NCHRP PROJECT 8-42

Rail Freight Solutions to Roadway Congestion

Interim Report on Transportation Trends, Road-to-Rail Diversion and Model Elements for Decision-Making
(Task 3-4-5-6 Report)

DRAFT

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CONTENTS

Chapter 1: Background and Introduction

1.1 BACKGROUND

1.1.1 Context: Progress to Date - This document is an interim report in NCHRP Study 8-42, which is examining how rail freight solutions may be identified and used to help address road congestion. It is one of a series of ongoing reports on various tasks conducted as part of this study. For purposes of clarity in presentation, findings from the various tasks are being reported in terms of logical groupings rather than in their original task number order. The project status to date is as follows:

- Earlier reports had focused on describing current experience: Literature Review (Task 1), Case Studies (Task 2) and Current Practices & Policies (Task 7).

- This document focuses on identifying key issues and tools to address them: Underlying Trends Affecting Freight Movement (Task 4), Road-to-Rail Diversion Constraints and Impacts (Task 3), and Analytic Tools to Assess Decision Choices (Task 5).

- It concludes by outlining the elements of a Basic Framework for Public Decision-Making, building upon earlier Task 1-2-7 results and new Task 3-4-5 results. As such, it effectively represents the draft Task 6 interim report.

- Future documents will focus on additional analytic elements for decision-making: Review of Best Practices (Task 8), Decision-Making Model (Task 9), Data Sources (Task 10), Guidebook (Task 11) and Implementation Strategies (Task 11).

After receiving comments by the review committee on findings from each task, the project team will compile information from all of the tasks, make additional refinements as needed, and then prepare a final report, describing the study findings and the resulting guidebook and decision-making model.

Interpreting this Report: This and other interim reports are intended as private communications between the Project Team and the Review Committee. They are intended to show progress to date towards shaping the ultimate study product, and they are intended to elicit comments on how findings to date can be best used to enhance the nature of that final product. These interim task reports are not designed to be stand-alone studies. Rather, they are all designed to focus on illuminating key elements and factors to be considered in development of the final decision-making guide and model.

1.2 OVERVIEW

1.2.1 Perspectives and Issues to be Considered in a Decision-Making Model - The growing challenge of road congestion, and the related issue of transportation capacity, make it important to understand *when* public planners should widen their focus from the construction and management of the roads themselves, to the active consideration of multi-modal solutions. The public interest, and especially the possibility of public investment, can also potentially change the considerations, priorities and alternatives of private rail planners as they select their markets and design their services. For both parties with their different objectives, the question is this: When is public investment in freight rail most promising, because the challenges are addressable and the potential for rail is realistic?

The following chapters shed light on this fundamental question from three perspectives:

- What are the situations in which multimodal planning is most useful?
- What are the conditions in which railroad solutions most probably bear fruit?
- What are the trends that shape prospects for railroad carriage of freight?

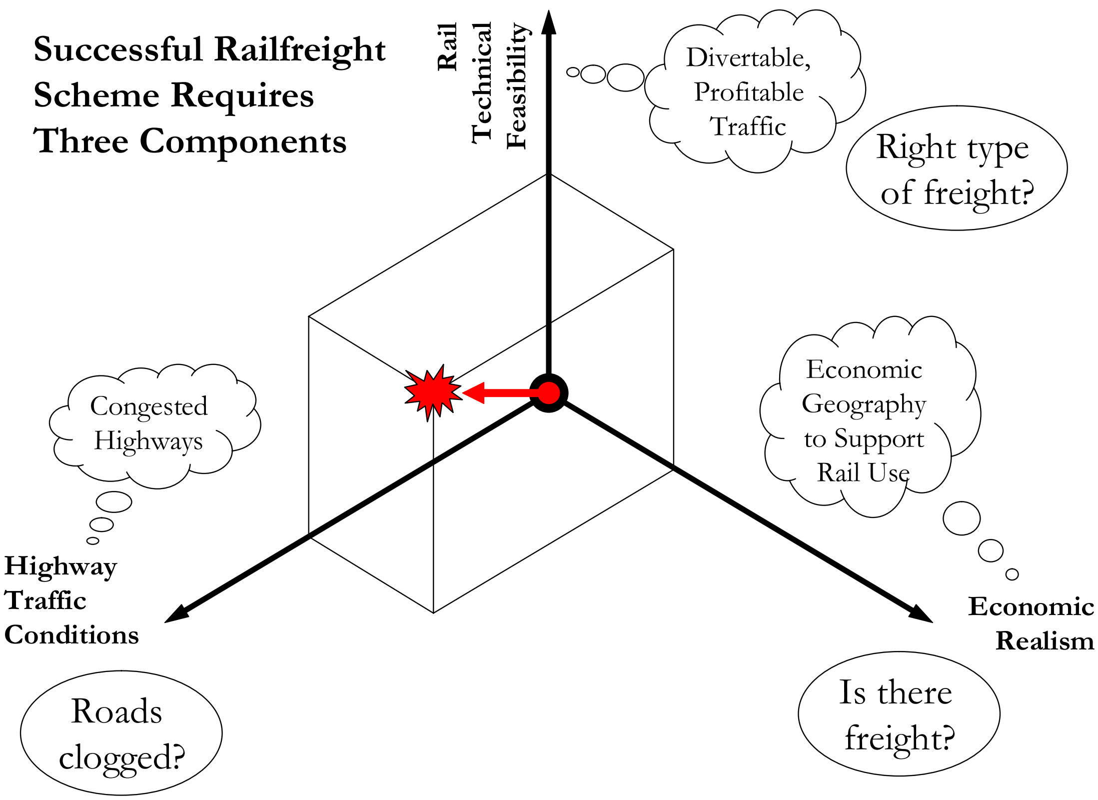
These perspectives will be presented in reverse order. The initial chapter (corresponding to Task 4 in the Scope of Work) reviews important economic and transportation trends that are shifting the nature of opportunities to promote rail freight solutions. The second chapter (corresponding to Task 3) takes up the issue of diversion between the rail and highway modes, investigating the circumstances and constraints that affect its success, and the social impacts when it occurs. The third chapter (corresponding to Task 5) classifies the occasions when rail should be considered among public program options, and identifies needed elements for evaluating alternatives and assessing their feasibility.

All three of the chapters, in fact, converge on the matter of feasibility: are the trends advantageous for rail? (Chapter 2); can diversion to rail make sense for private business? (Chapter 3); is rail an appropriate and sound solution for all parties involved? (Chapter 4).

There are common threads running through the series of analyses, and they can be translated through different lenses. For example, economic factors should be differentiated by industry or commodity, which in turn relate to categories of transportation equipment and service. Similarly, travel distance is a function of business location and supply chain trends, is an important determinant of competitive modal economics, and can affect rail financial productivity in such a way that beneficial and profitable projects may not attract private capital. The culminating purpose of this sequence of chapters is to suggest to planners public and private, when they should move from familiar solutions to the less familiar sphere of public/private cooperation, because they will be able to establish that a realistic potential exists in that sphere for rail.

This structure is illustrated in the accompanying diagram, which identifies the three dimensional nature of feasibility. The three dimensions are: (1) Highway Traffic Conditions, (2) Rail Technical Feasibility and (3) Economic Realism. Together, these three dimensions establish when there is a traffic congestion problem with rail freight as a potentially feasible solution.

This diagram emphasizes the transition in the final chapter to evaluative techniques. This serves the additional purpose of preparing the way for the final step in this first phase of research: the preliminary outline of models and principles of guidance, which will be explored and developed as the product of the second phase.



Chapter 2: Underlying Trends in Freight Movement (Task 4)

2.1 OVERVIEW OF TRENDS DISCUSSION

2.1.1 Objective - This chapter is a re-distillation of the trends analysis for Task 4. In the context of this report, it is focused on a single straightforward objective – to summarize key transportation and economic trends that affect the nature of roadway congestion and potential opportunities for using rail freight as a solution to that problem. Since this need to address congestion and the opportunity to use rail freight is already presumed in the justification for this very study, informed transportation planners may consider many of these trends to be self-evident. However, the priority that politicians and decision-makers may give to rail freight solutions will in fact be driven by our first establishing the strength of the case that: (a) congestion is a growing problem, (b) it is changing in its nature due to shifting economic and land development trends, and (c) rail freight can sometimes be part of the solution.

2.1.2 Organization - Accordingly, this Task 4 report is organized in terms of five additional sections:

- Section 2.2 – *Congestion Cost Trends*. This section documents the fact that growing traffic levels are leading to increasing road congestion problems. In addition, rising transportation labor costs are exacerbating the costs of congestion delay to shippers. These factors help to justify increased public attention to the business costs of congestion and the need for solutions that reduce those costs in the future.

- Section 2.3 – *Role of Trucks in Congestion*. This section provides summary data illustrating the fact that truck traffic is a major contributor to overall roadway traffic. As more and more roadways approach full capacity, the incremental impact of trucks on congestion delays is also rising. These facts help to explain the need for attention to trucks as an increasingly important part of the congestion problem, and thus an important part of its solution.

- Section 2.4 – *Growth in Freight Activity Levels*. This section examines how changes in the US economy are increasing freight volumes but particularly for small size, shorter distance and higher value shipments. These trends are useful to highlight, since the feasibility of rail freight alternatives to truck shipments also vary systematically by distance, commodity value/weight ratio and ultimate destination. Freight diversion and public investment decision models, discussed later in this interim report, will build upon this type of information.

- Section 2.5 – *Business Location and Land Development*. This section examines how business location and urban land development patterns are systematically moving towards a dispersion of activities that tends to favor highway shipping and disfavor rail shipping. This helps to explain what is already known – that truck is growing faster than rail as a mode for freight movements. However, this information has further use, for it also helps to establish a basis for determining the situations under which rail can (or cannot) be a potentially feasible alternative to truck for freight movements.

- Section 2.6 – *Technology Trends*. This section outlines key aspects of technological change affecting the feasibility and cost-effectiveness of both rail and truck to serve freight movements. There is still much debate in the industry over which technologies will blossom in the years to come, so this discussion is focused on documenting what is now occurring and how potential future changes may affect future tradeoffs among rail and truck to move freight in some congested areas and corridors.

