraft can carry up to 9-foot-6 inch high containers. The commercial cargo versions of the DC 10 and Lockheed 1011 are limited to 8-foot high units however, and the future Boeing 767 is also expected to be limited to this height. Thus, since shipment of containers by air requires suitability for carriage by a wide variety of aircraft, the air standard is likely to remain at eight feet high for the forseeable future.

For the above reasons we will, therefore, confine ourselves to analysis of the following major internal elements of the current system.

a) Highway Mode
   - Semi trailers
   - Trailers

b) Rail Mode
   - Flat cars
   - TOFC trailers
   - Transfer equipment
   - Yard hostlers

c) Marine Mode
   - Containers
   - Chassis
   - Chassis transfer devices (gantry cranes, yard chassis)

d) Air Mode
   - Containers
   - Ground to aircraft transfer devices.

A measure of the investment in each of these is the current replacement cost. In the calculations which follow, physical life, rather than tax life, has been considered, and equipment costs are those generally in effect at the end of 1979.

2.2.1 Motor-Carrier Plant

The Motor Vehicle Manufacturers Association, based on 1977 registration data obtained from the 50 States, publishes the following figures for equipment in service: (10)

Semi Trailers	2,513,028
Trailers	372,290

These data are consistent with that reported by other, and more recent, sources (11). Because of the different registration requirements and rules of each state, precision cannot be attained. Based on these data, the current asset value of trailers, exclusive of TOFC trailers, can reasonably be estimated at:

2,513,000 Semi Trailers	@	$ 11,500	=	$ 28,899,500,000
372,300 Trailers	@	13,000	=	4,839,900,000
Total				$ 33,739,400,000.

The economic life of trailers is ten years, with an average fleet age of five years; this results in an estimated remaining life of five years.

2.2.2 Railroad Plant

The present fleet of rail flat cars, primarily owned by the Trailer Train Co. (TTX), and suitable for TOFC trailers and containers is:

TTX Railcars (see Appendix A)	No. of Cars
GTTX Series - Piggyback Cars	2,234
LTTX Series - Low Deck Hitch Cars	2,303
TTX Series - Standard Deck Hitch Cars	28,736
XTTX Series - Four Hitch Equipped Cars	694
TTAX Series - TOFC/COFC All Purpose Car	12,113
TTCX Series - Container Cars	697
Railroad-owned cars (see Appendix B)	7,000
Total	53,777.

This equipment has an average age of approximately 12 years, with an estimated useful life of 40 years, which is the maximum allowed by the AAR rules for free running equipment. Thus, at a current cost of about $52,000 per car, the existing fleet has an asset value of approximately $2,796,404,000, with an average remaining life of 28 years.

Piggyback trailers that are designed for TOFC service, number approximately 120,000 at an average current cost of $12,100. These represent an asset value of $1,452,000,000. More significantly, however, the useful life of this equipment, as in the case of highway trailers, is only about 10 years. It has an average age of five years and a remaining life of only five years. The remaining economic life may well be shorter, since most of the current fleet of TOFC trailer vans is only 40 feet long and 45 foot long equipment is being introduced. Forty-five foot long trailers can be expected to become more common as new railcar equipment, (Santa Fe, TTX, etc.) capable of handlin the 45 foot long trailers, is put into service.

Finally, in the rail mode, transfer equipment represents a significant, but considerably smaller, investment. There was no available single source of data on the total number of mechanized handling equipment in use by American railroads. As a result data were obtained from the three leading manufacturers of gantry cranes and front end loaders (Piggypackers): they estimated 70 gantries and 130 front end loaders in rail service. According to a recent study, (12) there were a total of 131 mechanized facilities in the U.S., 67 provided with gantries, 53 provided with front end loaders, and 11 with both types of handling equipment. Thus the above estimates of 70 gantries and 130 front end loaders appear reasonable. The estimated total investment, therefore, at current costs, is:

70 gantries	@ $ 500,000	=	$ 35,000,000
130 front end loaders	@ 300,000	=	39,000,000
Total:			$ 74,000,000.

The total number of yard hostlers is also not available from any single source, and we have estimated an average of four units per mechanized facility as a reasonable approximation. This would result in a total of 131 x 4 = 524 units, at a current cost of about $40,000 each. This results in an asset value of $20,960,000. The life of the hostlers is estimated at eight years with four years of average life remaining.

2.2.3 Marine Plant

The world-wide inventory of marine containers numbers approximately 2,500,000 (13), all of which can potentially move in and out of the United States as traffic demands. Containers owned by American steamship companies number approximately 180,000, with an additional 580,000 units owned by American leasing companies. The units are primarily 20, 35 and 40 feet long, although some 24, 27, and 30 foot long containers have been built, and consist of dry van, dry bulk, liquid tank, open top, platform, automobile and livestock types. As of the date of this report, Sea Land Service, Inc., the largest user of 35 foot-long units, has filed an application with the U.S. Maritime Administration to dispose of its SL-7 class of vessels. Even if these vessels are placed in the reserve fleet, this projected sale implies that the 35 foot long containers will no longer be a large part of the available inventory. Sea Land has announced that such inventory will be replaced by new 40 foot long equipment.

The total number in United States traffic is difficult to determine, since U.S. steamship owned equipment is also used in trade lanes that do not include the United States, and much of the equipment owned by U.S. leasing companies is leased to foreign operators. Similarly, the operations of foreign carriers affect the total number of units in U.S. commerce. Based on reported container import export traffic, it appears reasonable to assess the total asset value of American operations as the sum of the total steamship and leasing operators.

The investment in this equipment is difficult to calculate, because the number assigned to American commerce is variable because of the mix of 20 and 40 foot long units, and also because there are many different types of construction. Materials used are steel, aluminum, and fiber glass reinforced plywood; a reasonable current average replacement cost is $5,000 per unit. Whereas the asset value of the world wide fleet is in excess of $12,400,000,000, American interests for shipline owned and leasing company owned containers is a smaller yet significant $3,400,000,000.

The life of the containers is generally assumed to be 15 years; steel containers, of which there are a great number generally require major refurbishing after eight years. The present American fleet is an average of seven years old, with replacement programs for very old equipment now in progress at several companies. Our estimate is that eight years of life remain for the existing units.

81,570 Chassis are owned by American steamship companies, and another 86,000 are available from American leasing companies(14). At an average asset value of $5,000 for the mix of various lengths, the value of these chassis is $837,850,000. With proper maintainance, a 15 year life, with 10 years of life remaining, is to be expected.

Transfer devices consist of container cranes used for ship loading and various yard handling devices such as straddle carriers, mobile cranes, side loaders and stacking cranes. Mobile cranes can also be used for ship loading. For the most part these are owned by various Port Authorities and furnished to common users, but a substantial amount of equipment is privately owned. The total number of cranes assigned to container work is unknown, since in many ports cranes are used for more than one purpose. For example, mobile cranes are used both for container and breakbulk cargo. Also, there are many types of auxilliary equipments for the handling of containers, such as fork lift trucks, that may also find general use. The current estimate of equipment in use in the United States is (15):

Container Cranes	139	@	$1,500,000	=	$ 208,500,000
Straddle Carriers	96	@	500,000	=	48,000,000
Top Loaders	36	@	300,000	=	10,800,000
Yard Cranes	27	@	600,000	=	16,200,000
Total					$ 283,500,000.

The life of the handling equipment is estimated at 30 years for container cranes, and 15 years for all other units; remaining life is 20 and 10 years respectively.

2.2.4 Air-Lift Plant

At the end of 1978, there were less than 200 air mode containers officially classified as air/land types per Specification AS 832B (16). These were of the 20 foot length.

The total asset value of these 20-foot containers, less than $1,800,000 (17), is insignificant in terms of the total investment in freight transportation equipment. Similarly, the ground-to-aircraft transfer devices capable of transferring 20 foot intermodal containers to and from aircraft were small in total number. It is estimated that these did not exceed 40, world wide, with perhaps ten in the United States. At a cost of $100,000, the asset value is approximately $1,000,000.

The life of this equipment is difficult to assess because of the relatively short experience to date. Damage to air containers has been severe during the introductory period, but this is expected to decrease as both shippers and operators become familiar with the equipment. It is reasonable to assume a ten year life, with eight years of life remaining for both types of equipment.

2.3 PHASE-IN REQUIREMENTS

Table 1 lists the major investments in decreasing value order and is helpful in assessing the impact of change to the major elements of the systems asset base. In addition to the gross investment in assets, other factors control asset replacement. For example, semi-trailers, whether TOFC or highway type, have a relatively short life, are easily saleable, and represent an ongoing reinvestment cycle on the part of the industry. Any change to a trailer, whether in length, width, or even adoption of a container/chassis system, can be essentially complete within a ten year period. Further, if the change is one that does not appreciably increase the acquisition price there will be an incentive to make the change.

On the other hand, the railroad system's largest single component, the rail car, presents a different problem; referring to Table 1 it can be seen that rail cars have an assumed life of 40 years (with good maintenance they can last longer) and, they have poor resale value. Aside from the financial impact of a rapid wholesale replacement or modification of the present rail car fleet, there is a question of whether there is the physical ability to do so from the point of:

a) Manufacturing and assembling new equipment by a car building industry geared to a 40 year cycle.

b) Changing the underlying maintenance and repair facilities of the railroads themselves, also geared to the 40 year replacement cycle.

c) Problems of introducing new operating techniques and requirements to the rail organizations which are generally slow to accept change.

Table 1. SUMMARY OF CURRENT INVESTMENT IN GENERAL FREIGHT CARRYING/TRANSFER MEANS
COMPONENTS OF THE U.S. DOMESTIC TRANSPORTATION SYSTEM

(In Decreasing Order of Magnitude)
(1979 Dollars)

Asset	Number of Units	Unit Cost (Dollars)	Investment (Dollars)	Estimated Average Life (Years)	Estimated Average Remaining Life (Years)
Semi-Trailer (Highway)	2,513,000	11,500	28,899,500,000	10	5
Trailers (Highway)	372,300	13,000	4,839,900,000	10	5
Marine Containers (U.S. only)	760,000	5,000	3,800,000,000	15	8
Rail Flatcars (TOFC/COFC)	53,777	52,000	2,796,404,000	40	28
Rail Van Trailers	120,000	12,100	1,452,000,000	10	5
Marine Container Chassis	167,570	5,000	837,850,000	15	10
Marine Container Cranes	139	1,500,000	208,500,000	30	20
Other Marine Transfer Equipment	various	various	75,000,000	15	10
Rail Side Loaders	130	300,000	39,000,000	15	8
Rail Gantries	70	500,000	35,000,000	15	10
Rail Yard Hostlers	524	40,000	20,960,000	8	4
Air Mode Containers	200	9,000	1,800,000	10	8
Ground to Aircraft Transfer Devices	10	100,000	1,000,000	10	8

2.4 SUMMARY

Table 2 shows the same assets ordered by remaining asset value, i.e., the total investment multiplied by the ratio of average remaining life to total average life. Except for the railroad owned gantries and side loaders, which reverse position, the order is identical to that of Table 1. Also shown is the estimated annual reinvestment for each type of equipment, i.e., the total asset value divided by the average total life. This assumes a uniform replacement cycle, which is not always followed in the real world, but does serve to identify the magnitude of the current annual reinvestment in the major components of the system. It shows that introduction of a container system in lieu of a portion of trailers and semi-trailers is not restricted by lack of investment funds.

Tables 1 and 2 further show that any new system that requires scrapping of existing rail cars, or other long term investment or even rapid large-scale modification to an existing plant, will be met with deep resistance or even outright opposition from the rail industry. As a corrolary, change to container/chassis equipment in lieu of trailer equipment can be accommodated just as easily by the railroad industry as by the highway industry. Finally, rail handling equipment in terminals, it can be seen, is of such a low magnitude that change in this area would have minimal financial impact.

Unless a new system provides easily perceived dramatic advantages it will meet with resistance if it requires scrapping large amounts of assets with a long remaining life which cannot easily be sold or used elsewhere. This suggests that any proposals for systems such as the ROLLOADER (Appendix H), or any system which requires an entirely new fleet of rail cars, should be looked at very carefully, even though the system may be mechanically sound. This is emphasized because, of all the plant assets reviewed above, railroad rolling equipment appears to be the most sensitive from this point of view.

Table 2. REMAINING INVESTMENT AND ANNUAL RE-INVESTMENT IN GENERAL FREIGHT CARRYING/TRANSFER MEANS COMPONENTS OF THE U.S. DOMESTIC TRANSPORTATION SYSTEM

(In Decreasing Order of Magnitude)

Asset	Investment (Dollar)	Estimated Average Life (Year)	Estimated Average Remaining Life (Year)	Remaining Investment (Dollar)	Annual Re-Investment (Dollar)
Semi-Trailer (Highway)	28,899,500,000	10	5	14,499,750,000	2,889,950,000
Trailers (Highway)	4,839,900,000	10	5	2,419,950,000	483,990,000
Marine Containers (U.S. only)	3,800,000,000	15	8	2,026,667,000	253,333,000
Rail Flatcars (TOFC/COFC)	2,796,404,000	40	28	1,957,482,800	699,010,000
Rail Van Trailers	1,452,000,000	10	5	726,000,000	145,200,000
Marine Container Chassis	837,850,000	15	10	558,566,700	5,856,670
Marine Container Cranes	208,500,000	30	20	139,000,000	6,950,000
Other Marine Transfer Equipment	75,000,000	15	10	50,000,000	5,000,000
Rail Gantries	35,000,000	15	10	23,333,000	2,333,000
Rail Side Loaders	39,000,000	15	8	20,800,000	2,600,000
Rail Yard Hostlers	20,960,000	8	4	10,480,000	3,620,000
Air Mode Containers	1,800,000	10	8	1,440,066	180,000
Ground to Aircraft Transfer	1,000,000	10	8	800,000	100,000

3. CRITICAL TECHNOLOGICAL AREAS

3.1 INTRODUCTION

This study is to gather more knowledge and understanding of the critical technological areas affecting domestic containerization. It recognizes that widespread use of containers for domestic freight continues to be an elusive goal since the acceptance of the container in international trade, and that a domestic container freight system will have the greatest impact on the rail and highway modes of transportation, since these modes move the majority of freight. For this reason the following discussion concentrates on the rail and highway mode.

Extensive studies have been made to determine the feasibility and economics of using containers in rail and truck interchange. Yet the extent to which technological problems have hindered the acceptance of the container has been ill defined. Perception is often confused with reality, and the tendency has been for each mode to relate the use of containers to its specific problems. That the perceptions of how container technology might be applied to an intermodal freight system differ substantially from the reality is evidenced in many ways. For example, during our study we interviewed many persons in the industry, and the comments received show that some persons perceived the potential of a domestic container system only as a means of driving cargo from trucks back to the rail mode, while others hope that a domestic container will be the means for transferring all the *empty* truck miles to the rail mode. (See Appendix D)

These extreme views are indicative of why the real and perceived problems of a container system have made both the rail and trucking industries hesitant to commit themselves to such a system, although some companies are already taking steps to favorably position themselves for the future. For example, Interpool, a major leasing company, has recently purchased 1,800 forty-foot units for TOFC service; these have been leased out to several railroads. Instead of conventional TOFC trailers, Interpool has purchased containers and an equal number of chassis. (Appendix D) After positioning one container on a chassis, the twist lock fittings are welded shut; for the forseeable future the combination is a trailer. If future needs require a container system, the units can again be made separable.