2.1.3 Perspective - It is important to place this Task 4 report in the proper perspective. It is intended to provide a collection of information that can be cited as references in other Task reports -- as a basis for evaluating needs and opportunities for alternative solutions. The facts outlined in this report specifically serve to help justify the Task 3 classification of diversion impacts and the Task 5 evaluation of alternative model approaches. They will also help to ensure selection of representative types of cases for both the Task 7 review of current practices/ barriers and the Task 8 review of public-private partnerships.

Altogether, the six sections of this chapter illustrate the need for a model framework that can evaluate rail and truck freight tradeoffs to address roadway congestion, building upon screening processes to distinguish freight demand and supply solutions by: (a) type of area and distance, (b) size/type of freight, and (c) type of existing service routes and access facilities.

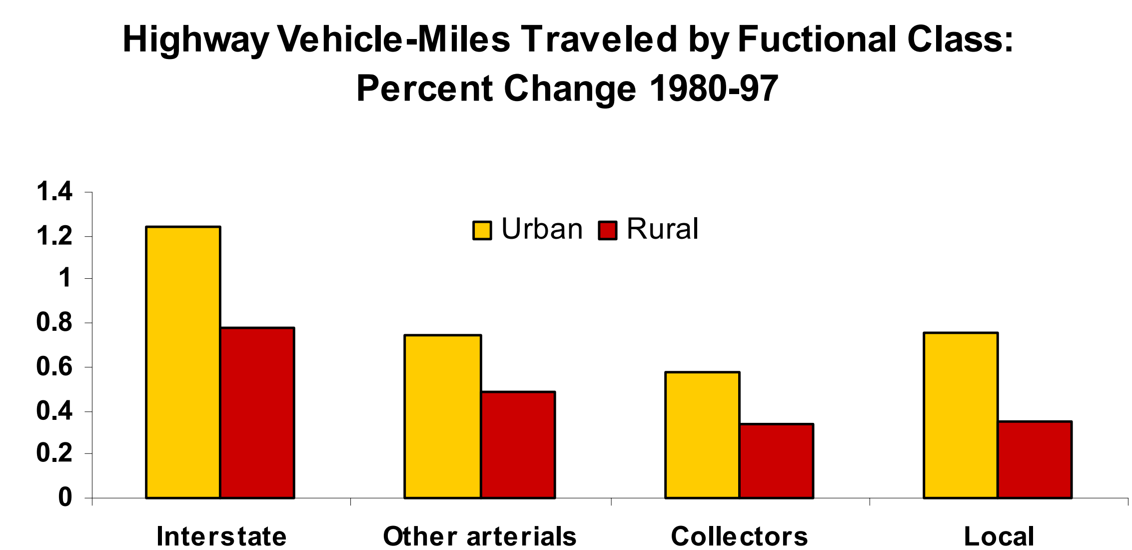
Note on Freight Data Sources: All attempts have been made to present the data up to the most recent year. However, some of the national estimates of freight shipment characteristics presented in this report are based on Commodity Flow Surveys (CFS), conducted by the Bureau of Transportation Statistics and the Census Bureau every five years. Conducted first in 1992 and then in 1997, the CFS is the nation's primary and most comprehensive federal data source on domestic freight movement. Earlier commodity surveys were conducted between 1962 and 1982, but data for 1982 were not published. No data were collected for 1987. In December 2003, a preliminary report on CFS 2002 was published. Final CFS data is still coming, so some of the traffic and commodity flow trends shown here only go through 1997. Nevertheless, these variations in data availability do not affect the nature of validity of the trends illustrated here.

2.2 CONGESTION COST TRENDS

This section provides summary data illustrating the key fact that traffic demand is growing and leading to increasing road congestion over time. Additional factors are also increasing the economic stakes, in terms of the unit cost of congestion delay to shippers. While these facts may seem obvious to informed transportation planners, the depth and breadth of this growing problem is not universally known to all public decision-makers. Yet, an appreciation of the problem is a necessary first step for even considering the investment of time in exploring multi-modal solutions and public-private cooperation.

2.2.1 Road Travel Demand Continues to Increase - Total vehicle-miles traveled (VMT) on public roads has continued to grow. It increased 68% between 1980 and 1997. The urban VMT growth (83%) outpaced rural VMT growth (49%) over this period, which is a reflection of population shift from rural to urban areas. (See Chart 2-1.)

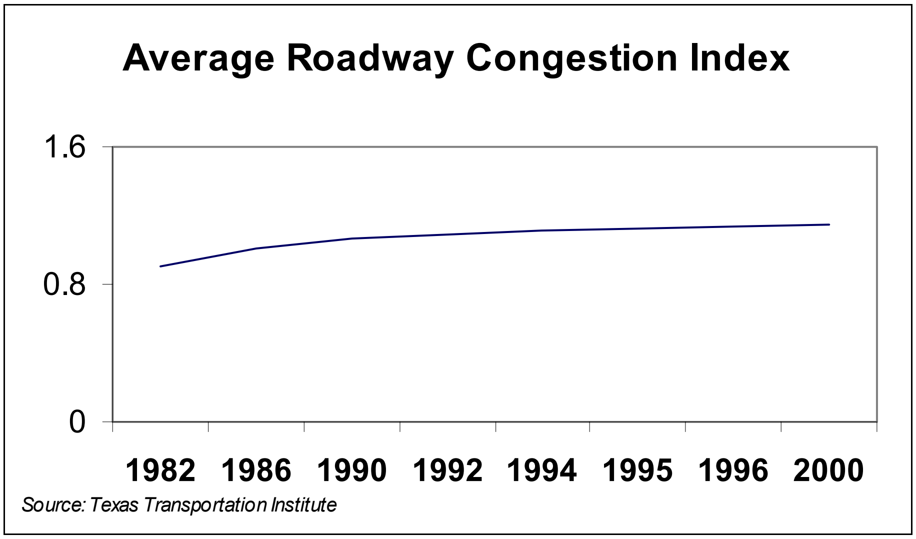
Chart 2-1



Source: U.S. Department of Transportation, Federal Highway Administration, Highway Statistics

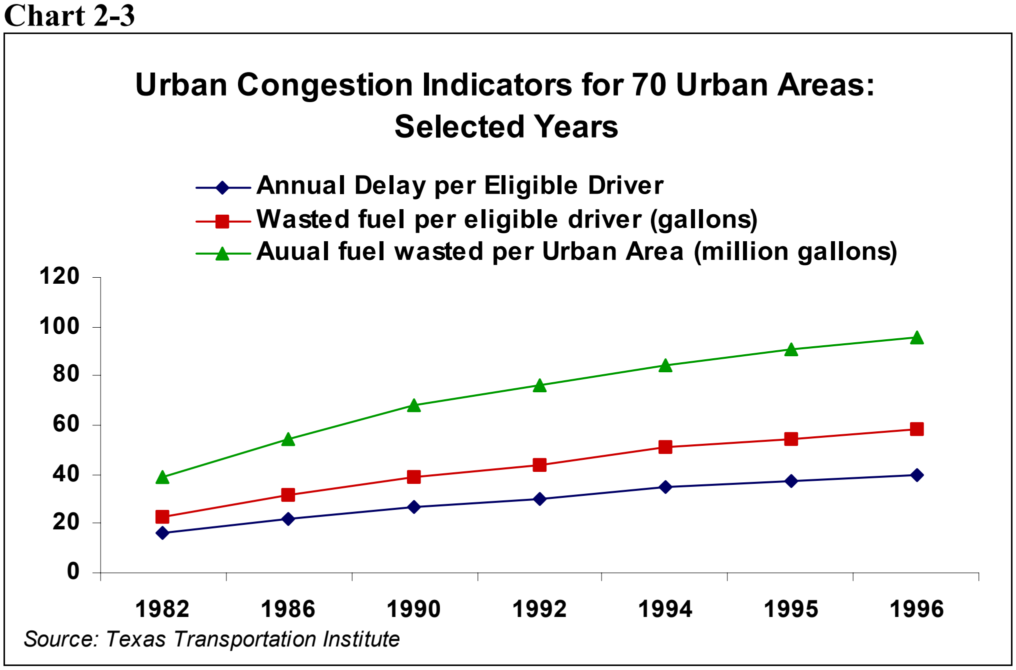
2.2.2 Rising Congestion as Supply Does Not Keep Up with Demand - According to the Texas Transportation Institute's (TTI) annual report, the average highway congestion index (measured by volume per road lane) has been steadily rising over time. It increased 25% between 1982 (average value of .91) and the year 2000 (average value of 1.15). (See Chart 2-2.)

Chart 2-2



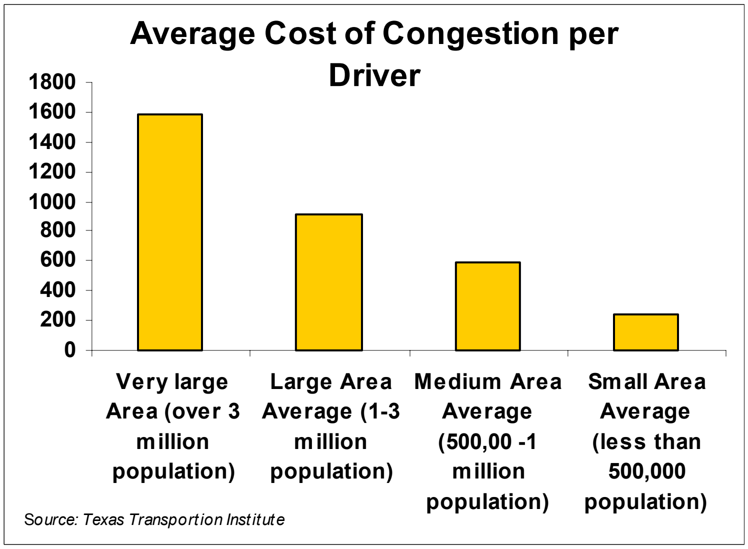
Urban highway congestion and traffic delay in the US is particularly rising. According to the urban congestion indicators for 70 urban areas compiled by TTI, drivers experienced an average 40 hours of delay in 1996. This was 8% more than in 1990, and 150% more than in 1982. (See Chart 2-3.)

Chart 2-3



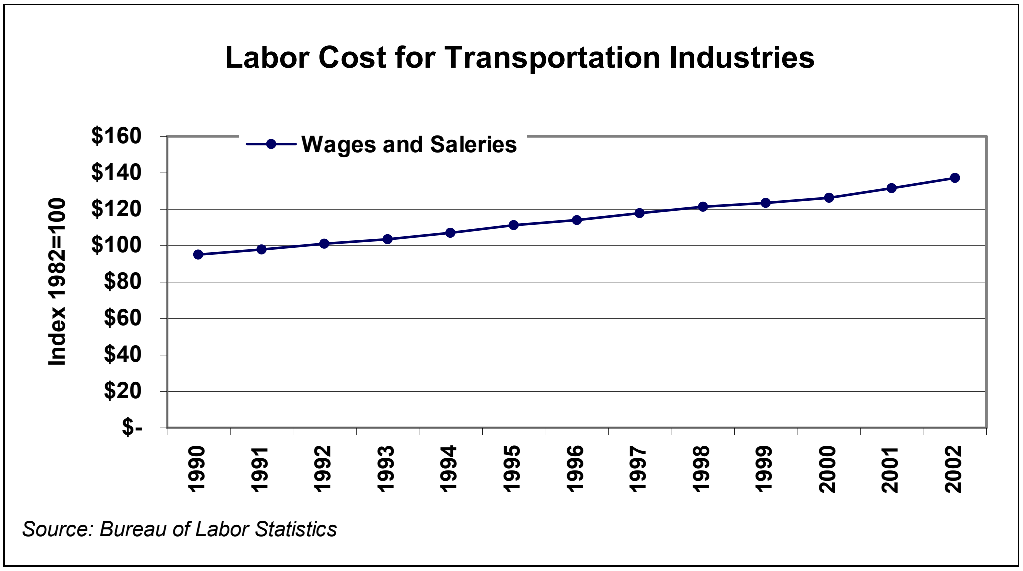
2.2.3 Rising Cost of Congestion - The TTI study estimated that, the total annual cost of congestion in 75 urban areas reached $67.5 billion by the year 2000. That value is estimated to include $58.5 billion due to time delay (labor productivity loss) and $9 billion due to wasted fuel. Average costs of congestion ranged from $595 per driver in smaller cities to $ 1,590 in large cities. (See Chart 2-4.)

Chart 2-4



Even after adjusting for inflation, the unit cost of labor in transportation industries has continued to grow. Between 1990 and 2002, transportation labor costs increased by 47% (Chart 2-5). In trucking operations, driver wages constitute about 30-50% of the costs of trucking operations. Altogether, this means that the unit cost of truck driver time delay is continuing to rise, making the total business cost of congestion rise even faster than the growth in congestion time delay.

Chart 2-5



2.2.4 Increasing Breadth of Congestion - Traffic congestion is expanding to more communities and inter-city corridors across the US. The two charts that follow were developed by Batelle Memorial Institute from FHWA data, and they show the geographic breadth of highways that are over-capacity (shown in red) and approaching full capacity (shown in blue), for both 1998 conditions and forecast 2020 conditions. The growth of congestion among inter-city corridors is particularly striking.

Chart 2-6 Total Traffic and Congested Segments (Shown in Red and Blue) -- 1998

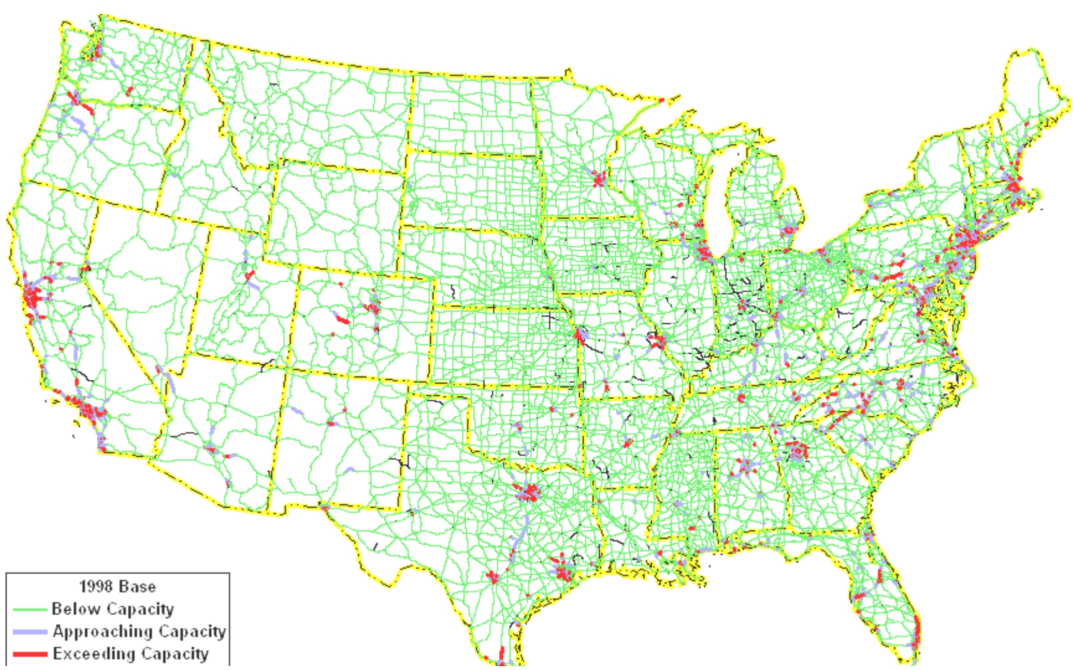
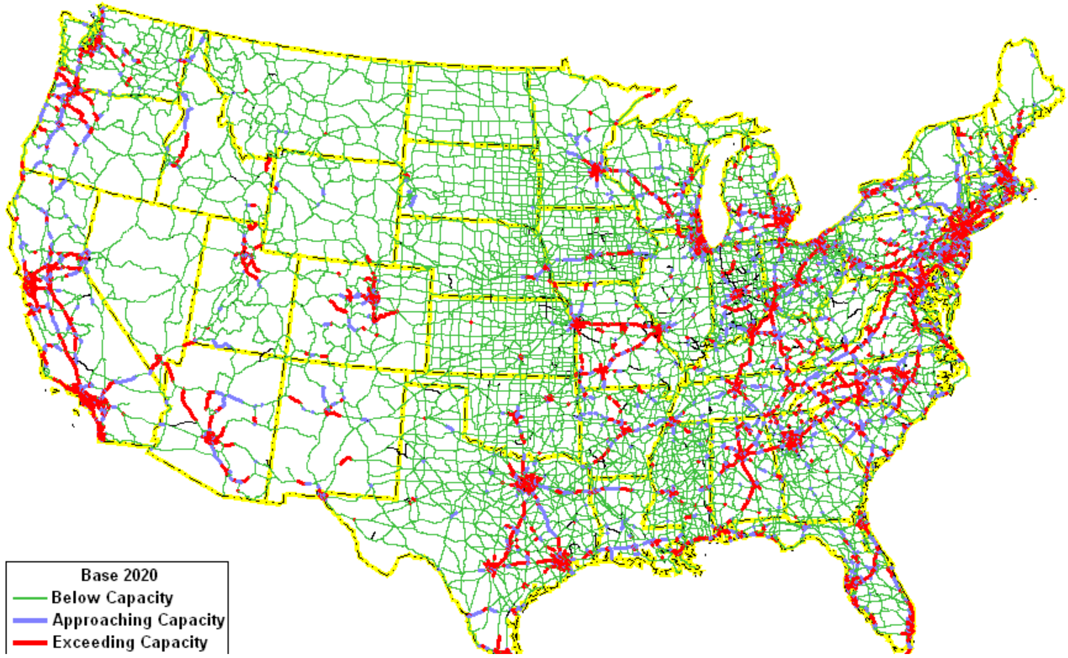


Chart 2-7 Total Traffic and Congested Segments (Shown in Red and Blue) – Forecast 2020



2.3 ROLE OF TRUCKS IN CONGESTION

This section provides summary data illustrating the fact that truck traffic is a major contributor to overall roadway traffic, in addition to passenger cars. As more and more roadways approach full capacity, the incremental impact of trucks on congestion delays is also rising. Again, many of these facts are well known to informed transportation planners, but public decision-makers can sometimes consider congestion to be largely a problem of nuisance among rush-hour commuters. It is therefore important to help public decision-makers to understand the critical role that trucks and freight flow patterns can play as part of the congestion problem and also its solution.

2.3.1 High Volume Truck Routes - Chart 2-8 shows data from FHWA's Freight Analysis Framework, showing that the portion of national highway segments with over 10,000 trucks is forecast to rise dramatically between 1998 and 2020, for both urban and rural segments of the Interstate Highway System (IS) and the rest of the National Highway System (NHS).