Our study has shown that the major problems, those that are thought of most frequently when containers are being considered are:

a) Equipment size

b) Tare weight of containers/chassis combinations

c) Chassis availability

d) Transfer equipment between rail and highway modes

e) Equipment control and ownership

f) Equipment condition at the time of interchange between carriers.

These problem areas are discussed below.

3.2 EQUIPMENT SIZE

3.2.1 Highway Mode

Each of the states promulgates its own regulations with regard to maximum size and weight of highway vehicles. The influence of the varying regulations on trucking costs are documented in several research reports, which indicate that a greater influence than a particular limit is the variation in limits which may make a given combination legal in one state but not in an adjacent one. Thus any through movement between states is governed by the most stringent state limits.

The highway mode is thus under absolute constraints which make it desirable to decrease tare weight and increase cubic capacity. A 40-foot long, 13-foot 6-inch high trailer has an internal nominal volume of 2,740 cubic feet Depending on the density of the cargo, the gross weight of the lading will var Since it is almost axiomatic that most traffic lanes have relatively low density cargo in at least one direction, (including empty movements) the trucking operators desire maximum cubic capacity in their vehicles to accommodate this condition. Since it costs very little more to haul a 45-foot long unit than a 40-foot long unit, the larger units are desired for the entire fleet because it removes the need to assign and control equipment for specfic movements. The logic of this is supported by the fact that according to recent surveys, only about 10 percent of highway shipments are weight limited; this is also true of typical military shipments. (Appendix E)

In the context of this study it is sufficient to highlight the key factors involved in the choices of the dimensions of highway equipment, and to project a size of unit that is most likely to emerge as the standard of the future.

3.2.1.1 Vehicle Height - Vehicle heights above 13-feet 6-inches are conceded to be of least importance to truckers. Existing dock heights at shippers and consignees and overhead clearances on highways have made 13 feet 6 inches (nom inal) the accepted standard. Loading practices, i.e., the ability of men to stow cargo to greater heights, as well as the potential damage to cargo in lower tiers if too much weight is superimposed, further mitigates against a higher unit except for very special movements. From the safety viewpoint, overturning of the vehicle due to too high a center of gravity also is a limiting condition.

The 13-foot 6-inch height equates to a 9-foot 6-inch high container wh mated to a chassis of four foot deck height. Many containers of this height exist in the marine mode; none have been built higher except for a few isolat and very specialized cases where the movement is exclusively dock to dock.

3.2.1.2 Vehicle Width - A large volume of materials used in the building industry are shipped in multiples of 2, 4 and 8 feet, and there is some demand for exterior width greater than 8 feet to accommodate such shipments. However, in the broad range of commodities shipped the total amount of such movements is relatively insignificant, since the limitations of driveways, alleys and warehouses preclude many shippers from utilizing equipment wider than eight feet.

Furthermore, increased width causes problems due to side clearances on bridges, and due to signposts and other abutments to the roadway, as well as the obvious problems along narrow roads and on curves. While even a six inch increase in width would allow better tractor drive design, only 8 states have allowed a width increase above 96 inches; the interstate highway limit is still 96 inches except for buses.

3.2.1.3 Vehicle Length - Length is the most critical dimension as far as freight movements are concerned, and where length limits allow, two shorter units, i.e., a 27-foot semi-trailer and a 27-foot full trailer, are preferred over a single long unit. This is so because two shorter units are easier to load (less walking) and because the number of axles is increased, and based on axle maximum allowable loads, the payload can be increased.

The axle limits are in addition to the gross vehicle weight limits, and on any particular movement, it is possible that either of the two limits may be in control. For example, most 20-foot container chassis are actually 23 feet long in order to achieve a reduced loading on the tractor fifth wheel. Since many shipments of freight include non-uniform merchandise, a longer trailer permits the cargo to be stowed so as to achieve a legal axle loading. In general, sliding tandem trailers are not favored because they can add up to 800 pounds of tare weight to the trailer; this in spite of the fact that moving the trailer axles permits a change in the reactions at the rear axle and fifth wheel to accommodate axle weight restrictions.

For urban pickup and delivery, a two unit combination can be easily split apart at the terminal; this is important in that it permits smaller shipments to be distributed without rehandling the freight at the terminal.

The arguments against longer vehicles are usually based on safety considerations. Restriction of sight distances, especially on curves, longer passing time, and off-tracking on curves are the principal factors. It is generally conceded that when a single unit exceeds 45 or 46 feet, off-tracking becomes a serious problem. If increased widths were permitted on current highways, the maximum length to limit off-tracking would be reduced to about 40 feet.

45-foot-long trailers are becoming the standard length for most truckers in general service; this is recognized by the railroad industry, which is designing new flatcars to carry 45-foot-long trailers (maximum) even though some railroads have recently purchased a large number of 40-foot-long trailers.

In their comments regarding S1383, a Senate bill addressing the problem of lack of uniformity of size and weight laws during periods of national emergency, Teamster Union spokesman, R. V. Burham, urged that the maximum length of semi-trailers be set at 45 feet and at 20 feet for each unit when multiple trailers are used. (18)

3.2.2 Rail Mode

In the rail mode the majority of containers are currently handled not by their corner castings, but rather by folding arms attached to the lifting spreaders which lift the containers by the bottom rail approximately 10 feet from each end. Thus, 45-foot-long units can be transferred using existing equipment. All of the newer rail flatcars (Santa Fe, Paton, TTX) are designed to accommodate 45-foot-long trailers, rather than 40-foot trailers. Since a longer trailer has increased cubic capacity, it will increase the average loaded weight, and the ability to carry 45-foot equipment improves the ratio of tare to loaded weight, and helps to increase the efficiency of the rail mode. Existing and new flatcars are designed to carry 65,000 pounds per space to allow carrying trailers loaded to maximum road limits.

In most published reports, (19, 20) the existing fleet of rail flatcars is reported as being capable of carrying only one 45-foot trailer and one 40-foot-long trailer in combination on one flatcar. This is cited as one of the limitations of the present rail operations, and the reason for the preference for 40-foot equipment in TOFC operations. The unspoken advantage is that when there are few 45-foot-long units, there is no operational problem in matching trailers to railcars. In some cases this limitation on length appear to be the underlying reason why comparisons are made by several authors betwee 45-foot-long trailers and 40-foot-long containers, an evaluation that naturall favors the trailer over the container. However, the assumed limitations of th present fleet of TTX cars is not justified.

Trailer Train Drawings A-2042 and A-1904, (see Appendix A), show that the 89-foot-4-inch railcars which comprise the majority of the fleet are capable of carrying two 45-foot-long trailers in one of two possible arrangements. Four railcars have actually been modified, two in each configuration, and are currently in service with no reported problems. The modification cost on this limited basis, was only about $5,000 per car.

The TTX drawings indicate that the 45-foot capability requires a particular shock absorbing system and fixed trailer hitches. Two types of shock absorbing systems are in use on railcars. In the first type, the individual trailer hitches are cushioned to prevent excessive loading of the trailer; in the second type, the draft gear itself is cushioned (end-of-car cushion) and the trailer hitches are fixed. The existing fleet of TTX cars comprises approximately 50 percent end-of-car cushion design, and these cars can be converted to the double 45-foot-long mode, at considerably less cost than construction of new cars.

Although the present design of trailer hitches does not permit the retractable hitch type to be used for the modifications shown in TTX drawings A-2042 and A-1904, redesign of the fixed hitches is feasible, and would allow the cars to be used in either TOFC or COFC service.

3.2.3 Summary

What sizes of equipment will a domestic container system have to accommodate? State vehicle laws are not static, and the direction in which the weight and size laws may change is of course unknown. Thus the possibility that multiple units, 27 feet long, will become popular on the East coast does exist. There is no question, however, that the 45-foot long unit is presently the preferred highway length, and that longer single units are unlikely to emerge as other than special vehicles. The railroads, in recognition of this fact, are preparing to accommodate more and more of this length equipment. Thus, an immediate conflict arises between the *current* container standard maximum length of 40 feet and domestic highway trends. We project that this conflict will be resolved on the basis of economics with a new, 45-foot long unit emerging as a domestic standard.

Quite obviously, current marine containers must be accommodated in a domestic system; these currently consist of 20- foot, 24-foot, 27-foot, 30-foot, 35-foot, and 40-foot long units. The 24- and 35-foot long units are recognized ANSI standard sizes; the 27-foot long unit is not (21). At the end of 1978 the population of sizes was distributed approximately as follows: (22)

Length (Foot)	Number of Units	Percent
40	250,000	32.89
35	63,000	8.28
30	1,000	0.13
27	4,000	0.53
24	12,000	1.58
20	430,000	56.58
Total	760,000	100.00%.

With the announced retirement plans of 35-foot long containers by Sea Land Service, Inc., which owns and operates 87 percent of the total fleet of 35-foot containers, it is seen that the fleet of marine containers of primary concern is the complement of 20-foot and 40-foot containers. The rail mode, the primary interchange with the highway mode, can, as shown, accept the four sizes, 20, 27, 40 and 45 feet with relative ease.

3.3 TARE WEIGHT OF CONTAINER/CHASSIS COMBINATION

Tare weight is an undesirable feature in all modes of transportation, and each mode emphasizes different aspects of the problem. The trailer versus container issue is two sided - containers used in COFC have less tare weight than TOFC trailers which is an advantage for the railroads. But members of the transportation industry interviewed during our study repeatedly pointed out that present container/chassis combinations have a tare weight penalty in excess of 2,000 pounds when compared to truck trailers in highway service. The idea that this is generic has found its way into the literature as a basic fact of container operation. In view of the importance of tare weight to the truck mode, it is imperative that the differences in tare weight between a container/chassis and trailer be critically examined.

3.3.1 Highway Mode

The word "container" evokes a picture of the typical marine unit, 40-feet long, with top and bottom corner castings built in accordance with International Standards Organization (ISO) and the American National Standards Institute (ANSI) standards. These two standards, ISO and ANSI, were organized differently; whereas the ISO standard is for a single type of container, suitable for multimodal interchange, the ANSI standard allows the user to select a unit for specific modes or combinations of modes. Thus it is possible to have a container that meets the ANSI standard and is suitable only for:

rail/highway

rail/marine

highway/marine

rail/highway/marine (equivalent to ISO).

All containers, however, regardless of modal use, must be equipped with top and bottom corner castings. Practically speaking, the choice has been a fiction, since the dynamic load factors that influence the design for each of the different mode combinations are not so far different from the most severe one, rail/highway/marine, that it is practical, at very little additional cost, to provide for the most severe service load. All but a few containers used in the United States are of the rail/highway/marine type. Thus the effect of the standard has been to penalize the highway mode.

In addition to the difference in dynamic load factors for the different modes, there are additional differences which have major impact on tare weight; these are summarized in Table 3 below:

Table 3. DIFFERENCES IN FUNCTIONAL REQUIREMENTS

ANSI MH5 STANDARD

Mode	Stacking	Racking	Lashing	Stacking in Terminals	Deflection
Marine	6 high	specified	specified	3 high	specified
Highway	none	none	none	3 high	none
Rail	none	none	none	3 high	none

The limitation on deflection of the container floor, specified for the marine mode, is based on the concept that the bottom longitudinal rails and crossmembers of an upper unit may not touch the top rail of the container immediately below. This is henceforth referred to as the "deflection" criteria. Although the principle is valid and the requirement is established, there is some question as to whether it is really necessary on a practical basis.

In order to assess the impact of the requirements of the ANSI standard on tare weight, a major American manufacturer of trailers, containers and chassis was visited and detailed engineering data were made available for the following equipment: (Appendix B)

a) A highway trailer, aluminum and steel exterior skin construction, 40 feet long, 96 inches wide and 102½ inches high, gross weight: 68,000 pounds.

b) A TOFC trailer, of similar construction but provided with the additional requirements to meet ANSI and AAR specifications for the rail mode, gross weight: 68,000 pounds.

c) A steel and aluminum tunnel type container, 40 feet long, 96 inches wide and 102 inches high, gross weight: 67,200 pounds; and a suitable container chassis.

Table 4 compares the tare weight of the three units, which are identical in their cargo carrying capacity.

The trailer which meets TOFC requirements weighs 640 pounds or 6.1% more than an otherwise identical highway trailer. This additional weight is accounted for by a strengthened landing gear assembly, a stronger roof, front wall and rear door, and by reinforcements for lower rail lifting. The container/chassis combination weighs 2,332 pounds more than the highway trailer, but only 1,792 pounds more than the TOFC trailer. Most of the additional weight is the direct result of the offshore marine requirements to which these containers are usually built.

Table 4. TARE-WEIGHT RELATIONSHIPS

ANSI MARINE CONTAINER, HIGHWAY AND TOFC TRAILER

(40 Ft. Long x 8 Ft. Wide x 8½ Ft. Cargo Unit)

Equipment		Tare Weight (Pounds)
Highway Trailer		10,535
TOFC Trailer		11,175
ISO Container (ANSI Marine/Rail/Highway)	6,517	12,867
Chassis	6,350	

Container Advantage in Rail Mode:	4,658
Container Penalty in Truck Mode: (TOFC Trailer)	1,692
Container Penalty in Truck Mode: (Highway Trailer)	2,332

The present ANSI standard allows containers to be built for the rail/-highway mode combination only, and these can have a lower tare weight than the marine mode container. For example, the ANSI rail/highway specification does not include a deflection criterion: thus aluminum lower rails and crossmembers can be substituted for the steel components with a weight reduction of 815 pounds. (Experience has dictated that the deflection criterion in the standard is not critical even in the marine mode, and many seagoing containers are in operation which in fact do not meet the criterion as a result of operator choice.)

The racking load requirement, present for the marine mode only, adds approximately 113 pounds to the container. Thus a weight saving of 928 pounds is possible for an ANSI rail/highway container. The tare weight relationships for a rail/highway container are shown in Table 5.

3.3.2 New Standard - Potential Domestic Container

A review of the ISO standard for freight containers, and the history of the development of the ANSI standard, shows that the need of marine operators for relatively long time storage has forced a three high stacking requirement even on the permitted rail/highway combination. This requirement should be thoroughly reviewed in a new standard that addresses only the domestic needs. After all, TOFC trailers cannot be stacked, and since the rail service is more frequent than ocean service,(hourly or daily compared to weekly or monthly) there appears to be no need for this feature. (Empty container storage is not a problem and does not really require corner posts and castings.)

If the corner casting and stacking requirements are eliminated, and domestic containers are handled by bottom rail lifting devices similar to current TOFC mode operations, an additional 177 and 281 pounds, respectively, can be saved. Thus, potentially, a domestic container and chassis combination would weigh only 946 pounds more than a highway trailer, or 306 pounds more than a comparable TOFC unit. Table 6 summarizes the tare weight relationships.

3.3.3 Materials of Construction

Conceptually, the only real difference between a container/chassis and a trailer is that a chassis has two full length rails that are not required on a trailer; on the latter the axles are mounted directly to the body. If the king pin setting is taken at three feet typically, and the tandem structure at 12 feet, the extra lengths of rail are 25 feet long for a 40-foot-long unit. At 38 pounds per foot (rails and stiffening structure) this amounts to 950 pounds, compared to the 946 pounds calculated previously.