Chart 2-8 Percentage of National Highway Segments with Over 10,000 Trucks (Comparison of 1998 to 2020)

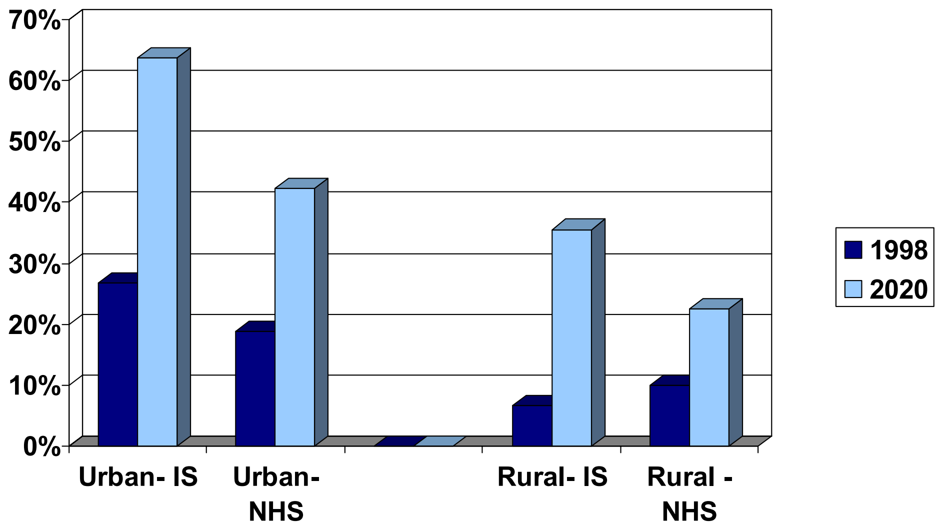
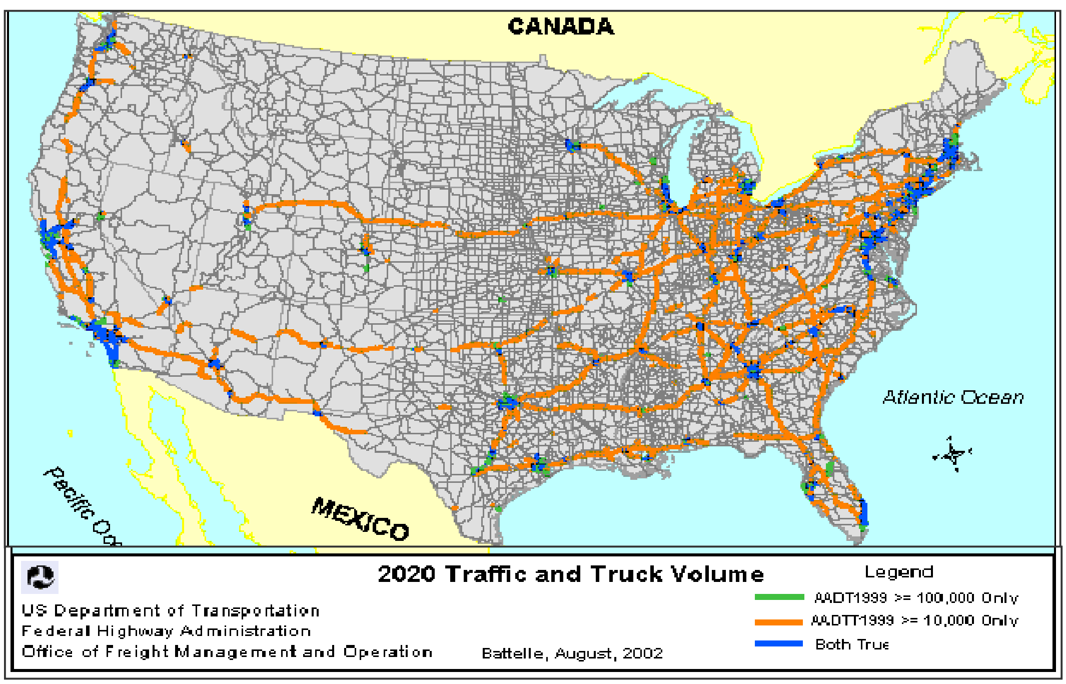


Chart 2-9 shows that a large and growing amount of highway mileage in the US is forecast to have *both* high total traffic levels (average total daily traffic over 100,000 vehicles) and high truck volumes (average daily truck traffic over 10,000 trucks). These segments are located among many inter-city corridors all across the nation, as shown in the map.

Chart 2-9 Highway segments with high traffic & truck volume – 2020



2.3.2 Truck Contribution to Total Congestion - When trucks are added to other traffic on the NHS, the percentage of highway miles that either approaches capacity or exceeds capacity doubles. This is true for current conditions (1998 values) and it remains true as congestion is forecast to grow over time (through 2010, and 2020 forecasts). (See Chart 2-10.)

Chart 2-10 Mileage and Portion of Road System that is Under Capacity, Approaching Capacity and Over-Capacity (Current and Forecast Future)

V/C Ratio	1998 NHS Mileage (%)		2010 NHS Mileage (%)		2020 NHS Mileage (%)	
	No Trucks	All Traffic	No Trucks	All Traffic	No Trucks	All Traffic
v/c < 0.8	151,457 (95.7%)	145,969 (92.2%)	144,792 (91.5%)	131,203 (82.9%)	139,933 (88.4%)	118,839 (75.1%)
0.8 < v/c <1.0 (Approaching)	3,731 (2.4%)	6,577 (4.2%)	5,707 (3.6%)	11,940 (7.5%)	7,078 (4.5%)	14,849 (9.4%)
v/c > 1.0 (Over capacity)	3,076 (1.9%)	5,716 (3.6%)	7,764 (4.9%)	15,120 (9.6%)	11,253 (7.1%)	24,576 (15.5%)

This effect becomes even more dramatic when viewed cartographically. Charts 2-11 and 2-12 map the depth and breadth of rising congestion, when forecast truck traffic levels are added to forecast car traffic levels.

Chart 2-11 2020 Congestion without Trucks

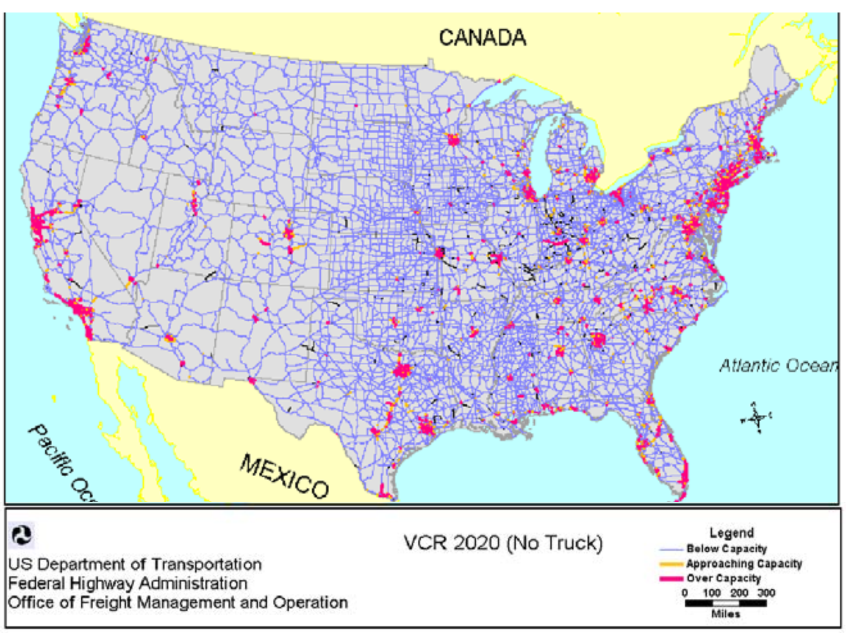
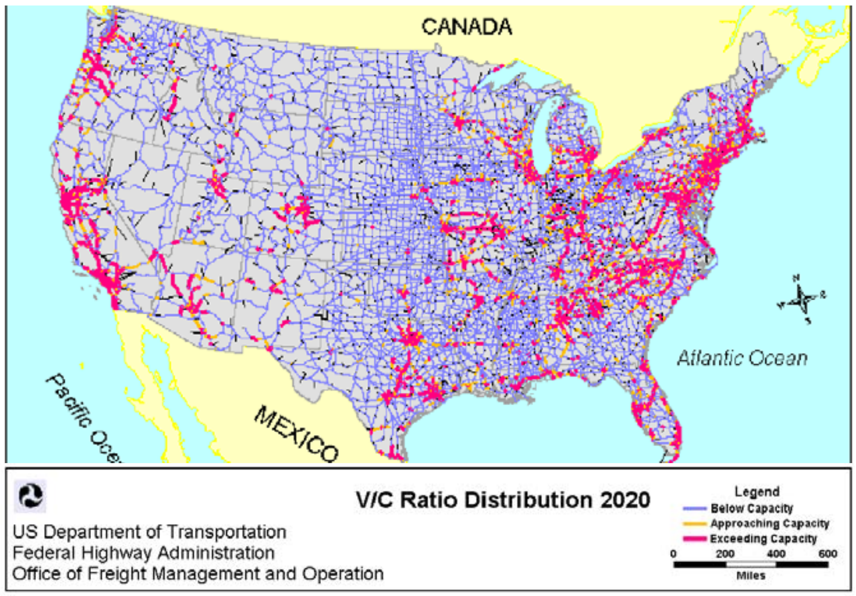


Chart 2-12 2020 Congestion with Trucks Added



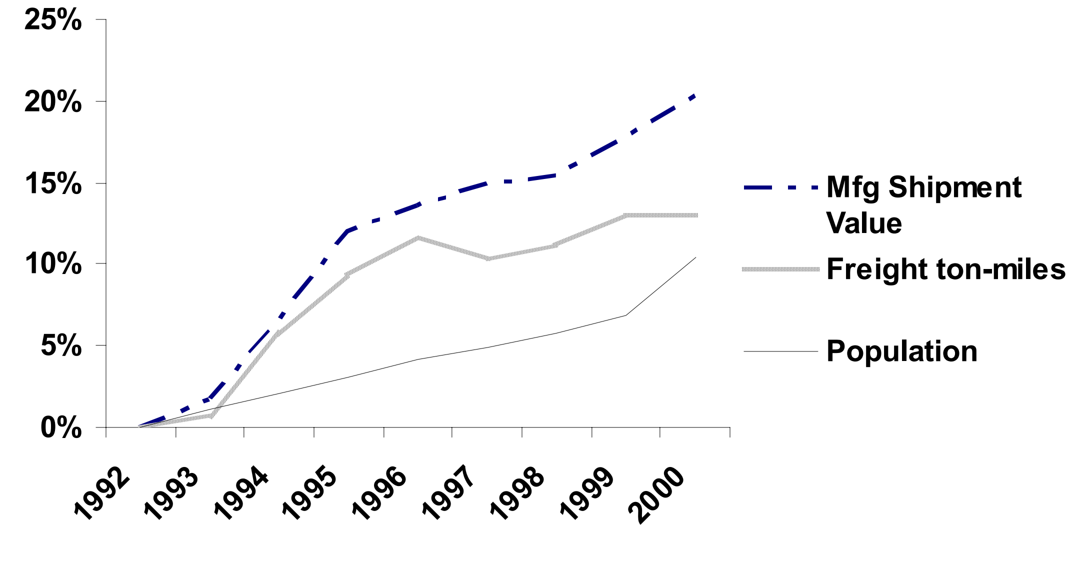
2.4 GROWTH IN FREIGHT ACTIVITY LEVELS

This section examines how change in the US economy is leading to continued growth in freight volumes, and also focusing that growth on smaller size, shorter distance and higher value shipments. These trends are useful to highlight, since the feasibility of rail freight alternatives to truck shipments also vary systematically by distance, commodity value/weight ratio and ultimate destination. Freight diversion and public investment decision models, discussed in later chapters of this interim report, build upon this type of information.