On this basis, the tare weight penalty of a 45-foot-long container/chassis combination is estimated at 1,140 pounds when compared to a highway trailer.

The foregoing analysis shows that new materials of construction must be sought both in the construction of container/trailer bodies themselves, and perhaps, more importantly, in the construction of chassis.

Table 5. TARE-WEIGHT RELATIONSHIPS

ANSI RAIL/HIGHWAY CONTAINER, HIGHWAY AND TOFC TRAILER

(40 Ft. Long x 8 Ft. Wide x 8½ Ft. Cargo Unit)

Equipment		Tare Weight (Pounds)
ISO Container (ANSI Marine/Rail/Highway)		6,517
Eliminate		
A - Deflection Criterion	(-) 815	
B - Racking Criterion	(-) 113	- 928
Rail/Highway Container		5,589
Chassis Tare Weight		6,350
Total Tare Weight		11,939

Container Advantage in Rail Mode:	5,586
Container Penalty in Truck Mode: (TOFC Trailer)	764
Container Penalty in Truck Mode: (Highway Trailer)	1,404.

Table 6. TARE-WEIGHT RELATIONSHIPS

NEW STANDARD (POTENTIAL DOMESTIC) CONTAINER, HIGHWAY AND TOFC TRAILER

(40 Ft. Long x 8 Ft. Wide x 8½ Ft. Cargo Unit)

Equipment		Tare Weight (Pounds)
ISO Container (ANSI Marine/Rail/Highway)		6,517
Eliminate		
A - Deflection Criterion	(-) 815	
B - Racking Criterion	(-) 113	
C - Corner Castings	(-) 177	
D - Racking Requirement	(-) 281	- 1,386
Rail/Highway Container		5,131
Chassis Tare Weight		6,350
Total Tare Weight		11,481
Container Advantage in Rail Mode:		6,044
Container Penalty in Truck Mode: (TOFC Trailer)		306
Container Penalty in Truck Mode: (Highway Trailer)		946.

3.3.3.1 Container/Trailer Body Materials - In the United States, container and trailer bodies are built primarily of aluminum since this produces low tare weight. Steel containers are a European innovation, since aluminum is an expensive, and not readily available raw material there. Several new materials of construction for body walls have been developed in recent years, but have not yet been introduced, primarily because of cost.

McDonnell Douglas has distributed literature describing "The Isogrid Container" (23) which claims to achieve a tare weight reduction of 4,000 pounds in a 40 foot container. Investigation has revealed that as late as 1979, the Isogrid concept, a filament wound structure, was not yet fully developed; the process, sponsored by Georgia Institute of Technology, was abandoned some time ago when development funds ran out. Apparently McDonnell Douglas, after making small, cylindrical samples, and without having made flat panels, did not actively pursue this concept. Renewed interest has recently been shown in the concept because of newly developed fabrication techniques; however, no full scale prototypes have been built, and assuming that technical and cost criteria can be satisfied, the earliest commercial application of the technique to container body construction is estimated to be in the late 1980's.

Two other attempts worthy of note have been made in recent years to apply the technology of filament winding and foamed panel construction to the trailer industry. Dana Corporation acquired the assets of Whitney in 1969 and transferred operations to the Dana Whitney Corporation in Pennsylvania, where filament wound containers were produced in combination with a foamed-in-place construction. These units were produced for use as refrigerated containers becaus of the low thermal heat transmission resulting from the technique. Several production runs of marine containers were completed prior to the plant being destroyed by flood. It did not reopen after the flood because of the poor response of the industry to these units(24).

Xentex Corporation, a subsidiary of Exxon, developed a glass fiber reenforced structural panel surfaced with "Tedlar" PVF film. In 1976, Mr. Whitney Saidla, general manager of the firm, stated that "Our first and deepest market penetration has been with builders of trucks and trailer vans." (25 Xentex panels were claimed to match or surpass the strength of competing materials at less weight and competitive cost. In late 1979, after extensive studies of the market potential for both dry van and refrigerated vehicles, the company ceased operations because it could not achieve a competitive cost posture.

The increase in oil prices has dramatically altered the cost relationships of certain plastics, so that the use of these plastics is relatively mor expensive than aluminum, which has also increased in price. Efforts to use polyurethane foams are now under way in Europe and Australia, and these do hold promise for cost effectiveness. However, these materials are being developed as alternatives to aluminum in an environment where the cost of aluminum is very high.

Although new construction materials for container bodies cannot be dismissed because of past experience, it is important to note that new materials for container construction will not affect the tare weight penalty of the container/chassis combination, since the same technology can be applied to trailer construction, and the net differences will remain constant. Whether or not any of the new materials could achieve cost effectiveness, given the much larger production runs that would be required to supply the transportation industry, is speculative at this time. Among the factors to be considered are maintenance and repair costs, increased internal cube, abrasion resistance and resistance to puncture, all of which would benefit both containers and trailers.

3.3.3.2 Chassis Construction Materials - As previously noted, the tare weight penalty of a container/chassis combination results from the longitudinal rails required in a chassis, and we do forsee possible breakthroughs in tare weight reduction resulting from the application of new technology for chassis construction. To evaluate cost effectiveness of potential solutions, we begin by calculating an approximate cost of the steel work in a typical, 6,350 pound chassis, now quoted at about $5,300 plus excise taxes. The eight tires typically account for 880 pounds and about $1,000; the axles and brakes account for about 1,680 pounds and $1,150. Thus the structural steel frame work is about $0.85 per pound.

The use of aluminum in chassis construction is possible. At a cost of about $3.00 per pound, but with a weight saving of almost two thirds, the cost would be only slightly higher than a steel chassis. Major problems are encountered with the use of aluminum, however. One is the difficulty of field repair, since special welding equipment and techniques are required. The second one is that springs and axles are of steel, and the use of dissimilar metals hastens corrosion.

New materials are currently in use in airframe structures, with important benefits. These are commonly called composite structures, and may find application in chassis construction. Two materials are being used with good results. One is a graphite re-inforced system; its current cost is in the $10.00 to $20.00 per pound range, and this is likely to remain out of the price effective range for chassis for quite some time.

Kevlar(R), now being commercially produced at the rate of about 20 to 30 million pounds per year, is available in many shapes manufactured by pulltruding in an epoxy binder; it's cost is in the $5.00 to $10.00 per pound range, but it is about six times stronger for an equal weight of steel. The application of standard shapes to chassis design requires considerable development, principally in the area of joining such shapes by simple manufacturing techniques, and the integration of certain steel components, such as the king pin, into the structure. Other problems not fully resolved are the sensitivity of the materials to ultraviolet radiation, and to attack by acids. (26)

Since the use of such materials in chassis construction would represent a tremendous volume that eventually could justify investment in specialized production facilities, their application should be further investigated and tested.

3.3.4 Rail Mode

Tremendous emphasis has been placed on reducing the tare weight of TOFC/ COFC railcars both as a means of saving fuel, and also as a means of reducing maintenance-of-way costs. These latter costs are generally agreed to be a linear function of axle load.

Trailer Train Co., jointly owned by the major railroads, supplies flatcars (TTX cars) for TOFC and COFC service. Trailer Train is experimenting with a new articulated unit designated the HLS 100. Whereas the older, 89-foot 4-inch long railroad flatcars have a tare weight of about 70,000 pounds, the newly designed HLS car has a tare weight of only 60,000 pounds, or about 30,000 pounds per van space. (see Appendix D)

Ten-Pack cars, a new design pioneered by the Santa Fe Railroad, (27) achieve a greater reduction in tare weight, to approximately 23,000 pounds per space, but do so by use of construction features that make the car non-interchangeable among the railroads. Other new cars, such as the Paton low profile car, achieve tare weights of about 25,000 pounds per space.

Since tare weight reduction saves both fuel and maintenance-of-way costs, it is instructive to compare the tare of containers and TOFC vans in the rail mode. A typical 40 foot TOFC van weighs 11,175 pounds, whereas a container built to current ANSI marine specification, weighs 6,517 pounds, a tare weight difference of 4,658 pounds. When separated from its chassis for rail movement, a container, on existing rail equipment, will achieve a tare weight saving equivalent to the use of new HLS cars (see Table 7). It can achieve this saving today, with no additional investment. In the future, when new HLS cars are readily available, the combined use of the new HLS cars and containers results in a total tare weight equivalent to the Santa Fe Ten-Pack car in TOFC service; it achieves this result in a fully-interchangeable system.

On a round trip between Chicago and Los Angeles, the light weight Ten-Pack train will save nearly 6,000 gallons of diesel fuel. (28) It will also provide for a reduction in motive power from 4 units to 3 to handle the Ten-Pack with 100 trailers. Nearly equivalent savings for railroads using the present fleet of TTX cars are achievable by switching to ANSI marine containers.

If, instead of ANSI marine containers, the rails adopted a rail/highway unit, or a container to a new standard, the savings achievable are equal to those achieved by the Santa Fe Railroad (see Table 7).

We have previously shown that the single most important investment in the present transportation system is the existing fleet of railcars; this is because of both the magnitude of the investment and its long remaining life. The use of containers in the rail mode should be encouraged to enhance the rail mode's energy efficiency while making the greatest use of existing assets.

Table 7. TARE-WEIGHT COMPARISON PER SPACE

RAIL MODE

Equipment	Railcar Only (Pound)	Railcar + TOFC Trailer (Pound)	Railcar + ISO Container (Pound)	Railcar + ANSI Rail/Highway Container (Pound)	Railcar + New Standard Container (Pound)
TTX Cars (Present)	35,000	46,175	41,517	40,589	40,131
TTX "HLS"	30,000	41,175	36,517	35,589	35,131
Santa Fe "Ten Pack"	23,000	34,175	29,517	28,589	28,131

3.4 CHASSIS AVAILABILITY

When a container arrives at its destination, it can be unloaded from the line haul vehicle either by placing it on a chassis, or by placing the container on the ground. To keep the container on the line haul vehicle is not good economics since the line haul vehicle is in effect, unusable until loaded with outbound freight.

The above statement is treated as axiomatic by nearly all air mode and marine mode operators, and has been adopted by the railroads as well, even though in many cases the railcars sit idle from morning until they are reloaded in the evening with outbound loads. As a part of this project several rail piggyback terminals were inspected. It was observed that they provided for a high ratio of trailer parking to through-put and that trailers seem to spend considerable amounts of time in the terminal before and after movement by train. This observation was born out by the findings of the Kearney Study (29). Kearney found that more than 53% of all trailers remained in TOFC terminals 24 hours after arrival by train. (Further research will have to be done in this area, but two likely reasons for the prolonged periods stated by those interviewed were problems in information flow - papers did not reveal routing instructions - and the desire on the part of the shipper or consignee for free storage.)

This mode of operation, which is in use with TOFC trailers, carries over to container shipments. In view of the fact that current container moves require the rails to match a given container owner's container with the same owner's chassis, the shortage of chassis has indeed been a problem. Generally, the terminal incurs a cost of $20.00 each time a container must be grounded, and an additional $20.00 when the same container must be rehandled to place it on a chassis at a later time. Conrail now charges $41.00 per container each time a chassis is required and is not made available by a steamship company. Similarly, container terminals charge $20.00 per move; two moves, one on and one off, are made each time a container must be grounded.

There are several reasons why a domestic system need not be hampered by a chassis shortage.

3.4.1 Chassis Ownership

One of the major complaints of the railroads is that steamship operators will not interchange owned containers. The companies insist on preserving their identity by marking each individual container with their name. Therefore, the railroads may have empty units - containers and chassis - belonging to company X, while at the same time they are moving empty units belonging to company Y into position for loading. Containers owned by leasing companies have not provided a solution, since many of these units are on long term lease and must, in effect, be treated identically to owned containers.

In a domestic scenario, this institutional constraint need not be; the mechanism is in place for free interchange of equipment among railroads and truckers. Examples are Trailer Train and Railbox equipment, and any freight train is ample proof that standardized equipment can move freely. Without a doubt, capability can be extended to containers and chassis.

3.4.2 Chassis Fleet Size

Chassis availability is a problem that decreases as the number of containers in service grows. A good example of this is the development of Sea Land Services' combination 35/40 foot container. When six test units were put into service, 12 chassis were required, six at each end of a restricted, 2 port origin-destination pair. Had it been desired to serve all four points on the route, 24 chassis would have been required, since it is always possible, in a random system, to have all six containers be in the port at the same time. With over 10,000 such units now moving worldwide through 97 ports, recent studies show a container-to-chassis ratio of 1.4 containers per chassis, which compares (closely) with Sea Land's other container/chassis ratio. This results from the fact that the system, at any port, is no longer random but is predictable, within limits, based on the daily line haul capacity to that port.

Obviously, the chassis availability problem is aggravated if more than one size container must be carried by the system. In addition to multiplying the problem, depending on the number of different sizes to be handled, there is an additional adverse effect in that no one size may achieve a large volume.

If it is assumed that a domestic container system will emerge slowly, then it may well be that at the start of the system, containers should move as TOFC; this must not, however, be permitted to become the long term operating mode and positive steps must be taken to assure this. An additional point worthy of note is the inherent fleet size problem if a container suitable for only one mode were to be developed. If for example, the rail mode had a unique container, and these replaced all TOFC trailers, the total population would approach only 120,000 units, a number that is equalled if only 4.8 percent of present highway trailers are changed to containers.

3.4.3 Terminal Operating Considerations

The need for chassis can be minimized by proper operational techniques in rail/highway transfer yards, especially if a domestic container system is geared to low chassis use.

It is instructive to consider the actual operations in a marine yard using the chassis system, where the need to conserve both space and chassis is great. A typical container hatch on a container ship holds about 100 containers, (10 wide, seven high below deck and three high above deck) and if these were all first unloaded, 100 empty chassis, occupying about 1-½ acres of land, would have to be available for this purpose. Instead, the usual practice is to first unload all containers on deck plus one cell below deck, a total of only 37 empty chassis. Subsequent removal of inbound containers are made on two way moves; an outbound container is brought to the ship and loaded into the empty cell, and an inbound container is then removed from the next cell and placed on the now empty chassis.

This technique can be applied in rail terminals. A container train, arriving in the early morning hours, is not unloaded at once, but only as consignees' drivers arrive at the rail yard for pickup. In nearly all cases the drivers will also deliver an out bound load in order to make for an efficient highway move. This load can be placed on an empty railcar and the chassis immediately re-used for the inbound container.

If we accept the general assumption that rail *line haul* costs are less than a motor carrier's, and that nevertheless rails cannot compete with motor carriers in the under 800 mile range, the only explanation can be that TOFC terminals add delay and cost to the through movement which overcome the line haul cost disadvantages of an all-highway move. If containers are to become a truly common, viable domestic transport system, they must be able to produce efficient, economical transportation in the 300 - 800 mile range at a profit to each of the underlying modes. This being the case, it is in-escapable that line haul economics become secondary in importance in this mileage range, and that the only way to achieve overall system economics is to reduce costs and delays at transfer points dramatically below today's experience at most TOFC terminals. Whatever is causing high costs and delays at railroad transfer points, motor carriers of all-highway truckload traffic experience similar problems and frustrations, but do not have the equivalent problems. Motor carrier terminals have little or no parking for truck load trailers, their function is primarily to handle cross dock LTL traffic.

More research remains to be done, but European experience is instructive. Faced with a well developed rail network characterized by a large number of small terminals of limited land area, long term parking of trailers cannot be accommodated. Thus emphasis has been placed on using the terminal as a flow process rather than a batch process. The British claim that their Freightliner service (a rail/highway container system) breaks even at distances less than 250 miles; the orientation suggested above may well be the reason for this. Typical of this approach is the terminal at Basel, Switzerland. It consists of a number of parallel rail tracks, served by a gantry that also covers a single adjacent roadway. As in the United States, truckers prefer not to travel bob tail, i.e., without a trailer attached to the tractor, and generally bring one trailer to the terminal and pick up another. (This well known fact, incidentally, accounts for the results of numerous studies which show that the number of trailers parked at a facility tends to be constant.) The short lengths of track are filled with strings of incoming, loaded railcars as well as with a number of empty railcars. As a trucker arrives with a load, it is detached from the tractor and placed on an empty car. When this sequence is completed, a loaded unit is removed from the train and given to the trucker. Parking of trailers is virtually eliminated, and one of the key problems in a container operation, viz., the chassis availability problem is minimized.

Compared to the above operation, it is obvious that present TOFC terminals seem to be mis-applying marine container technology rather than using more appropriate motor carrier dispatch methods. Rail pricing appears to be contributing to this by permitting trailers and containers to stay in terminals for long periods without heavy penalty. The result is a system which requires costly parking facilities, increased hostling expenses and decreased equipment utilization.

To minimize the chassis problem, thinking must be re-directed from assembling and dis-assembling trainloads to that of moving cargo containers. A high proportion of containers should be loaded directly to and from the rail car to the PUD vehicle which would eliminate hostling and parking altogether, and, as important, vastly improve service and total transit time.

This redirection of the function of a rail terminal has other, significant advantages. Older, smaller rail terminals could be utilized. These are generally in downtown industrial areas, which will reduce the PUD mileage and time. The total number of chassis required is minimized, not only because of the "one-off/one-on" principle, but because of increased equipment utilization.

3.5 TRANSFER EQUIPMENT BETWEEN RAIL AND HIGHWAY MODES

Two means are used for loading and unloading railcars. The first is the "circus" method, or ramp, in which trailers are backed onto rail flatcars and locked into position. Bridge plates are lowered from the ends of coupled cars to allow loading of more than one car in a string of cars. In the second method, applicable to containers as well as to trailers, the freight unit is lifted on or off the flatcar by a mechanical device.

The claimed advantage of the "circus" method is that no complex material handling equipment is required; a tractor backs the trailers onto the railcars and then simply pulls away.

Despite the apparent ease and economy of circus loading, railroads are abandoning this method of loading. Many of the ramps exist only for tariff purposes, and motor carriage is actually substituted to the nearest mechanized loading facility. The major problems of ramp loading are:

a) The trailer hitches in all spaces of a string of cars must be lowered to the surface of the railcar in order to allow loading of trailers to the furthest point. They must then be raised again at each individual location where a trailer is being loaded.

b) Because trailers must be backed into position, the length of the string of cars is limited. Shorter car strings incur greater yard shunting costs.

c) All cars must face in the same direction, i.e., the hitches must all be toward the ramp. There is no ability to pick a specific trailer unit from the consist.

The declining importance of ramp loading is demonstrated by the new railcar designs now being developed. Neither Trailer Train's HLS 100 car, nor the Paton Low Profile car, both of which are for interchange service, is equipped with bridge plates that would make circus loading possible.

(The fact that the Santa Fe "Ten Pack" is not capable of ramp loading is not a factor, since it is not now capable of interchange service.)

Even more important than the operational problems with ramp loading is the fact that railroads have decided to concentrate on the longhaul, dedicated TOFC/COFC train business, rather than establishing a complete network of facilities. They have thus consolidated their operations through major terminals which can justify more sophisticated mechanical handling devices.

The two most common mechanical devices are front loaders (often called side loaders since they load railcars from the side, even though the device resembles a fork lift truck operating from the front end) and overhead lifting devices. Of the overhead lifting devices the most popular is a diesel driven straddle carrier. Each provides certain advantages.

The front end loader is the more versatile of the two pieces of equipment, since it operates from the side of the railcars; it can move to any poition without regard to whether or not a given position is occupied. It thus can easily adapt to "hot" loads, those for which the consignee is waiting as the train arrives: however, it requires more operating space, generally 50 feet between tracks, which is costly in terms of land use. The operator has restricted vision when approaching either a trailer or railcar, which can, and does, lead to considerable damage to equipment.

Straddle carriers, as the name implies, are essentially an overhead lifting device mounted on legs which straddle the load as well as an adjacent lane, such as a rail siding. Because the straddle carrier is constrained to move in a straight line once it has been positioned over a string of railcars, the loading and unloading operations are generally conducted in sequence.

Typical cost performance curves for the different methods of loading are shown in Figure 1. (30) There is relatively little difference between the different methods at higher volumes, but for volumes under 50 transfers per day, the ramp technique appears to enjoy lower costs. Because of the small difference in cost between front lift and gantry operation, the reasons for the apparent preference for front lift equipment is not clear.

European operations are principally gantry type, with electric powered, fixed rail gantries instead of the diesel powered, rubber tire versions preferred in the United States. Although it is true that a rubber tire vehicle is not confined to one work area, and in case of a breakdown, it can be pulled out of the way, electric driven units are more reliable and are generally faster. Also, because of their generally greater rigidity, they can easily span more than one track, and thus increase yard utilization. The disadvantage of fixed rail gantries is the installed cost of the rails which cannot be relocated without considerable expense.

Given the deemphasis on ramp loading, and aside from small mechanical improvements to front loaders and gantries, there is no new lift on/lift off technology in even experimental use in the United States. There is a great

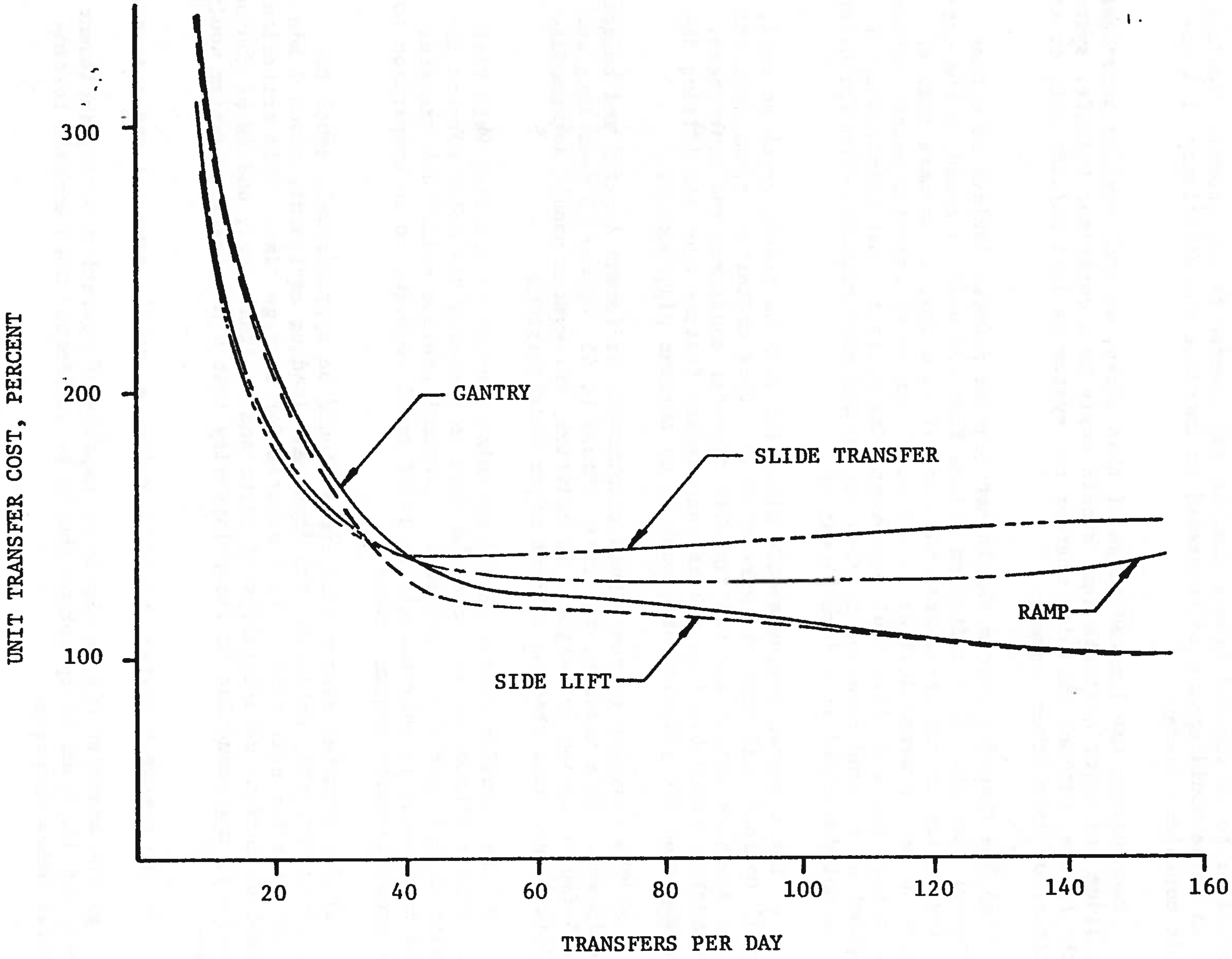

Figure 1. RELATIVE COST PER TRANSFER FROM ROAD TO RAIL

need for transfer devices for containers in low volume applications, such as the Steadman side transfer system, or the MSD system (Appendix F) which allows a container to be removed from a chassis and lowered to the ground. Devices such as these would appear to be needed to increase the efficiency of a domestic container system.

Recognizing the limited scope of this study, we will confine ourselves to listing the major criteria that should apply to a container transfer system of the future, without defining whether the system is lift on/lift off, or side transfer, or some other concept.

a) The transfer system should not require powered devices on either railcar or chassis. This criterion arises from the need to preserve the current investment in flatcars, from the general rule that it is more cost effecrive to have powered devices at a limited number of transfer points rather than on each piece of line haul equipment, and further, that maintenance of equipment at a fixed location is less costly and more reliable than equipment that is not domiciled at a fixed location.

b) The transfer system should allow for rail to truck, truck to rail, and rail to rail utilizing the same concept. This criterion arises from the need to minimize weight and cost in both transfer equipment and containers. For example, corner fittings are an unnecessary feature when the lifting devices employed are grappler arms such as on current piggypackers.

c) The transfer system should accommodate different lengths and heights of equipment. As a minimum, the sizes should be 45, 40 and 20 feet long and up to 9 feet 6 inches in height. In addition, the system should accommodate possible future size changes without major modifications.

d) The transfer system should minimize changes to existing rail flatcars. This criterion arises from the need to preserve the major current investment in transportation equipment. Although present rail/truck transfer device investment is substantial, it is of small consequence in comparison to total transportation system assets.

e) The transfer system time cycle should be approximately equal to cycle times currently achieved with front end loading equipment, about 2 minutes per move for best time, 3 to 4 minutes for average time. This criterion is based on current relationships of labor and capital costs, and is of course, sensitive to any reduction in labor intensity that a new transfer system would achieve.

f) The transfer system should be reliable, easily serviced and maintained.

g) The transfer system should be capable of operation during inclement weather, and the speed of operation should be unaffected when exposed to temperatures below freezing.

3.6 EQUIPMENT CONTROL AND OWNERSHIP

Equipment control is a need in all forms of transportation in order to maintain high equipment utilization rates. Except for the rail mode, each of the modes now operates fairly independent systems, with most companies within each mode not participating in any equipment sharing program, and controlling their own equipment as individual needs exist. The International Container Bureau (BIC) (31) and the Equipment Interchange Association (EIA) (32) assign marks for containers, trailers, chassis and bogies in intermodal service and assure that such marks are not inadvertantly duplicated, but do not monitor the location of equipment.

The rail mode, with long established procedures for interchange service of rolling stock, has extended their interchange procedures to TOFC trailers, as published in the Interchange Agreement Trailer/Container-on-Flat-Car (TOFC/-COFC) Service. (33) However, these rules govern interchange between any two carriers, and do not really address the problem of free movement of equipments in the overall freight system among all modes. As previously stated, one of the major complaints of the rail mode is that when handling containers, free interchange is not possible, and the container owners identity must be preserved. A container owned by steamship company A may not be used for a shipment on company B's vessels.

The availability of leased equipment has had only minor impact on this problem; most equipment is on long term lease, or even when on short term lease, becomes identified with a particular company, to the point where decals showing the leasee may be attached to the equipment.

There are several reasons for this state of affairs. Most significant is that no one freight unit, such as the ISO container, has emerged as equally suitable in all modes of transportation. In the air mode, for example the air/land container emerged as a separate unit only after attempts to include it in the ANSI MH5 standard series failed, primarily because the air mode requires a smooth bottomed container to minimize concentrated, or point, loads. Therefore the rail and highway carriers have not found it economic to purchase equipment except for their own use and it is axiomatic that free interchange is only possible when all modes share in the benefits as well as in the investments.

Whether or not the emergence of a single, preferred freight unit, such as a 45-foot long container, would change this pattern requires further study, since such units will still be taken directly to the shipper's or consignee's dock, and the pressure to preserve the "service mark" is strong. Frequent air travellers have often been delayed because company X's gates were all occupied, while an adjacent gate, belonging to company Y was available; uniformity of equipment is no panacea for the problem.

Trailer Train, and Rail Box, are examples of what can be achieved if carriers work together. In each of these cases the railroad operators agreed on the basic vehicle and the benefits of free interchange. These were perceived to be of more importance than a particular railroad's name painted on the equipment.

Aside from these institutional factors, a powerful constraint on free interchange is the ability to locate, and trace, equipment in the system. Whereas computers have the demonstrated capability of performing the task of keeping track of the paperwork, the accurate input of accurate information has been a severe problem in the freight transportation industry.

The railroads have used the Automatic Car Identification (ACI) system for several years. In this system a specially coded, retroflective placard is placed on the equipment and optical scanners read the code as the equipment moves in front of the scanner. In the period from 1974 through 1978 several steamship companies spent substantial sums to placard containers and chassis in order to achieve compatability with rail mode equipment. After several years of use, the system is now considered to be unacceptable due to errors caused by dirt on the placards, environmental conditions at the time of scanning, and errors in coding which occur when a placard is damaged or destroyed. It is not now being implemented on new equipment.

In addition to the ACI system, (which is passive since the vehicle mounted equipment, i.e., the placard, requires no power supply) optical systems that can read standard fleet number decals have been experimented with over the years.

To date, none of these systems has been sufficiently developed to the point where even limited testing is warranted.