2.4.1 Rates of Freight Growth - In general, population growth and economic activity growth are commonly viewed as key factors determining freight demand growth. However, with much news about the loss of manufacturing jobs in the US, there is a common belief as well that freight output also is declining. All of these beliefs are wrong, as freight value and volume continues to grow at rates exceeding population growth. While population increased 9% between 1990 and 2000, total employment increased 18% due to a robust service economy. During this same period, freight ton-miles increased 19% and the value of manufacturing shipments increased 38% after controlling for inflation. Sales by the manufacturing sector, wholesale sector, and retail trade sector grew (in constant dollars) by 38%, 57% and 70%, respectively.

Chart 2-13 illustrates the key relationship between manufacturing value of output, freight tons and population growth.

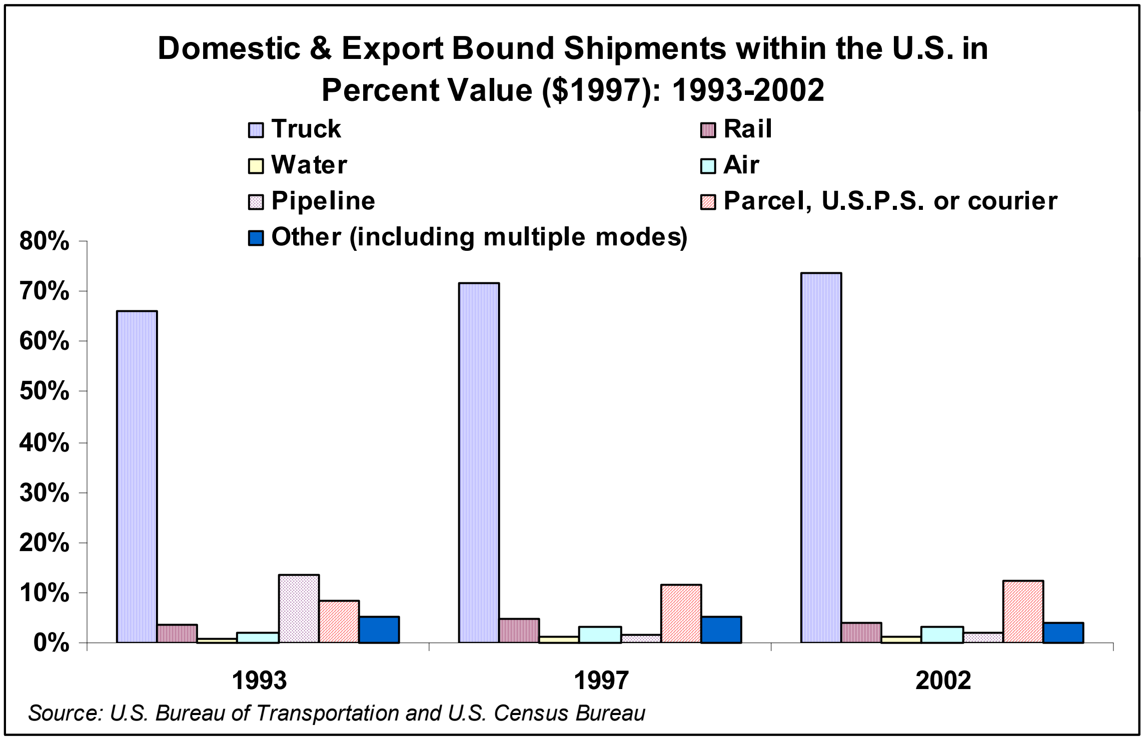
Chart 2-13 Growth in Shipment Value and Ton-Miles, Compared to Population Growth



Source: Ton-Miles: Bureau of Transportation Statistics, Transportation Statistics Annual Report 2001; Population: U.S. Department of Commerce, Census Bureau, Statistical Abstract of the United States, 2000, table 2; Manufacturing: US Census Bureau, Annual Surveys of Manufactures 2001.

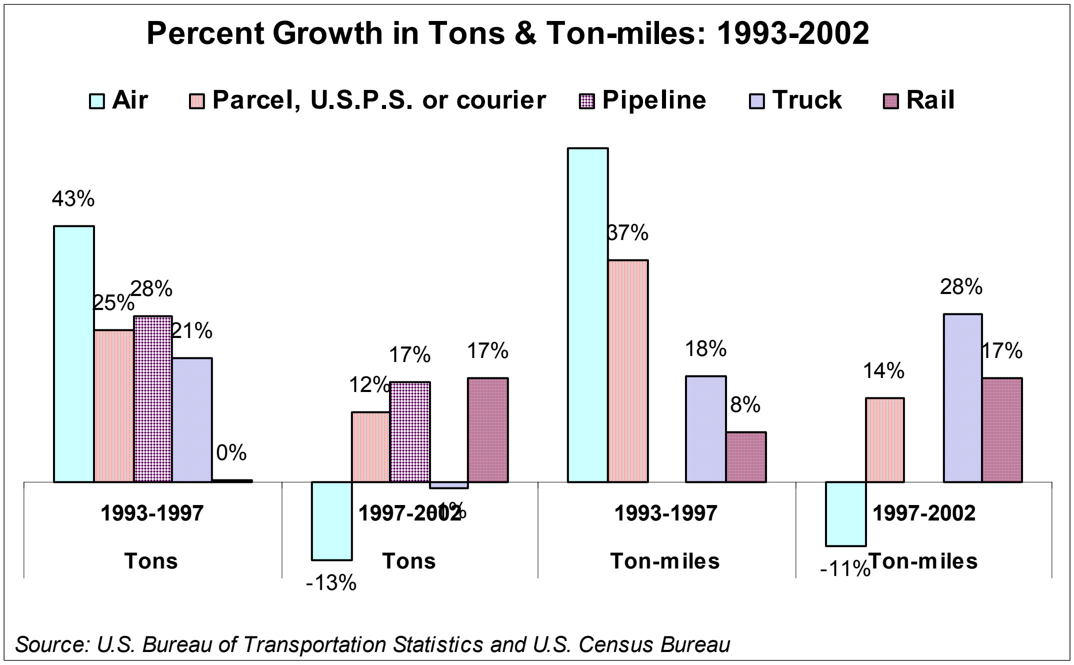
2.4.2 Mode Shifts - Trucks account for the vast majority (well over two-thirds) of the total value of all shipments in the US, as illustrated in Chart 2-14. In fact, this dominant share held by trucking has continued to grow over the ten-year period from 1993 to 2002.

Chart 2-14



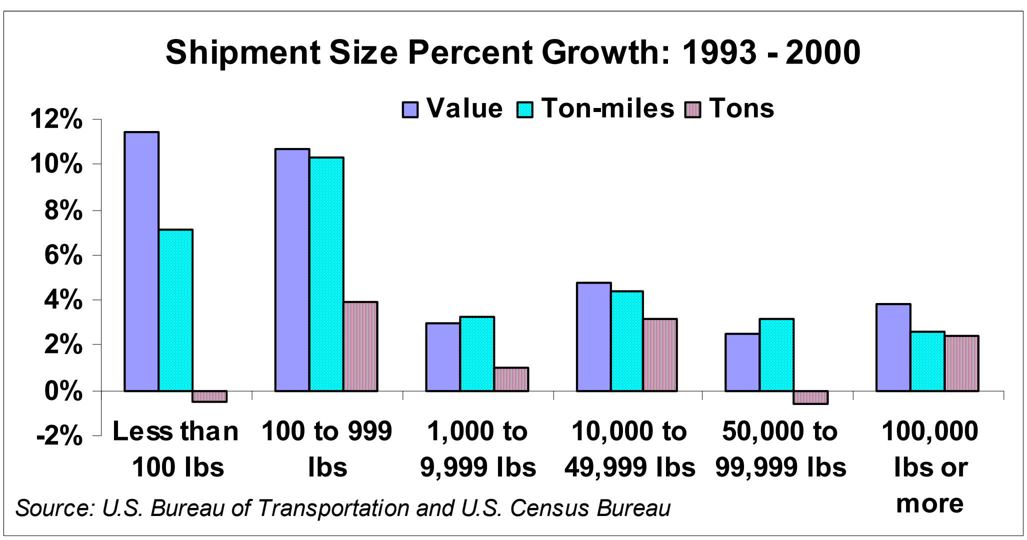
A detailed analysis of changes in freight shipments over the ten-year period from 1993 to 2002 shows a continuing pattern of differential growth by transport mode. Chart 2-15 shows the percentage growth in tons and in ton-miles, by mode, for the first and second halves of this period. During the 1993-1997 period, it shows that Air, Post/Courier, and Truck shipments all experienced significant (21% to 43%) growth in tons from 1993 – 1997, and all also experienced growth in ton-miles (18% to over 50%) during this period. Rail shipments also grew in ton-miles and pipeline shipments grew in tons during this same period. During 1997-2002, freight shipment growth was generally slower for all modes and in particular negative for the air mode following the 9/11 calamity, security restrictions, and an economic downturn. In contrast, rail shipments experienced more growth in tons and ton-miles during this latter period. This chart is useful because it shows how each mode's growth patterns change differently over time.

Chart 2-15



2.4.3 Shipment Value and Weight - Over this same ten-year period, there has been a continuing trend towards growth of higher value, lower weight and longer distance freight shipments. Chart 2-16 shows the growth in freight shipments among different weight classes. When measured in terms of either *total value* or *ton-miles*, the rate of growth was greatest in the lower two weight classes. In most weight classes, there was faster growth in value than in tons or ton-miles, implying a shift towards higher value shipments. In all weight classes, there was also faster growth in ton-miles than in total tons, implying a shift towards longer average distance for freight movements.