In addition to the optical reading methods, microwave systems, such as Siemen's SICARID® system, have been developed and tested. These use car-mounted transponders which are swept by a given frequency of electromagnetic energy from track mounted equipment, and respond with identification codes preset into the transponder. Another version, SETRID®, uses similar technology but requires that the transponder be equipped with a battery, since the transponder has active circuitry. (Appendix H)

The SICARID system is a 12-inch-long transponder, intended primarily for railroad service. It can be programmed using a special programming module, in which the code numbers are entered, and indicating lights then show where the special cavities of the transponder must be tuned by insertion of rods.

The SETRID system uses a small housing, about 4 x 6 x 1 inch, in which a transponder is placed. The only access to the transponder is for battery replacement in order to prevent tampering by unauthorized persons. One unit, containing a new, ten year life battery has been tested, and only prototype production is expected for the next year or two. The cost of transponders, currently in the $50.00 to $100.00 range, may be lowered in quantity production; Siemens is currently working to reduce costs.

To date, there is no overriding case that can be made for any of these systems, and because of past failures, there is no rush for adoption of any one technique. The optical systems, utilizing wavelengths smaller than particles of dust and snow are subject to significant errors, while the microwave systems are more expensive and require much more sophisticated vehicle mounted equipment.

It is interesting to note, in passing, that the problem of marking of marine containers is still not fully resolved by either the International Standards Organization or by the American National Standards Insitute, and that the problem of identifying domestic equipment, assuming a completely free interchange system, will require considerable effort to resolve. ANSI Standard MH5.3, 1970, "Specifications for Identification and Marking of Cargo Containers", is now undergoing a major revision, and ISO document, DIS 6346, "Identification and Marking of Freight Containers", is still only a draft document. Earlier documents, although still in force, are essentially obsolete and not extensively used.

3.7 EQUIPMENT CONDITION ON INTERCHANGE

Equipment condition on interchange affects each of the modes in quite different ways. A primary example of this is the air mode, where the requirements of airworthiness are a precondition to carriage aboard an aircraft, and where, because of the roller bed transfer mechanisms in use, any damage to the lower surface of the container may hinder the transfer.

When equipment is found to be deficient, and repairs are required, the carriers involved must have the means to perform the work properly, as well as to account for the expense. Proper repair implies the availability of both skilled manpower and unique parts as required, plus the ability to judge whether or not a particular container can be repaired with cargo inside, or whether the unit must first be unloaded. An example of this is a cargo of flammable waste paper in a container which must be repaired by welding.

The marine industry has begun to address this problem, although at the time of this report only the major leasing companies participate in using common container parts. The Institute of International Container Lessors has developed standardized sections for various framing members for steel containers in order to assure a worldwide supply of common parts for repair purposes. The technological challenge for a domestic container system is to develop repair procedures and materials that can be readily utilized under various field conditions for the many different types of container construction which exist.

The checks performed by each of the modes, and by carriers within each mode, is further affected by management policy, and regulatory requirements. Among the latter, the principal requirements are:

3.7.1 Rail/Highway Interchange

Since in a container system the chassis is not normally moved by rail, the inspection of equipment is considerably easier than for TOFC equipment. The condition of the chassis is under the control of a driver, thus no inspection of brakes and lights would normally be required.

3.7.2 Marine Mode

Marine mode containers are subject to the CSC convention governing safety, and will bear safety approval plates subsequent to 1982. Also, bi-annual inspections will be required. The inspection, and safety of the containers, is the responsibility of the owner, and except for the mis-description of contents, free movement of such containers should not be a problem.

3.7.3 Air Mode

The Aerospace Standard, AS832B, establishes two types of containers, Type A for air only, and Type B for air/land. The 40 foot standard container is designed for a maximum gross weight of 45,000 lbs., a requirement directly related to the aircraft capabilities; thus assurance must be given on interchange that this load is not in fact exceeded by a particular container. The marine industry has experienced several instances where serious consequences resulted from overloads and failure of the shipper to adequately state the contents; poisons, flammables and other hazardous cargo has been shipped, often because neither the shipper nor shipping company was aware of the dangerous nature of the contents.

The requirements of the air mode must thus be known prior to dispatch and loading of a container to provide assurance that the contents will not have to be reloaded at an air terminal. This will require training of personnel in the air mode requirements if the containers are to be freely interchanged.

3.8 SUMMARY

There are a number of other technological issues which have impact on the adoption of a domestic container freight system. Among these are the effect of the Noise Control Act, under which the Environmental Protection Agency is required to issue noise abatement standards for railroad facilities and equipment, the need for specialized cargo restraint devices in containers, such as an intermediate deck, and the relative fuel efficiencies between rail and highway modes when all areas of fuel use, not just line haul use, are considered.

These issues, while important, are nevertheless secondary to those detailed in this section. Agreement must be reached by all modes as to the size and operating characteristics of the freight unit; special attention must be paid to the air mode so as to bring about compatibility between it and other modes, and to insure that ISO containers used in the marine mode, are adequately provided for. Provision must also be made for chassis availability, free container and chassis interchange and for the control and inspection of equipment to meet all modal requirements.

The rail/highway combination, due to the sheer magnitude of freight traffic involved, is necessarily the key combination to a viable overall system. Many of the benefits of containerization already favor the rail mode, therefore, the critical constraints must be resolved in a way that also benefits the highway operator for a true intermodal system to emerge.

4. IMPACT OF CONTAINER TECHNOLOGY ON DOMESTIC SHIPPERS AND CONSIGNEES

4.1 INTRODUCTION

The impact of containers on domestic shippers ranges from practically none to the possibility of greater integration of the shipping process with manufacturing. In addition to the general domestic freight market, the needs of the agricultural and the military sector of the economy were considered separately.

Regardless of the nature of the goods shipped, shippers want low cost coupled with good service time and reliability of service. Their interest in how the goods move, i.e., carrier and routing, exists only because past experience has shown one mode or another to be superior in one or more of these aspects.

If equipment is available, the number of physical transfers of the vehicle between rail or highway during transit is not material to the shipper; economies resulting from faster transfer operations, if passed on to the shipper, are of primary interest, however. The standard response to the question of what problems might be encountered with containers is "None - make it look like a truck."

This is not meant to imply that any given shipping vehicle is an optimum size for all shippers, but rather, that shippers will adapt to a given size if it is standardized and if the benefits of standardization are passed on to the shipper. The trend toward lighter density of goods shipped, both due to increased use of plastics and increased packaging, demands that a domestic container have as large a volume as possible, with dimensions generally equal to those of current trucks, to which industry has already adapted its products and packaging. The concurrent trend towards smaller shipment sizes at greater frequency, in order to lower inventory costs, would appear to negate the need for large volume freight units, but this is not so. Less-than-truckload shipments (LTL) are frequently combined to fill out trailers, or are used to fill out partial load or even truckload (TL) shipments where weight allows and volume remains in the vehicle. These standard practices of the highway operators must be accommodated in any container system since they have been proved to enhance the economics of highway operations.

The acceptance of the container in international shipping has created a favorable environment for introduction of containers in all modes of transportation. The major factors which have made container operations in the marine mode attractive to shippers are:

a) Protection of cargo from weather, pilferage and handling. These losses occurred on the docks, where cargo was rehandled for loading onto vessels.

b) Simplified packaging for offshore trades.

c) Faster transit time when intermodal moves are considered.

d) Lower total cost.

Some of these benefits also apply to domestic shippers, although obviously, no sizeable reduction in packaging expense is likely to accrue to domestic shippers as a result of a container freight system.

4.2 CLASSIFICATION OF DOMESTIC SHIPPERS

Shippers may be classified in several ways, for example as users of common carriers, private carriers or exempt carriers. For the purposes of this study the classification by type of packaging is most useful, since a domestic container system is based on the suitability of the freight unit to handle the broadest range of products. Thus, palletized or slip-sheeted grocery items and palletized radios are essentially equivalent, as are products requiring temperature control, such as boxes of lettuce or boxes of apricots. Bulk commodities are quite different from either of the above, however, in that liquid and dry flowable materials, unless packaged in drums or containers, require a more specialized transport vehicle. Heavy machinery, coils of steel, and ingot materials require a still different vehicle, usually of flat bed construction to make loading and unloading by mechanized means possible.

The effects of a domestic container system on shippers and consignees can best be examined by grouping shipments into:

a) General Merchandise, i.e., boxed and palletized goods and unboxed items, such as tires, trunks, and bagged items which can be handled individually.

b) Perishable Agricultural Products, i.e., items requiring a protective environment, such as lettuce, deciduous fruit and citrus. Items such as bagged potatoes, which do not always require environmental control, are treated as general merchandise in practice.

c) Bulk Agricultural Products, such as grains or grain derived products. i.e., flour.

d) Manufactured Products moving in bulk, such as liquid sugar or plastic resins.

e) Military Shipments.

4.3 GENERAL MERCHANDISE

Interviews with key executives in the freight transportation industry (see Appendix D) has elicited the general comment that any container system would be acceptable provided that, when on the highway, "it looks like a truck."

Dissatisfaction with the loss of cube in marine containers was expressed by many of these same persons.

Jane R. C. Bayes, in summarizing the Canadian experience with domestic containers, quotes R. C. Gilmore, Vice President of Marketing and Sales, Canadian Pacific (CP) "We've seen for some time that plan 2 (Door to Door Rail Service) was ripe for containers, but not ISO standard 20 foot or 40 foot boxes, because these are not favoured by shippers who don't like the loss of cube." (34) The CP has purchased a fleet of high cube, 44-foot-3-inch long containers for domestic use - two will fit on a standard 89-foot-4-inch rail car - to compete with truckers.

A container system will have little impact on the general merchandise shipper, whether common carrier or private, provided the size issue can be resolved. (The private shipper, will of course experience additional impact in his role as operator, which is discussed in Chapter 5.) There are, however, potential benefits to certain segments of the industry in that a container system has the potential for reducing a shipper's or consignee's costs in addition to any cost savings passed on to the shipper by the operators. It is important to note that a properly constituted domestic container system *will have no negative impact on shippers*.

4.3.1 20-Foot Containers

There is a sizeable market of shipments which can fit into 20-foot containers, and in addition, there is a significant number of LTL shipments for which a 20-foot long freight unit is considered to have some potential. The reasons why the 20-foot long freight container has become popular in international trade, and the poor acceptance of this size in domestic commerce, is rooted in the different requirements of the two transportation systems.

The original concept of the marine system consists of modular 10, 20, 30 and 40-foot long containers. Since the ten foot long unit was found to have little practical value due to its low cube, both it and its complementary 30-foot long unit has been only rarely implemented.

Road and railcar length restrictions in the U.K. and other countries gave shipowners concern that the 40-foot long unit would be too long. For example, Italy initially required steerable rear axle chassis for 40-foot long units to operate over narrow streets. These concerns have proven to be needless; 40-foot long units now move freely over the road in the U.K. and elsewhere.

Additionally, shipowners perceived the 20-foot container as a means of maximizing use of the vessel volume. Modern containerships, with approximately 30 percent of the container complement above deck, are testimony to the relative low density of most commercial shipments. In certain trade lanes, at certain times, it is obviously productive to have smaller cargo units, and there are other trade routes, such as U.K.-Australia, where the major product is very dense, e.g., frozen meat, and a 20-foot long unit is very efficient.

Finally, the use of 20-foot long containers with a 20 long ton load limit poses no problems where road legal limits do not exist. In the United States, however, road legal limits do exist, and the 20 ton load can only be carried on a 23-foot long chassis in most states in order to comply with the bridge formulae. Twenty foot long containers, on 23-foot long chassis, only fit three per railcar in the TOFC mode, even if the load is below the railcar maximum.

In the highway mode, the 20-foot long unit is uneconomic for the truck operator, since the driver's time, and cost, is the same regardless of length, fuel savings are only marginal, and additional handling costs are involved.

The U.S. Department of Defense has estimated that for overseas shipments, from depots located fairly close to port areas, the effect of over-the-road costs is such that a 63 percent cube utilization in a 40-foot long unit - about 1,350 cubic feet - is equivalent to a 75 percent utilization in a 20-foot long unit - about 790 cubic feet (see Appendix E).

For domestic transport, where the line haul distance is shorter, and proportionally a smaller portion of the total cost, the breakeven percentage for a 40 foot container is even lower, and to date no domestic highway carrier has found it economic to use 20 foot length units.

Twenty seven foot long units have, however, proven to be of value where local laws permit the use of "double bottoms", i.e., two trailers pulled by one tractor. Therefore, it is not unreasonable to expect that 20-foot long units will become part of a domestic container inventory wherever it will be legal to pull two units with a single tractor. In this way the inconvenience and cost of transfer equipment, to remove the containers from a 40-foot long chassis to load the front container, will be avoided.

4.3.2 Specialized Chassis Designs

The ability to separate the container from the chassis allows the system to adapt to an almost unlimited number of circumstances. One problem often encountered is the delivery of goods to consignees not equipped with truck height receiving docks. It is technically feasible to provide chassis with lift gates, so that the container can be easily unloaded to road level. Lift gates add to the tare weight of a chassis or truck; in the case of a truck or semi-trailer this tare weight is a constant penalty; in a container system this weight penalty is incurred only when the feature is needed, and the properly equipped chassis is used.

4.3.3 Grounding of Containers

Another feature is the ability to separate the container from road chassis at shippers or consignees, if desired. The separation may be effected to put the container on a rack or stand, or it could be lowered to ground level, if desired. This feature is of importance where temporary storage is a part of the shipping cycle, such as accumulation of full truckloads to a common consignee, or intergration of the shipping cycle with a manufacturing process.

The benefits of grounding containers seem to occur only in isolated cases, however; our discussions with a sample of shippers (see Appendix D) did not uncover any who saw grounding as a benefit, and many who stated flatly that they would never ground a container. This is because of the time and cost involved with the equipment involved in raising and lowering containers. Two separate 40-foot long trailers, at $13,000 each, represent an investment of $26,000; two 40-foot long containers and a single chassis represent an investment of approximately $18,000, a difference of $6,000. Assuming a 10 year equipment life, and a 10 percent capital cost, the higher investment is justified if annual savings from operating two separate trailers exceed $1,300 per year. Transfer costs at high density rail and marine yards, average $20.00 per move (a container on or off a chassis); therefore the cost of operating two separate trailers is lower whenever the number of moves is greater than 65 per year, a quantity that would be exceeded in any well run operation.

4.3.4 Alternative Routing of Cargo

Rail movement of TOFC trailers is severely limited in the Northeast area of the United States due to tunnel and bridge restrictions on several major railways. Among these are:

a) The bridge clearances in the Washington, D.C. area connecting the Southern Railroad and Conrail systems.

b) Tunnel restrictions in Baltimore and New York City on the Conrail system.

c) Height restrictions on the Conrail New York/Albany route.

Since containers are four feet lower in height than the equivalent trailer units, it makes operations over these routes feasible. This is critical for a domestic freight system, since the Northeast represents a major freight market, and the routes to the West and South are seriously constrained by the present height restrictions. In addition to its importance to the operators, the shipper's benefit as a result of being able to use 9 and 9½ foot high equipment in intermodal service.

An additional advantage made possible by the use of containers is the use of rail movement compared to highway movement for heavy goods that can now be shipped through states that have low gross vehicle weight limits for highways. The states with lower limits are generally in the East; the greater height of containers, which would be possible in rail service, will result in greater payloads, and ultimately in reduced rates.