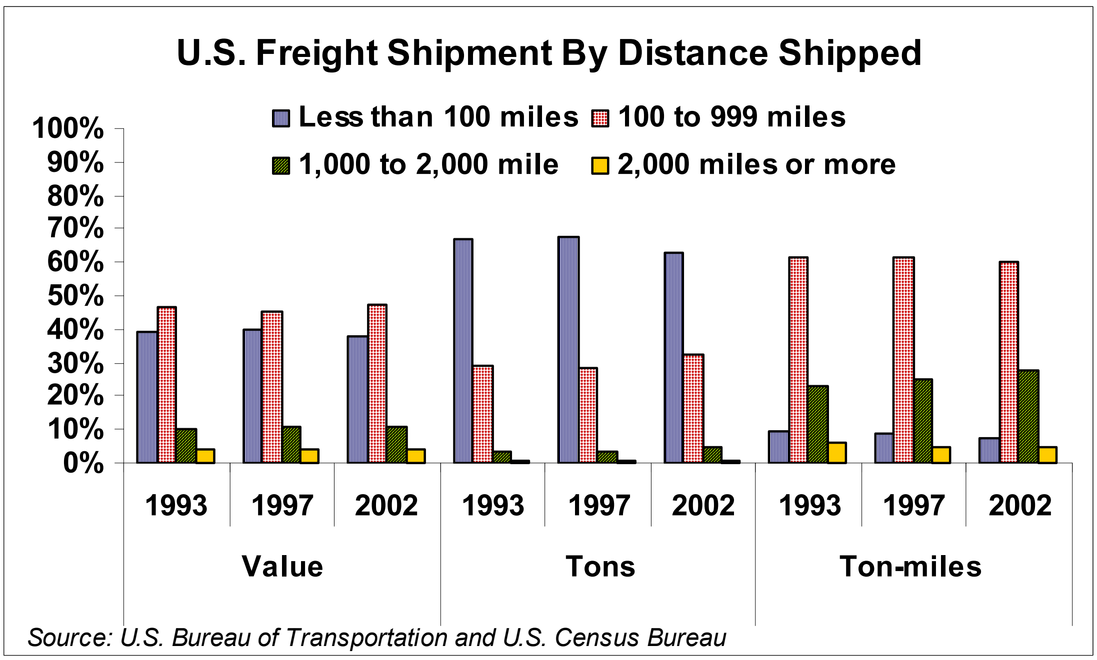
Chart 2-16



2.4.4 Shipment Distance - The complexity of weight, value and distance trends becomes more apparent when viewed from the perspective of Chart 2-17. Using the same database and the same study period as the prior two charts, this chart shows profiles of total value, total tonnage and total ton-miles by distance class:

- The very short distance class of deliveries (0-99 miles) accounted for the greatest share of total tonnage.
- The second shortest distance class of deliveries (100-999 miles) accounted for the greatest share of total value and ton-miles.
- Together, the two shortest distance classes account for approximately 45% of the value of goods shipped, 29% of tons shipped, and 62% of ton-miles shipped.

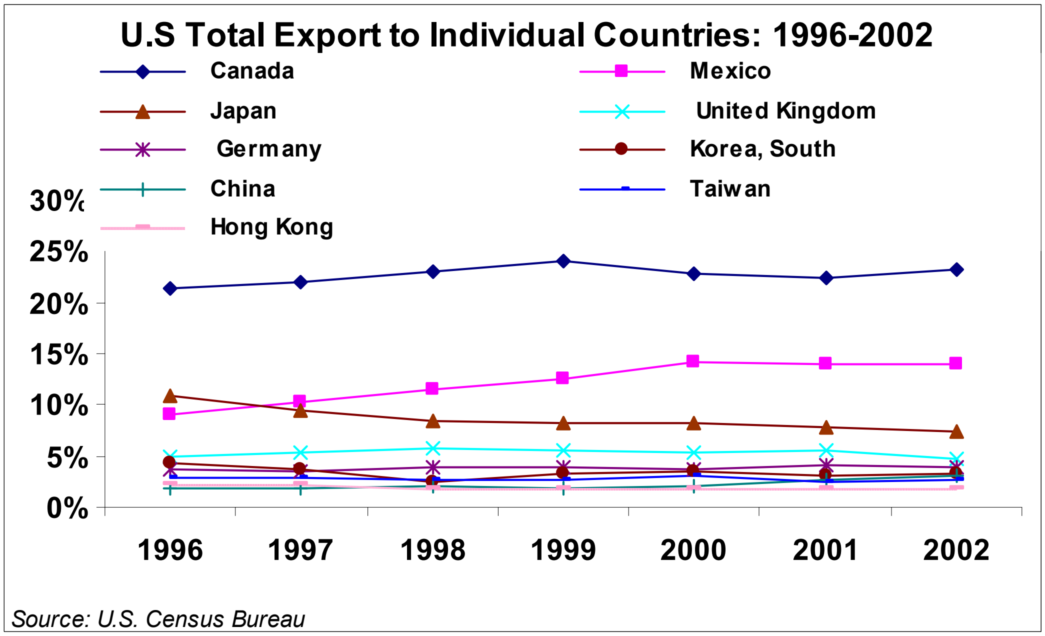
Chart 2-17



Changes in the location of manufacturing plants and assembly units, and increases in just-in-time (JIT) productions and distribution systems over the last two decades, are partially responsible for the notable increases in interregional (1,000 to 2,000 mile) freight shipment in ton-miles.

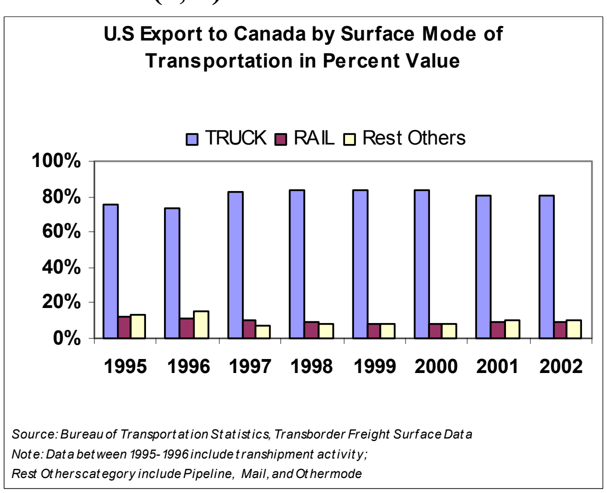
2.4.5 Export Destination - With continued globalization of business markets, it is becoming increasingly important (from an economic standpoint) to understand the pattern of freight flows to and from international borders and ports. First, it is notable that US trade with Canada and Mexico continue to represent the top two destinations of US export freight shipments. This includes US exports to final destinations in Canada and Mexico as well US exports to overseas destinations that travel via Canadian and Mexican ports. Together, the two countries bordering the US account for over 34 % of all US international trade. Between 1996 and 2002, exports to Mexico grew by 72% and exports to China by 84 %. However, US trade with China constitutes only 3% of total US trade, while, Mexico's 14% trade share and Canada's 21% trade share remain still the largest foreign freight shipment destinations. (See Chart 2-18.)

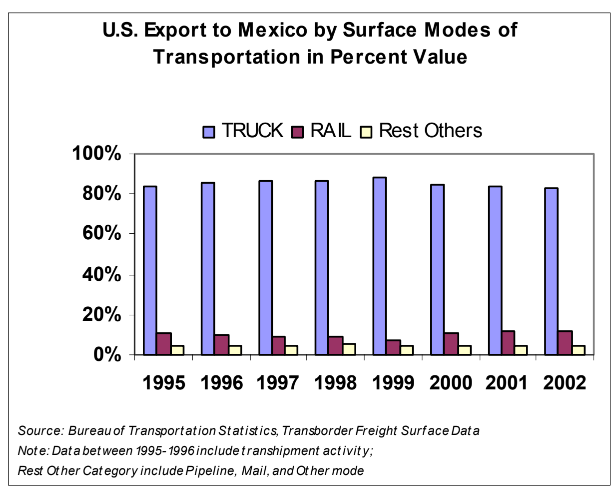
Chart 2-18



US exports to Canada and Mexico continue to rely primarily on trucking, which accounts for between 70 and 80 percent of the total value of export to those countries. Rail freight movement played a greater role in US - Canadian trade than in US - Mexican trade. (See Chart 2-19.)

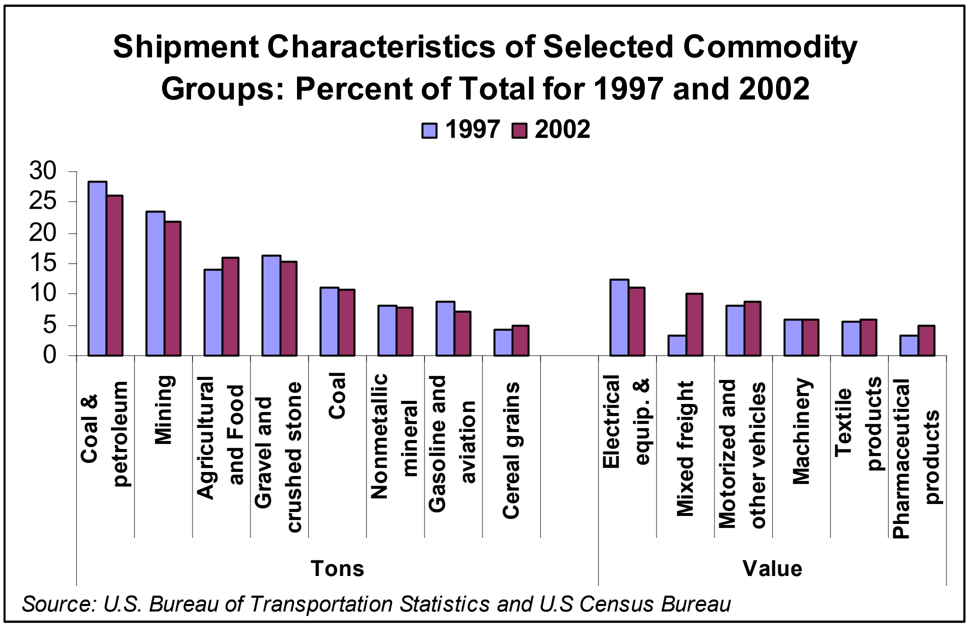
Chart 2-19 (a, b)





The commodity mix of export shipments shows that agriculture and fish products, coal and petroleum products, and wood, textile, and leather products represented the highest trade share of tonnage. Waterway is the most common mode of transportation used for these exports. However, when viewed in terms of shipment value, then we see that motor vehicles, computers, telecom equipments, and aircraft are among the top U.S export commodities. (See Chart 2-20.)