4.4 PERISHABLE AGRICULTURAL COMMODITIES

In the area of perishable transportation the use of containers could potentially be of great significance to shippers. This is because past efforts to transport refrigerated and heated trailers ("Reefers") in a combined highway/rail move have generally proven unsuccessful. In 1977 there were

760,000 carload equivalent shipments of fresh fruit and vegetables between the producing areas and major cities. While much of this traffic is capable of being carried by rail about 90 percent moved by truck. (35)

"Reefer" trailers or containers are conventional freight units provided with insulating walls, floor, roof and doors to retard heat transmission and are equipped with mechanical refrigeration units to condition the interior volume to the desired transit temperature. As opposed to dry freight units, reefer units are also subject to mechanical breakdown, and require periodic refueling. These two factors have made all highway transit the preferred mode, since there is one driver per unit, and at each rest or fuel stop he can check that the unit is maintaining temperature. If a problem occurs, aid from a local garage or refrigeration service dealer can be obtained. This provides both the shipper and consignee with a great degree of protection.

Whenever the railroads have carried reefer trailers they have been subjected to heavy cargo losses due to breakdown of units or lack of fuel. Even if a periodic yard check is made by competent personnel, the refrigeration units, mounted to the nose of the trailers, are difficult to service, as they are at least 10 feet above the deck of the flatcar. The solution to the problem has been for the rails to offer service as Plan III under which the rails carry reefer trailers without assuming any responsibility for either the contents or failure of the refrigeration machinery.

In addition to container mounted refrigeration units, when carried as COFC, being more accessible from the deck of the flatcar, domestic containers, 45 feet long, offer additional advantages that are often overlooked when the typical 40-foot ISO container is considered.

A 40-foot, 9-foot-6-inch high reefer container, with typical insulation and a recess at the front of the container for the refrigeration plant has an internal volume of about 2125 cubic feet compared to a standard dry van of approximately 2650 cubic foot volume. This represents a cube loss of almost 20 percent when a refrigerated container is used for dry freight on back hauls; it is as if only a 32-foot long trailer were being used. The 45-foot long reefer container, of identical construction, benefits both the head and return haul; most agricultural products are of low density, and the 45-foot long container has a 13 percent increase in useable cube, compared to a 40-foot long unit.

The shippers of agricultural products will also gain from the ability of high cube containers to be carried as COFC. The majority of perishable commodities move from the South and West to the Northeast, especially New York City, a route that does not permit TOFC operations because of tunnel restrictions, but which can easily accommodate COFC.

Since the cost of a "Reefer" container is about five times the cost of a dry container, refrigerated units must be treated separately, with return routing to the origin area as rapidly as possible. The indiscriminate use of "Reefer" equipment for general cargo is not advocated, but the potential for efficient use in back haul operations is important in reducing empty equipment miles.

4.5 BULK AGRICULTURAL PRODUCTS

4.5.1 Grain Shipments

Some of the largest domestic transport moves consist of bulk agricultural commodities; the largest examples of this are grains moving from farms and fertilizer moving into farming areas. It does not appear that a domestic container system will play a major role in this sector of transportation.

Most farm bulk products are quite dense and free flowing; as a result, the trend has been to optimize the transport vehicle for each leg (by specialized design) and to transfer the product at each nodal point using highly mechanized facilities. (36)

On the rails, for example, grains are now typically handled in 100-ton covered hopper cars. These are loaded through roof hatches from the spout of a grain elevator; at destination, gates in the bottom of the car are opened and grain is dropped by gravity into a pit at the receiving facility, all at very low cost.

To compare the use of domestic containers with the above system, the possibility of a combined highway/rail movement was investigated, using various size containers and assuming:

a) A 100 percent *loaded* return for a container system.

b) A 100 percent *empty* return for a covered rail car system.

c) All rail flatcars achieve the low tare weight of the Santa Fe "Ten Pack" car.

d) Special loading and unloading features can be provided for the containers with no addition to tare weight and no increase in cost.

In all cases, it was determined that the gross weight of only the loaded leg of a container trip exceeded the gross weight of a round trip of a covered hopper car carrying 100 tons of grain. Thus line haul costs would be greater; in addition, the investment required for a container system was greater.

The final area not yet compared, that of the terminal, would only make the case worse, because even if the containers were fitted with top loading and bottom discharge facilities, there would be considerably more movment required to load when compared with the relatively simple 100 ton covered hopper car.

Because of these fundamental considerations containerization would seem to have little to offer for the general day-to-day transport of bulk agricultural commodities.

There are two situations, however, where containerization can make a contribution. First, when there is a critical shortage of covered hopper car equipment, such as during a boom harvest, containers could be used if available. A second case is for specialized shipments, where handling should be minimized, for example for edible grains, where it is important to prevent possible adulteration or degradation at elevators. In either of these cases the premium cost for containerization *might* be acceptable. The market is not large, and no regular container shipments of grain could be documented during this study.

The occasional use of containers would not justify special fittings, such as roof hatches and bottom dump capability in all containers of a domestic system. Another study came to similar conclusions; it also analyzed the capability of a container for storage of agricultural products and concluded that presently available specialized storage bins were economically superior. (37)

It is estimated that the roof hatches and dump features would add a minimum of 800 pounds of weight at a cost of about $1,000. In planning use of containers for bulk agricultural commodities, therefore, consideration should be restricted to provide the necessary side strength to prevent bulging, and the ability to have grain doors fitted inside the regular doors.

4.5.2 Bulk Delivery of Refined Agricultural Products

Many agricultural products are delivered to consignees, such as bakeries, in either refined or milled form, sugar and flour being the prime examples. Although containers on chassis could be used for this purpose, rather than the special equipment now used, there appears to be no practical reasons for doing so.

Flour, and products with similar characteristics are delivered in pressure differential trailers, since the products are not free flowing and require aeration and pressure to flow. (Flour in bags, which is a significant trade, is treated as general merchandise for purposes of this study.)

Containers built to withstand the pressure with roof loading hatches could be built, and the chassis equipped with the necessary pressurizing equipment. However, neither the container nor chassis would be general purpose equipment, and would not be used in any case for return hauls to prevent contamination of the interior. The combination would have greater tare weight than the special purpose trailers now used.

Sugar, which is free flowing, represents a group of products that can potentially be handled in general purpose containers. For such use, the container would be provided with a liner, such as Sea Bulk® in which the product can be loaded through the rear doors into the liner, and discharged by tilting. The tilting can be provided by a special chassis, or where the volume of shipments warrants, a special tilt platform can be provided at the consignees and a standard chassis used.

4.6 MANUFACTURED PRODUCTS MOVING IN BULK

4.6.1 Liquid Materials

A large number of liquids move by highway trailer and railcar; these range from food products to industrial chemicals. Tank containers are in use in the marine mode, and quite obviously could also be part of a domestic container system, although for large bulk moves, such as kaolin clay, the rail tank car provides great economy due to its weight capacity.

The benefits of tank containers to shippers will depend in large part on the product and the distance that the product is moved. It has been amply demonstrated in the marine environment that where transit time is great, the cost of cleaning tanks to achieve two-way movements of cargo can be easily absorbed in the transport cost; where the transit time is short, it is generally cheaper to accept the empty-return leg rather than to clean the tank. In highway transportation the same philosophy generally applies, especially since cleaning costs have risen dramatically because of environmental protection laws that regulate the discharge of cleaning effluents.

There is, however, no technological reason why tank containers cannot be used, and undoubtedly, some shippers will benefit from tank containers. One of the important reasons is that it frees the loading and discharging site from the requirement to be close to a rail siding.

4.6.2 Dry Materials

The discussion of paragraph 4.5.2 applies to all dry materials, not only to agriculturally derived dry-bulk materials. Containers are ideally suited to situations where there are small variations in grade of resins, or in color, where lot sizes are relatively small, and where a large inventory must be maintained.

Perhaps the greatest potential benefit to such shippers and consignees is the possibility to integrate containers directly with the manufacturing process. A prime example is the operations of Union Carbide, where containers are used in the transport of plastic pellets and powders, and the containers are also used as storage while awaiting processing. When needed in the manufacture of the end product, the containers are simply tilted and unloaded to conveying devices within the plant.

Although existing plants are not generally designed for access of trailers within a plant (headroom restrictions being among the major constraints), containers offer flexibility in this regard. The degree of integration will vary from industry to industry, and undoubtedly will first be implemented by larger companies, possibly using owned equipment. Based on the interviews conducted, we project that this will occur only after a domestic container system is in place and operating successfully for a number of years.

4.7 MILITARY SHIPMENTS

The military establishment is a large user of transportation, both domestically and internationally. Goods are transported from manufacturers to depots and then to the various consignees, or directly from manufacturers to the various military destinations. To the extent that items transported are subsistence items, the range of products is similar to non-military goods. These goods tend to be lower in density than industrial items, and the emphasis on maximum volume of the transport vehicle is as important as for other shippers.

Non-subsistence items tend to be of higher density, such as ammunition, although ammunition is considered hazardous cargo that must move under special rules. Since such higher-density cargo is generally a one-way move, it again falls into the previously discussed category; namely, that a general-purpose transport vehicle, to achieve maximum utilization, should have a high cube. It is more economic to move empty cube in the low proportion of high-density cargo movements than to limit the total weight that can be carried in low-density moves.

The military establishment currently utilizes containers for *overseas* shipments, and faces the classic distribution problem of matching shipment size to lowest total inventory cost. As presented at the DOD Container Utilization Conference on December 11, 1979, the overseas shipments are preferably made to single destinations. The smallest container available is used to achieve maximum cube utilization since only about 10 percent of all shipments are weight-limited. The term "cube utilization" is somewhat arbitrary since it is based on the maximum internal volume of a container when loaded with a liquid, which is almost impossible to achieve with general cargo. However, since the DOD pays for containers on such cube basis; i.e., a given sum per container regardless of loaded volume or weight, the use of "cube utilization" is a rough measure of transport efficiency.

Obviously, if goods were held at depots for a great length of time, all containers could be stuffed to near 100 percent cube utilization. Since the pipeline to overseas units is long, holding cargo to fill containers increases the inventory cost. An apparent good rule of thumb is that 85 percent cube utilization is desirable.

Domestically, the military establishment will benefit to the same extent as other shippers. The potential benefits to the military of a domestic container system was discussed at the DOD Conference on Container Utilization, and it was decided that "there is no real advantage until the railroads improve operations, i.e., intermodal moves are possible."

In addition to using commercially available containers, the Department of Defense uses MILVAN containers for off-shore shipments. These are 20-foot long units, built to ISO specifications which have special cargo restraint provisions. These containers are available in dry van and refrigerated models. Further, the DOD uses special shelters, such as for kitchens and laundries, which are built to be handled by top-corner fittings in like fashion to ISO containers.

In case of a national emergency, the availability of off-shore transportation through commercial carriers is of course variable, depending on where containers and vessels are physically located, and which nations are friendly or unfriendly. On a purely random basis, there will always be a pool of containers and vessels in U.S. territory, and the MILVAN containers can be used as supplements to this capacity. No change to current planning is therefore required since it is a basic condition that a domestic container system must accommodate standard ISO containers. If domestic containers are used for bringing goods to marine terminals, the cargo would have to be transferred, but this is no different than if trucks were used to transport goods to these marine terminals.

5. IMPACT OF CONTAINER TECHNOLOGY ON OPERATORS

5.1 INTRODUCTION

The benefits of containerization are currently exploited by those modes in which the costs associated with containerization decrease the time to load and unload expensive line-haul equipment. Domestically, these benefits could also accrue if containerization were extensively used. These benefits will not be realized in all operations all of the time, but there are many areas where substantial cost savings can frequently be expected.

The major benefits can be realized by all modes. This is so because a container with multimodal capabilities is an inherently flexible unit, taking on the desired characteristics of the mode in which it is used. In the air, marine, and rail modes, it is a good unitizing device that enhances turn time of time-expensive line-haul equipment; in the highway mode, a container is, for all appearances and uses, equivalent to a trailer. In all modes, the great majority of the current investments will be preserved, or the introduction of containers will have only minor impact on the current reinvestment cycle.

However, the impact of a domestic container system on the operators will be especially important since it is the concensus of highway operators and shippers that only a 45-foot multimodal container will gain wide acceptance, and thus, a new-size container is introduced that will not fit existing chassis or modus operandi. As previously mentioned, the 45-foot long unit is considered superior, and the only one acceptable, in view of the existing highway regulations. If these laws should change, other sizes may dominate. However, unless these sizes are 40 and 20-foot long, the need for new chassis is identical. Since the majority of moves will be rail/highway, new opportunities and demands will primarily affect the motor carriers and railroads.

5.2 UNIMODAL CONSIDERATIONS

5.2.1 Highway Mode

It appears that the initial impact on the highway mode will be small since highway operators will utilize containers/chassis as if they are straight semitrailers. Given the current cost of $20.00-per-move-on and $20.00-per-move-off of a chassis, generally experienced at all intermodal terminals, compared with current chassis ownership and maintenance costs of about $3.50 per day, the separation of containers from their chassis at motor-carrier terminals is not likely. It requires that a container not move for at least 11 days for separation to be considered as a cost-saving operation. There is no saving in parking space when a container is grounded compared with a parked chassis, so that there are no offsetting cost reductions.

As the acceptance of a domestic container system grows, certain shippers will place demands for separation of containers from chassis on to the operators. This is because the shippers will find it useful for their own purposes to take the containers off of the chassis, either as temporary storage, or, if integrated with the manufacturing process, for internal handling. The operators will look to the shippers to pay for the transfer, either directly or indirectly. This is currently the case with certain large export shippers utilizing 20-foot containers which require rehandling of a 40-foot chassis to make for economic land transport.

In such cases, the availability of a return container from the shipper or consignee, either empty or loaded, is required to make for economical motor transportation. An important aspect of this operation will be the installation of a domestic empty-container-tracing system, similar to the Computerized Interchange System (CISS) recently installed by the Equipment Interchange Association for trailers. CISS, by matching empty trailers to available cargo, has reduced empty miles at an annual rate of 940,000 miles during its first nine months of operation. In the process, a reduction of 180,000 gallons of fuel, at a savings of about $703,000 in costs, have been achieved.

5.2.2 Rail Mode

5.2.2.1 Container Size - The rail mode will be affected primarily by the need to provide greater 45-foot capability on its railcars. This need can be satisfied by the conversion of existing railcars, and requires detailed engineering design and evaluation. This is so because a 45-foot container will overhang the 89'4" railroad flatcars, and provision will have to be made either to support a slightly overhanging lower-corner fitting, or preferably, to support a new design of domestic container about one foot from either end.

Of greater concern is the rapid trend to special, and new railroad flatcar designs, which, although they can accommodate either 40-or 45-foot trailers or containers, are designed exclusively for a lift-on/lift-off operation. If new side-transfer technology (either sliding or rolling) is to have a chance of acceptance, this technology must be explored rapidly so that new investments do not become a barrier to acceptance.

5.2.2.2 Reduced Rail Line-Haul Costs - Containers on flatcars have a lower tare weight compared with corresponding-size trailers. This results in reduced line-haul costs and in reduced right-of-way maintenance costs.

The line-haul cost advantage of the railroads compared with the highway mode is sufficiently documented. Because of higher terminal costs, the rail mode is generally not competitive for line-haul distances less than 800 miles. By further reducing the line-haul costs, the railroads' cost advantage becomes important at shorter line haul distances.

5.2.2.3 Reduced Terminal-handling Costs - Compared with TOFC trailers, container operations are potentially more efficient in rail/highway terminals. This increased efficiency results from several factors.

Assuming that a lift-on/lift-off system is used, containers

a) reduce the clearance height required under lifting equipment since the 4-foot high chassis is not moved on the rails,

b) reduce the mass that must be lifted by reducing the tare weight of the freight unit,

c) reduce the time to lock the freight unit in place on flatcars (container restraints are self-locking, TOFC trailers require manual tightening on the fifth wheel stanchion), and

d) allow for stacking of freight units in yards.

Of even more potential importance, the use of containers allows consideration of alternative transfer means between railcars and chassis. Side-transfer systems, which eliminate the need for lifting equipment entirely, and which require less energy in operation, are feasible. Several such systems have beeen developed; i.e., Flexivan®, Steadman®, etc. In existing rail/-highway terminals, the use of side-transfer systems has been stymied since TOFC trailers and ISO containers require lifting. This is not, however, a limitation on a domestic system. By reducing the costs associated with lifting systems, side-transfer systems offer especially great potential for terminals with small throughput that cannot otherwise justify the more expensive lift-on/lift-off devices.

5.2.2.4 Enchanced Train-to-Train Transfer - Most rail moves of containers are an extension of TOFC trailer movements, and are made utilizing dedicated trains between major terminals located a considerable distance apart. The railroads have found it to be uneconomic to move trailers over short distances. This is so because the need to make up trains of sufficient length for dedicated service adversely affects service time, and because the cost of transfer between trains is high. The cost of such transfers is considered prohibitive since railcars must be switched by destination at intermediate points. Overhead-gantry transfer of TOFC trailers from train to train requires a transfer device capable of a 33-foot clear lift (4-foot railcar, 13-foot 6-inch trailer to clear trailer on a flatcar, 13-foot 6 inch for trailer being lifted, 2-foot clearance). Lift-on/lift-off container transfer for an equivalent cargo unit requires only a 25-foot lift capability in the transfer device, and each lift requires only 74 percent of the energy compared with a TOFC trailer. Again, the use of side-transfer systems have considerable potential.

5.2.2.5 Improved Cube Utilization of Transport Mode - The increased cube utilization of line-haul equipment when using containers rather than trailers in the air and marine mode is obvious. In the rail mode, cube is of no direct concern, but it has been shown that containers achieve an advantage in line-haul costs which are related to the reduced cube. Tests show that air flow under trailers increases aerodynamic drag and increases fuel consumption above that experienced with containers. A more subtle advantage is that by lowering the center of gravity of the combined railcar/container unit, the ride characteristics of the railcar are improved.

5.2.3 Marine Mode

In the marine mode, the introduction of 45-foot long units will impact the cellular ship operators. Barge operations, and RoRo operations will not be impacted to any great extent, since they are currently carrying 45-foot long trailers, and would, in all likelihood, not even notice whether the freight unit is a trailer or container since the units are usually handled on wheels.

Cellular ship operators, such as Matson Navigation, would be restricted from carrying any size other than those for which the vessel cells are designed, and depending on the features built into a domestic container, may not be able to stack containers to the full six high under deck even if the dimensions are compatible. Furthermore, the lifting of marine containers by corner fittings is well established and is a requirement for stowage aboard ship with minimum loss of cube. A domestic container could provide for such lifting without meeting the six high stacking requirement, however.

In addition to these factors, the impact of international activities appears to make adoption of a unit other than 20 or 40 feet unlikely for cellular ship operators. The developing countries, the group of 73, has petitioned both ISO and the United Nations to keep the present ISO sizes as standard, and their petitions have found sufficient sympathetic ears to make any change unlikely.

5.2.4 Air Mode

The impact of domestic containerization on the air mode will be very small. This is because to be suitable for air mode, containers must have a tare weight in the range of 1.2 to 1.8 pounds per cubic foot, or for a 20-foot long, 8-foot wide x 8-foot high unit, approximately 1,536 to 2,304 pounds. Further, the containers must be designed to deflect a minimum of ± 3/8 inch to accommodate to the aircraft deflections, a requirement opposite that of ANSI and ISO containers for the marine mode. No aircraft currently exist able to handle 45-foot long, 8-foot wide, 9-foot or 9-foot 6-inch high containers, which are the likely future module for land transport.

We are aware of the research and development work now being pursued by various companies on concepts such as the "flatbed aircraft" (38) and other innovations. Knowing the range of commodities to be carried in general service which are not amenable to transport in environmentally uncontrolled conditions (pressure, temperature and humidity), such developments appear to be quite distant in time. We do not foresee the emergence of new cargo aircraft capable of 45-foot long container carriage in the current decade. Thus, an appropriately designed domestic container will influence aircraft design, rather than the reverse, which has led to a special air mode unit.

Air mode containers are about twice the cost of a standard ISO container, which is a further, and probably overriding constraint against their use in other modes.

5.3 INTERMODAL CONSIDERATIONS

5.3.1 Lower Total Investment

The cost of 40-foot highway trailers is currently $11,500; the cost of an equivalent ISO Marine 40-foot container and chassis is $6,800 and $6,000 respectively. (Excise taxes for the trailer and chassis only are included; containers are not currently subject to excise tax.) Assuming that *all* trailers are replaced by containers and chassis, one chassis per container, the total investment would be increased by approximately 11.3 percent. However, the argument for containerization is based on a complement of chassis less than the total number of containers; it would require only a 1.276 ratio of containers to chassis for the investment cost of a container and chassis sytem to be less than the current investment.

What is the possibility of achieving a ratio of 1.276 or more containers per chassis? Several assumptions can be made. One is that the highway mode is based on a chassis system; that is, for every container on land there is a road chassis. A second assumption is that the domestic system is used in a "grounded" system, i.e., containers are placed on chassis only when a highway move is contemplated.

A review of marine industry practice leads to some insight in this area. There are two U.S. steamship companies that practice one or the other system almost exclusively, and, in addition, use a unique size container so that the fleet composition data are not distorted by leased equipment. Although one of these companies serves a trade in which it has little competition, and service time is less of a competitive need, comparison of the container to chassis ratio can serve as a guide to the ratio that might be achieved in domestic operations.

Sea Land Service, a company that uses a chassis system almost exclusively, had the following equipment in service at the end of 1978 * (39)

35 ft. containers*	55,367
Vessel capacity, one container assumed per slot.	21,834
Containers on land **	33,533
35 ft. chassis	32,517

Ratio of all containers to chassis = 1.70

Ratio of containers on land to chassis = 1.03.

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* The total number of units does not account for units taken out of service due to damage, or owned feeder vessels of small capacity.

** It is assumed that all vessel slots are fully occupied at all times. This assumption is valid, since otherwise a container imbalance would exist over a period of time.

Matson Navigation Company operates 27 foot containers in a grounded operation.

27 ft. containers *	3,478
Vessel capacity, one container assumed per slot.	973
Containers on land	2,505
27 ft. chassis	1,132

Ratio of all containers to chassis = 3.07

Ratio of containers on land to chassis = 2.21

The container to chassis ratio is seen to be a function of the number of units on the line haul vehicles, as well as the type of ground support system used. A potential ratio for the rail mode can be calculated assuming an average of 50 mph as the line haul speed. A line haul distance of 400 miles thus represents a practical distance for overnight delivery. From 400 to 1,600 miles represents second morning delivery at best, and from 1,600 to 2,800 miles third morning delivery.

Overnight delivery, with trains in both directions, requires 2 sets of chassis for 2 train sets of containers. Assuming no grounding at the terminals since service time is critical in this mileage range, a container to chassis ratio of one to one is required for this service.

For second morning mileages, assuming 1 daily train in each direction, and further assuming that equipment is not idle on weekends, a ratio of 2.5 containers per chassis can be established. Similarly, for third morning deliveries a ratio of 3.5 containers per chassis can be calculated.

In the highway mode the anticipated ratio of containers to chassis will be one to one, since large scale separation of containers from the chassis is unlikely. The combined ratio of all modes of a domestic system, is thus *not* expected to approach that of the marine industry. This is of course to be expected, since the proportion of domestic containers in line haul service at any given time is smaller due to shorter distances and faster line haul speeds.

However, it is also not expected that containers and chassis will replace all trailers; the most likely application of containers and chassis is exactly in those portions of a domestic freight system where a substantial line haul is involved. Although it is not within the scope of this study to project a

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* The total number of units does not account for units taken out of service due to damage, or owned feeder vessels or small capacity.

final system wide ratio of containers to chassis, nor can it be done without extensive analysis of cargo flows, a system wide ratio of at least 1.276 containers per chassis appears a reasonable goal, and the overall investment should thus be less than with independent rail and independent highway systems.

It has been repeatedly demonstrated during startup of marine container services that an initial container-to-chassis ratio of one to one improves significantly as the service matures and expands. As COFC becomes well established, system wide investment will decrease as the container to chassis ratio improves.

5.3.2 Intermodal Terminal Design

If rail/highway intermodal transportation is to become widely accepted, service time and cost on short hauls must be decreased over the current time and costs. This requires major changes in terminal operations. Present rail/highway terminals, operated by the railroads, must not only change operational techniques, but must have a greater input of motor carrier requirements. The impact of terminal operations on both service time and cost, and the ability of rail service to compete with all highway service, is very important.

Figures 2 and 3 show the current TOFC system performance in terms of time and cost for two city pairs of equal daily volume but significantly different line haul distances. (40) Of a total of 28 hours transit time for the 279 mile distance, 70 percent, or about 20 hours is represented by terminal time. Assuming only a 40 mph average road speed, a highway move of 279 miles can be completed before the trailer has ever left the origin terminal yard.

The proportionately higher cost of the TOFC move can be analyzed by reference to Figure 4, an example of typical terminal costs (41). Approximately 38 percent of the total cost is for land and land-use-associated costs (taxes, etc.,); another 11.8 percent represents the cost of equipment (trailers and railcars) held in the terminal; finally about 20 percent represents labor associated with the physical loading and unloading of railcars.

Thus the problem of current rail/highway terminals is not one that can be significantly affected by small improvements in the operation of lifting equipment; even if all capital and maintenance costs for lifting equipment could be completely eliminated this would only provide a cost reduction of 4.2 percent.

The opportunity to design efficient rail/highway terminals must be addressed in new and innovative ways by the cooperative effort of qualified personnel of both the rail and highway modes. Present efforts to improve rail terminals are geared to efficient makeup of trains and to reduce rail costs only; it should be kept in mind that overall transportation costs may be reduced even if one of the modes incurs somewhat greater expense.

Thomas Richards of A. T. Kearney, Inc., addressing the question of how railroads can become a viable intermodal link, stated that "in order to compete in a viable manner, rail service must reflect the inherent characteristics

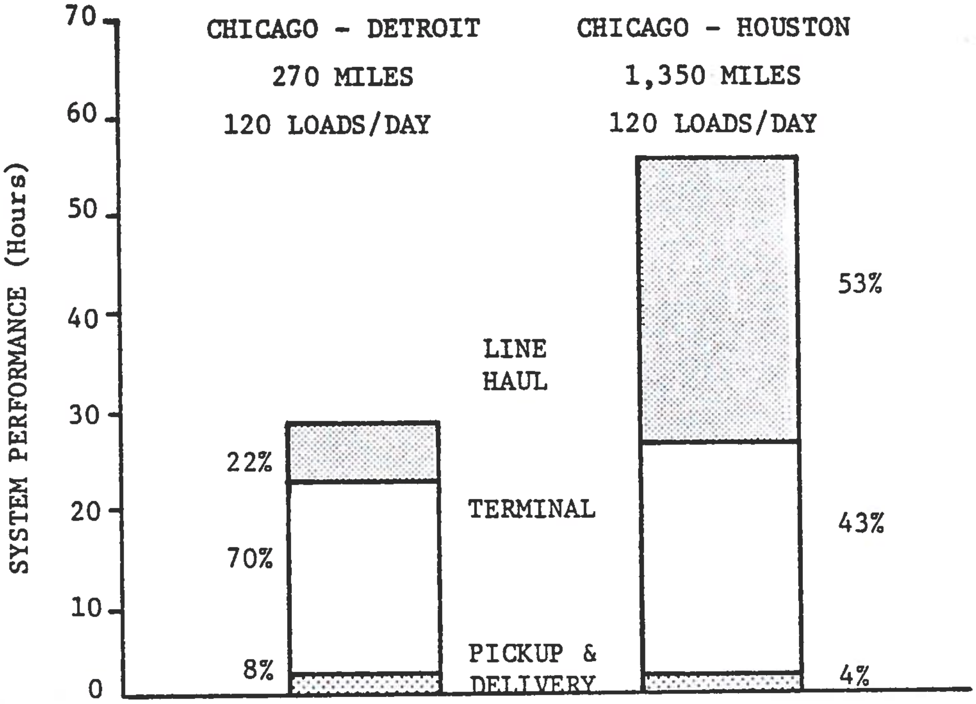

Figure 2. BREAKDOWN OF CURRENT SYSTEM PERFORMANCE

ONE WAY TRIP TIMES BY CITY PAIRS

(Door to Door TOFC)

SOURCE: A. T. KEARNEY

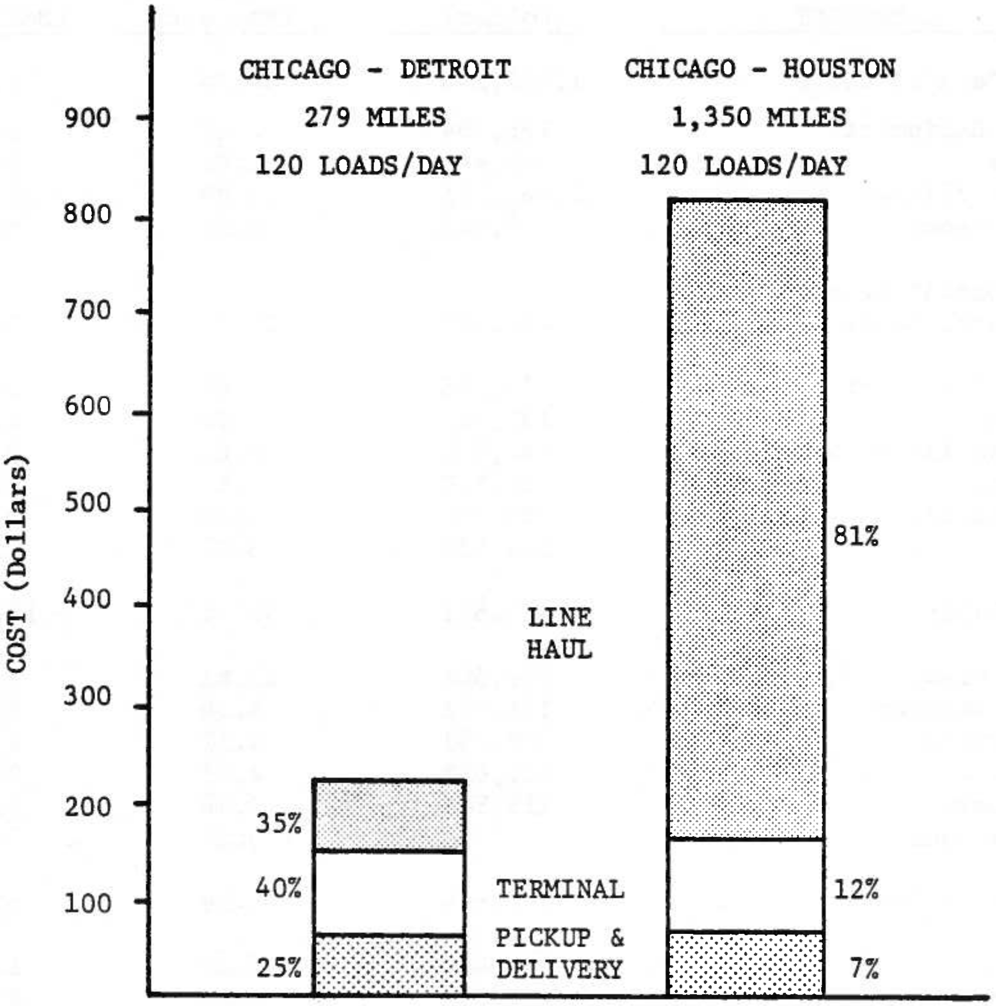

Figure 3. BREAKDOWN OF CURRENT SYSTEM COSTS

ONE WAY TRIPS BY CITY PAIRS

(Door to Door TOFC)