Chart 2-20



Altogether, we see that the changing nature of freight activity is involving some systematic shifts in products, weight, distance, and destination patterns. Shifts towards smaller size and shorter distance shipments[1] are related in part to increasing attention to tight scheduling and logistics planning. Shifts towards higher value exports reflect emerging global trade patterns that are increasingly concentrating export movements at key border and air/seaport sites. However, while a growing portion of the higher value exports are being shipped via air, it is still important to keep in mind that *all* exports going via airport or seaport still have to travel via surface modes (truck or rail) to those ports. Thus, these trends serve to underscore a key element of our three-dimensional decision perspective, which is that pricing and the economic feasibility of rail diversion will be defined in large part by emerging freight movement patterns.

[1] While absolute length-of-haul is rising, shipment growth still is concentrated in the low end of the distance spectrum.

2.5 BUSINESS LOCATION TRENDS

This section examines how business location and urban land development patterns are systematically moving towards a dispersion of activities within urbanized areas that in many (but not all) cases serves to favor highway shipping and disfavor rail shipping. This helps to explain what is already known – that truck is growing faster than rail as a mode for freight movements. However, this information has further use, for it also helps to establish a basis for determining the situations under which rail can (or cannot) be a potentially feasible alternative to truck for freight movements.

2.5.1 Development of Rail and Urban Industry - In the latter half of the 19th century and first half of the 20th century, industrial businesses were most commonly characterized by firms located to serve their surrounding regions. Business location surveys showed that industrial sites were often located where there was good accessibility to large labor pools, transportation (rail and canal), industrial supplies and raw materials, and major markets. This resulted in concentrations of industrial sites which minimized the costs of inbound and outbound freight movement and worker commute logistics.

During that period, the locations of manufacturing facilities were often close to the inner core of metropolitan areas. Because of the relatively high cost of constructing railroad rights-of-way and more constrained engineering parameters, rail lines tended to take more circuitous routes than today's highway network. The resulting network was often a hub-and-spoke type operation with sidings woven together to form branches, which merged to form mainlines and trunk routes – taking its cues from the natural system of waterways which often provided logical rights-of-way that decreased the costs of engineering.

The national rail network, which developed during that period, still reflects pattern of industrial development and freight shipping. Chart 2-21 shows that the US national rail freight network has clearly identifiable hubs in Chicago, Kansas City, St. Louis, Cincinnati, Cleveland and other cities. Hub by-pass flows exist, but less on a local level (as evidenced by the streaking lines throughout most of Nebraska, and the lack of direct connections between some large city pairs.)

2.5.2 Development of Highways and Dispersed Industry - The national interstate highway network, on the other hand, was developed during the latter half of the 20th century. Chart 2-22 shows that the highway network reflects a different sort of spatial pattern in which origins and destinations are more diffused. It clearly has visible 'mainlines', but even the smaller cities have direct connection with one another.

Figure 2-21 Rail Freight Network

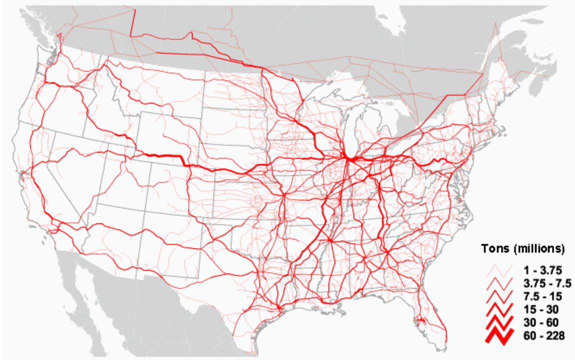


Figure 2-22 Truck Freight Network

Today's more dispersed pattern of development and industrial activities is almost entirely the logical result of the development of automobiles and highways – a transportation system that handles capacity in smaller chunks. This more dispersed pattern of highways and truck movements helped to grow a pattern of industrial activities and freight flows that does not always lend itself to more consolidated shipping methods such as rail. This becomes a key issue in screening alternatives in our proposed analysis framework, discussed later in Chapter 5.

Today, we see that the evolution of business location and freight movement patterns has caused a shift towards increasing dispersion of business locations. This is evident at two different spatial levels. Chart 2-23 shows the relative shift of business growth within metropolitan areas towards suburban locations. Employment in suburban areas increased by 39% between 1970 and 1980, and by nearly 14% between 1990 and 2000. Chart 2-24 shows that there was also an increase in manufacturing employment in non-metro areas and a decline in metro areas between 1990-2000.

Chart 2-23 Employment Trends

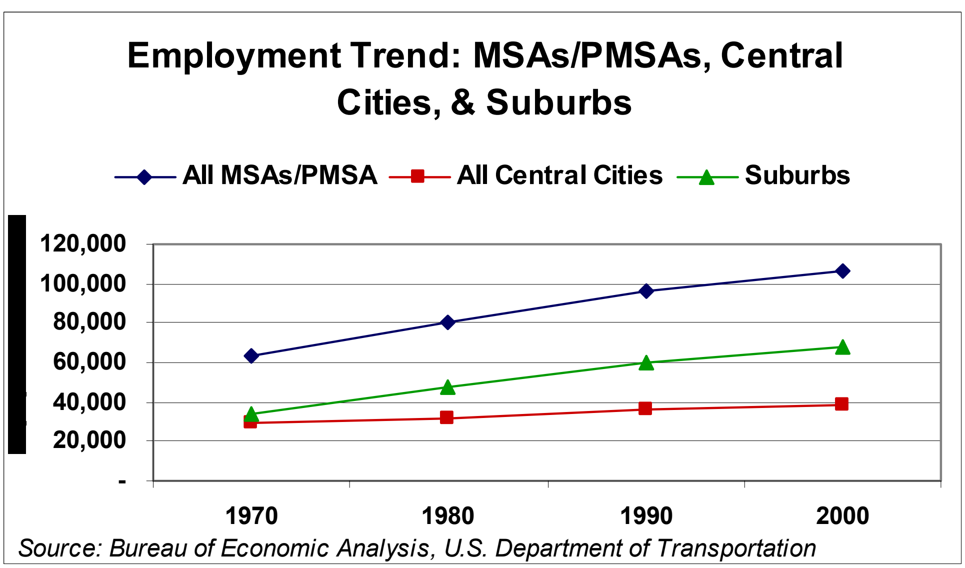
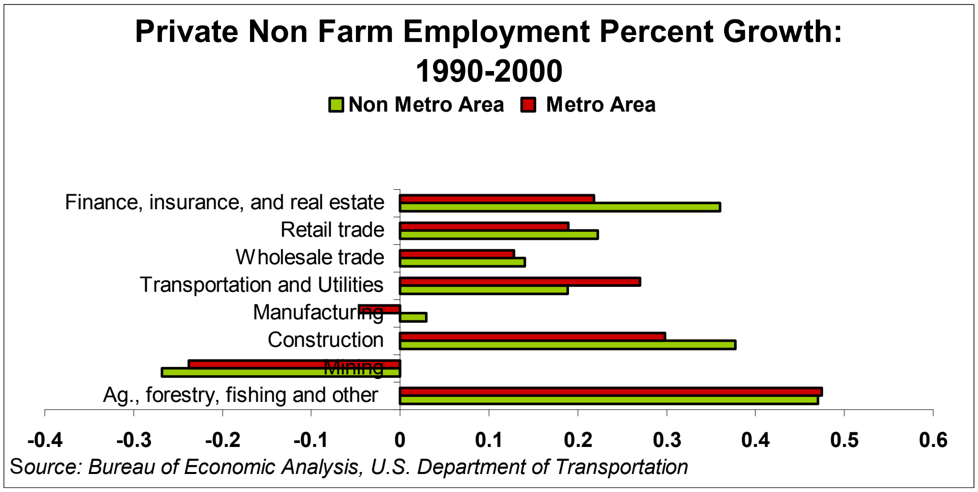
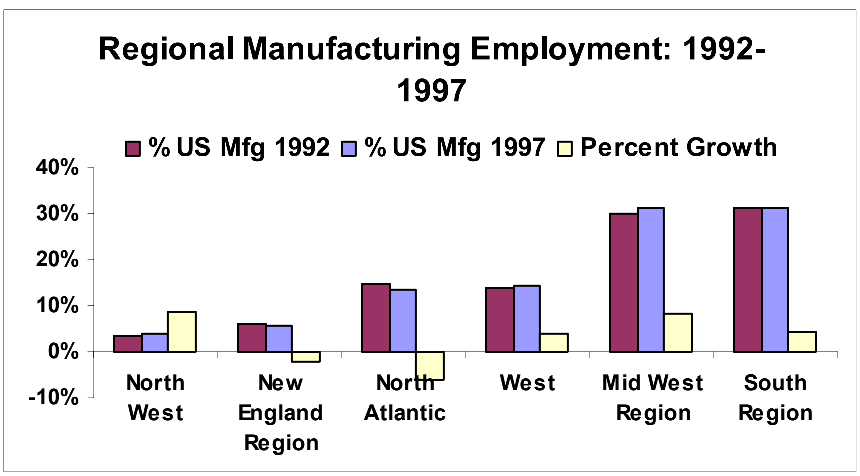


Chart 2-24 Private Non Farm Employment Growth: 1990-2000



Along with the dispersion of manufacturing and freight shipping patterns, there has also been a locational shift in manufacturing across America during the last three decades of the 20th century. Chart 2-25 shows the loss of manufacturing employment from the North Atlantic and New England regions toward the west, northwest and Midwest region. However, the South and Midwest regions still dominate as main manufacturing regions.