SOURCE: A. T. KEARNEY

COMPONENT	TOTAL ANNUAL COST (Dollar)	TOTAL TERMINAL COST (Percent)	COST PER LIFT (Dollar)
Terminal Capital Costs	1,646,296	34.74	12.53
Lifting Equipment	126,484	2.67	0.96
Hostlers	48,404	1.02	0.37
Fixed Facilities	1,463,748	30.89	11.14
Miscellaneous	7,660	0.16	0.06
Terminal Operating and Maintenance Costs	737,099	15.55	5.61
Lifting Equipment	70,346	1.48	0.54
Hostlers	193,453	4.88	1.47
Fixed Facilities & Mics.	30,000	0.63	0.23
Switching	32,850	0.69	0.25
Loco Hostling	80,300	1.69	0.61
Taxes	330,150	6.97	2.51
Terminal Labor	1,483,871	31.31	11.29
Loading Crews	559,501	11.81	4.26
Hostler Drivers	391,441	8.26	2.98
Gate Workers	309,053	6.52	2.35
Clerical	110,072	2.32	0.84
Supervisors	113,805	2.48	0.87
Miscellaneous	0	0.00	0.00
Rolling Stock Costs	871,636	18.39	6.63
Trailers	255,436	5.39	1.94
Railcars	305,051	6.44	2.32
Road Locomotives	311,148	6.57	2.37
TOTAL	4,738,897	100.00	36.06

Figure 4. EXAMPLE OF TERMINAL COST SUMMARY BY COMPONENT

BASELINE COST - ST. PAUL TERMINAL

SOURCE: A. T. KEARNEY

of the trucking industry. That is, reliability, speed, flexibility and low cost." (42) Since line haul speed of the railroads is roughly equal to that of motor carriers, and costs are less, flexibility and reliability of service must be addressed.

5.4 SUMMARY

Although not all of the transportation modes will benefit equally, the intermodal use of containers having multimodal capabilities can result in overall economies in domestic transportation. In addition, some of the modes will also benefit from the purely unimodal use of containers.

All modes, as well as the shippers, will benefit from a standardized freight unit, which will make free interchange of equipment among the modes possible. The larger the total fleet the greater is the potential utilization of the equipment. Empty mile reduction, the ability to shift equipment from one area to another on a seasonal basis and the ability to rapidly substitute service of one mode for another in times of emergency are potentials that can only be exploited if a transport vehicle is suitable to all modes.

The constraints of technology are compounded by institutional barriers that have prevented greater cooperation among the modes in agreeing on how the technology is to be applied. For example, the Equipment Interchange Association, which has recently introduced a new computerized system for interchange accounting, projects that it "will reduce these costs (accounting, etc.) to $11,812,500 for motor carriers; $10,443,250 for railroads; and $56,165,000 for water carriers, a total saving of $146,119,250." The realization of these savings is only possible if the great majority of operators agree to join the system.

These technological constraints can be overcome by a similar cooperation among the various modes by participation in further research and development in a limited number of areas, which are detailed in Section 6.

6. RECOMMENDATIONS FOR FURTHER RESEARCH

6.1 INTRODUCTION

Five areas of research are recommended to overcome the critical constraints identified during the study. These areas are:

a) Development of a Domestic Container Performance Standard

b) Prototype Development and Demonstration of Containers and Chassis

c) Intermodal Terminal Design

d) Equipment Control and Inspection Procedures

e) Evaluation of Foreign Operating Experience.

6.2 DOMESTIC CONTAINER PERFORMANCE STANDARD

The ANSI Standards for Freight Containers, which now cover rail/highway and marine containers, are directed to providing the greatest degree of equivalence to the ISO standards, which have the marine mode requirements uppermost in mind. Indeed, the existence of these ANSI standards is believed to have a negative effect on development of a domestic container system since the standard limits the permitted size to 40 feet in length.

Before a more appropriate standard can be drawn, the industry requirements must be detailed; this must include all modes, but principally the rail and highway systems. To attempt to perform the needed evaluations without industry participation, is, in our opinion, not likely to be fruitful, although preparatory work should be performed prior to inviting industry guidance.

Among the specific areas to be addressed in the evaluation are:

a) Sizes of freight module

b) Strength of freight module, i.e., load capacity

c) Handling Methods - rail to highway transfer (for example, lift-on/lift-off); stacking requirements

d) Compatibility with existing standards

e) Adaptability of railroad flatcar fleet to alternate handling methods.

The preparatory work should include a detailed analysis of existing standards. This effort should result in a draft standard which includes mandatory requirements, (for example, dynamic load factors for each mode), and various alternative suggestions for requirements that need industry discussion.

Initially, the proposed standard should address only the requirements, since test methods and procedures would be premature and impede identification of the industry's needs. For this reason industry participation should initially be limited to major industry associations, and major operators, rather than include manufacturers of equipment.

After agreement is reached on the requirements, the draft standard should be submitted for comment to the individual members of the industry associations to assure that no requirements have inadvertantly been overlooked. Subsequent to this review manufacturers and test organizations should be invited to review the document and to draft the test methods and procedures for the standard.

.This effort should be begun as soon as possible, since the process of preparing a draft standard that has broad industry input is of necessity a slow one. Figure 5 shows the proposed tasks and a Lead Time Chart for accomplishing the work.

6.3 PROTOTYPE DEVELOPMENT AND DEMONSTRATION OF CONTAINER AND CHASSIS

6.3.1 Prototype Development

The general characteristics of freight containers and chassis can be synthesized from past experience; light weight, abrasion and puncture resistance maintainability and weatherproofness being among some of the more important characteristics. Manufacturers of such equipment, as well as potential new entrants into the field, such as airframe manufacturers, are known to have expressed an interest in participating in developing new designs.

We recommend that the Department of Transportation invite the broadest possible industry participation by soliciting proposals for construction of prototype containers and chassis, possibly on a cost-sharing basis. Although a new container standard may change some of the basic requirements for containers, new materials and concepts can be tested by building prototypes to current ANSI standards, thus allowing for immediate demonstration of the prototypes in actual service.

The request for proposals should make it clear that consideration will be given to new and innovative ideas, and that the proprietary rights of the participants will be safeguarded.

Since government funding for such prototypes is likely to be limited, the Department of Transportation will have to screen the proposals to decide where government funds should be applied, it being understood that anyone desiring to do so may participate on their own. Further, DOT supervision of the program is required to assure compatibility; it may well be that a new chassis of one company may be integrated with a new concept of container from a second company.

The Department of Transportation should also take the lead in making participants in the program aware of the legal requirements, such as the Convention on Safe Containers, that the prototypes must meet.

6.3.2 Demonstration Phase

As part of its contribution to the effort, the Department of Transportation should use its good offices to assure adequate demonstration of the prototypes in intermodal and modal use. This should include:

TASK	MONTH													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Analysis of Present Standards	■	■												
Preparation of Draft Standard		■	■											
Industry Association Review				■	■	■								
Industry Comment							■	■	■	■				
Manufacturer's and Test Organization's Review											■	■		
Proposed Draft Standard													■	■

Figure 5. DOMESTIC CONTAINER PERFORMANCE STANDARD

TASKS AND SCHEDULE

a) Assuring that operators of equipment will use the equipment in regular intermodal and unimodal service.

b) Periodic inspection of, and evaluation of, the equipment in service.

c) Notification to the manufacturers of damages to equipment that may require more than field repair.

d) Access to any information that may be developed that will assist the manufacturer in improving his equipment.

6.3.3 Schedule

The prototype development, as well as the demonstration project, can be performed concurrently with the development of a new container standard, since the time frame to accomplish the two projects is roughly equal. Figure 6 shows the proposed tasks and schedule.

6.4 INTERMODAL TERMINAL DESIGN

The design of intermodal terminals must consider not only the transfer mechanisms to be used, but also the operating system to be employed. In turn, an intermodal terminal design must consider also the intramodal needs; for example, rail/highway terminal mechanization must be compatible with rail to rail transfer operations.

Although the principal terminal mode is rail/highway, the intermodal terminal study must also address the needs of the marine and air modes.

The determination of valid criteria for terminals is the first task to be accomplished. Very frequently, terminal criteria are not stated with sufficient precision. For example, to achieve rapid service time, words such as "flexiblity", "accessibility", and "random access" are often used. Criteria for evaluation of these attributes must be expressed in more specific terms, such as "Tranfer of containers from highway to rail in two minutes, 80 percent of the time, in three minutes 90 percent, and within five minutes 100 percent of the time".

Criteria for other factors, such as land use, and line haul equipment utilization, must also be developed in specific terms since it has been shown that these are the principal components of terminal costs.

Since intermodal terminals will not all be of the same size the study must address the differences in throughput, the suitability of converting existing railroad team track facilities at reasonable cost to intermodal facilities, and the impact of location of terminals on overall transportation cost.

It is recommended that this program be conducted in two distinct phases. Phase I is a preliminary study phase, in which the criteria are developed and a survey of existing facilities is made. The latter is important since it is unrealistic to design systems that require wholesale obsolescence of existing facilities.

TASK	MONTH																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Prepare RFP	■																	
Review Proposals				■														
Award Contracts or Cooperative Agreements					■													
Prototype Construction						■	■	■	■	■	■							
Demonstration and Test Planning									■	■	■							
Demonstration and Test												■	■	■	■	■	■	
Evaluation																■	■	■

Figure 6. PROTOTYPE DEVELOPMENT AND DEMONSTRATION OF CONTAINERS AND CHASSIS

TASKS AND SCHEDULE

Phase II is subdivided into several tasks. The first of these is to develop hardware and operating requirements for terminals of several different throughput ranges. Secondly, specific sites should be chosen from among those identified earlier where the impact of the new systems can be tested and evaluated over a sufficiently long period of time to validate the new systems. Ideally, terminals of similar characteristics would be paired in order to have a control terminal. An example of such pairing might be both ends of a single trade lane, such as the 'Sprint' system at Chicago and Minneapolis.

Figure 7 shows the proposed tasks and schedule.

6.5 EQUIPMENT CONTROL AND INSPECTION PROCEDURES

Intermodal use of equipment requires that means are provided both for the physical control of equipment and for financial accounting purposes. When physical control passes from one carrier to another, inspection procedures must be provided to establish responsibility for damage, if any, and also to assure that the equipment, and its lading, are suitable for carriage by the receiving mode.

One important feature that is necessary to make maximum use of a container system is the ability to locate empty equipment and to dispatch it for loading with a minimum of empty movement.

An additional desirable feature of a control system is that it permits tracing of a shipment while under the control of a specific carrier.

The use of computers to maintain a record of transaction is well known; the major problem has been the accurate input of accurate and complete information. To implement a truly intermodal system the various modes engaged in domestic transportation must agree on:

a) marking of equipment for identification

b) information required by each mode at time of interchange. This may include a description of the load, as well as the equipment itself.

The problem is compounded in intermodal moves since, at the initial transfer between mode A and B, it may not be known whether or not a further mode C will be involved. Unless the necessary information is transmitted to mode B at initial transfer, the information may not be available at the subsequent transfer.

The key to solving this problem is to establish the definitive requirements, and then to address the implementation separately. To this end, we recommend that a study be undertaken to:

a) Identify the minimum information needs of each mode, including information required to meet legal requirements.

b) Identify existing unimodal information systems in place, or in the planning and implementation stages.

TASK	MONTH																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Determine Operating Requirements and Establish Criteria	■	■	■															
Survey of Existing Facilities		■	■															
Develop Hardware and Operational Concepts				■	■	■	■											
Demonstration & Test Planning						■	■											
Demonstration & Test								■	■	■	■	■	■	■	■	■		
Evaluation															■	■	■	■

Figure 7. INTERMODAL TERMINAL DESIGN

TASKS AND SCHEDULE

c) Detail the mandatory and optional information requirements of an intermodal system.

d) Review of the Requirements Statement for review by the industry groups affected.

e) Prepare an implementation plan for the system.

Figure 8 shows the proposed tasks and schedule.

6.6 EVALUATION OF FOREIGN OPERATING EXPERIENCE

Many European countries have considerably greater intermodal operations than the United States. To a great degree this is due to nationalized rail systems, which have forced intermodal operations on the transport system.

The technology employed is essentially identical to that used in the United States. Operating philosophies differ greatly, however. In most cases the systems claim profitable operations in relatively short mileage hauls, which is approximately a 250 mile line haul.

A thorough financial evaluation of these systems, such as the British "Freightliner", to identify the impact of operating philosophies on return on investment, is needed in order to test the applicability of foreign operating techniques to U.S. domestic freight systems.

Figure 9 shows the proposed tasks and schedule.

TASK	MONTH															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Identify Information Requirements of Modes	▨	▨	▨	▨												
Assess Existing Unimodal Systems				▨	▨	▨	▨									
Establish Mandatory and Optional Requirements of an Intermodal System						▨	▨	▨	▨							
Requirements Statement Review by Industry										▨	▨	▨				
Establish Implementation Plan													▨	▨	▨	▨

Figure 8. EQUIPMENT CONTROL AND INSPECTION PROCEDURES

TASKS AND SCHEDULE

TASK	MONTH											
	1	2	3	4	5	6	7	8	9	10	11	12
Select Three Systems for Evaluation	▨	▨										
Detail Operating Philosophies and Techniques		▨	▨	▨								
Obtain Available Service Time, Cost and Financial Data				▨	▨	▨	▨					
Establish Additional Data Required by Field Observation						▨	▨	▨	▨	▨		
Evaluate Applicability to U.S. Operations									▨	▨	▨	▨

Figure 9. EVALUATION OF FOREIGN OPERATING EXPERIENCE

TASKS AND SCHEDULE

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