Chart 2-25 Regional Manufacturing Employment: 1992-1997



2.5.3 Industry Examples - Automobile and textile industries provide two examples of location shifts in the manufacturing sector. In early times, transportation cost was the decisive factor in industry location. Hence, traditional U.S manufacturing industries were based in big cities, with access to transportation (rail and canal), near major markets, and near industrial supplies. With modern times, markets opened, trade policies changed, and most important as operation cost rose, new manufacturing methods, like JIT penetrated, thus leading to shift in the industrial location.

In the 1950s, automobile manufacturers had assembly plants distributed across the country. As the U.S. share in automobile production declined, fewer plants were needed. In the 1990s, new plants were located in the center of the country in order to minimize distribution costs and vehicles had to be shipped to the rest of the country. (See Chart 2-24.) However, the changing manufacturing and supply relationships, the use of JIT systems, and the impact of the Internet on supply chains have further complicated the manufacturing process. Today, two types of automobile plants are in existence – a few auto and truck assembly plants and several thousand component plants that manufacture parts. Consequently, manufacture, assembly, and the sale of a single product may involve several different facilities located hundreds or even thousands of miles apart from each other.

Chart 2-26 Employment in Motor Industry: 2001-2002

State	Main Manufacturers	Numbers Employed	Year
Alabama	Honda, Hyundai, Daimler Chrysler (Mercedes-Benz)	83,710	2002
Georgia	Ford, General Motors	64,000	2002
Kentucky	Ford, General Motors, Toyota	87,659	2003
Mississippi	Nissan	30,000	
South Carolina	BMW	42,000	2001
Tennessee	General Motors (Saturn), Nissan	62,273	2001
Source: State Statistics; includes part supplies			

The textile, clothing, and apparel industry is another example of a business that has taken on a "global dimension" in the location shift pattern. In the 1960's and 1970's, Taiwan and Korea were the dominant textile export countries. However, in the 1980's and 1990's China, Malaysia, and Indonesia emerged as leading exporters.

Lastly, the freight railroads' share has been declining in part because freight railroads are inherently less flexible than trucks. The freight railroads have slower speed and hence are often less compatible with just-in-time delivery methods. Railroads can complete direct movements only on a network of 100,000 miles and must transfer loads or cars between railroads. Such transfers take a significant amount of time. In addition, the operating environment of railroads is far more complex than that of trucks. Railroads are one of the nation's most capital intensive industries. As a result, it is especially challenging for railroads to maintain and expand infrastructure. (See Chart 2-27.)

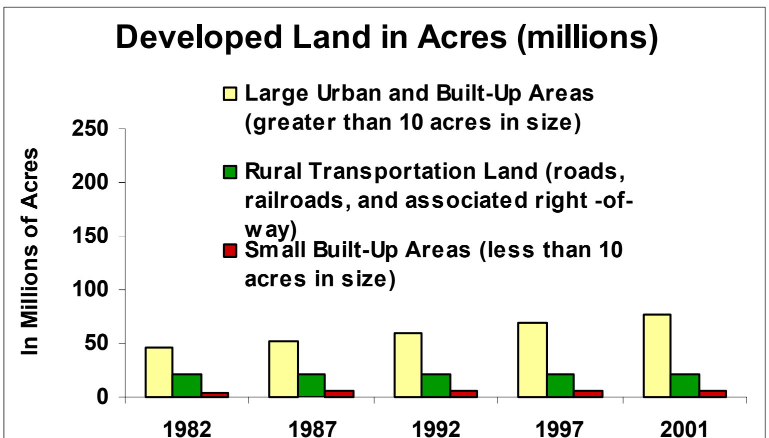
Chart 2-27 Rail Freight Share of Combined Truck-Rail Market by Region

Region	1993	1997	Change in Market Share
Northeast	8.9%	5.7%	-35.9%
Midwest	16.8%	15.7%	-7.0%
South	20.5%	17.7%	-13.4%
West	27.4%	24.0%	-12.0%
United States	19.5%	16.8%	-14.0%
Source: Bureau of Transportation Statistics, Commodity Flow Survey: 1993 & 1997			

Altogether, these trends and examples illustrate the need for any economically-realistic analysis of rail freight diversion to focus clearly on differentiating commodity markets, and then focusing on those which are most conducive to increasing use of rail freight options.

2.5.4 Land Development Trends - While industrial locations are dispersing across the country, localized development is being concentrated in built up parts of metropolitan areas. According to the Annual NRI "Urbanization and Development of Rural Land" Report for 2001, growth in urban land area development increased by 65% between 1982 and 2001, while total land area development increased by a much lower 46% (See Chart 2-28.)

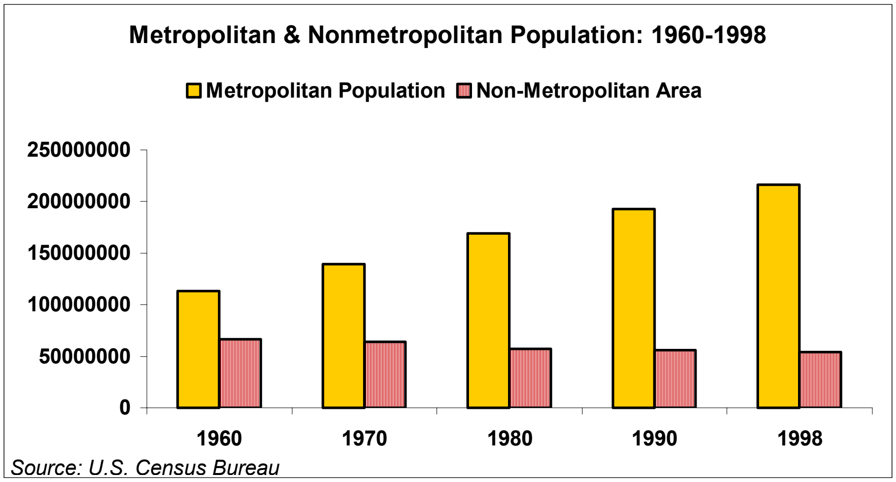
Chart 2-28 Developed Land



Source: National Resource Inventory, U.S. Department of Agricultural's Natural Resources Conservation Service

We can see this same trend towards urbanization in terms of population in Chart 2-29. It shows the concentration of population growth in metropolitan areas, while there was population loss in non-metropolitan areas. This trend towards metropolitan areas is partially responsible for increasing urban traffic (vehicle-miles traveled) and congestion levels.

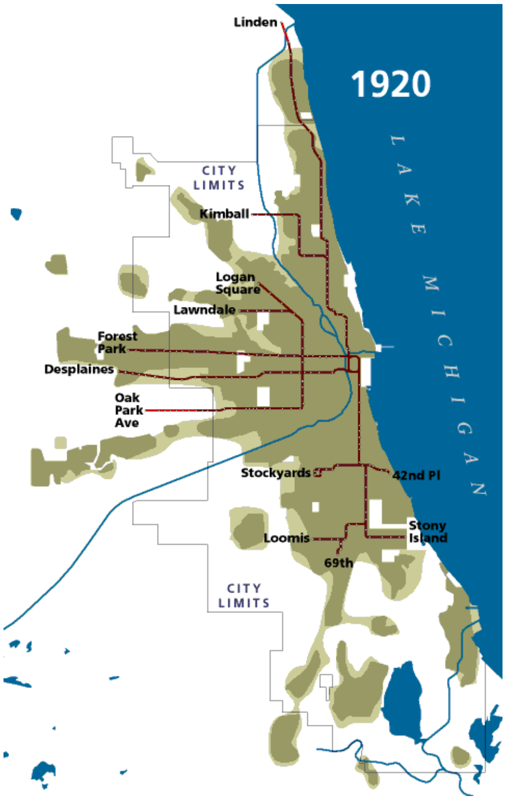
Chart 2-29 Metropolitan and Non-Metropolitan Population



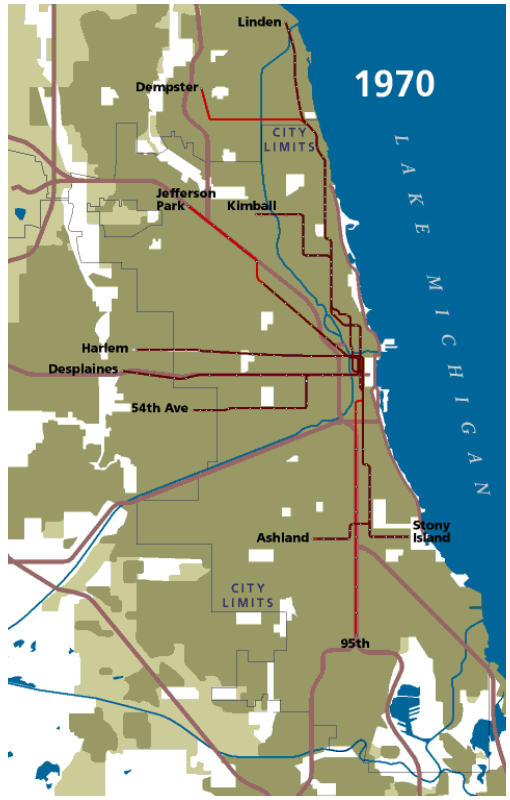
2.5.5 The Example of Chicago - The evolution of freight railroads in Chicago illustrates the type of transformation occurring across America. Chicago has long had the highest concentration of railroad activity in the US since the first railroad reached there in 1850. Recently, as the railroad industry transitioned from the boxcar age to the intermodal age, Chicago's many classification yards were re-cast as intermodal yards in a series of widely documented schemes. Union Pacific's recent effort to focus its resources on growing the intermodal business has seen the construction of Global III, a dedicated intermodal facility, at Rochelle, Illinois, about 50 miles from The Loop. The inability to expand its capacity at the downtown and inner-suburban sites, plus protests at a number of suburban sites closer to the downtown, contributed to the decision to construct the facility in the exurban area. Higher property values in the inner urban core also contributed to the decision.

This is not the first time freight facilities have been moved away from the downtown in Chicago. The Rock Island Railroad's Chicago Terminal, LaSalle Street Station, was a large station with a head house and an adjoining break bulk freight facility constructed in 1903. After the demise of the Rock Island Railroad in 1975, the facility fell into disuse and was replaced by office buildings.

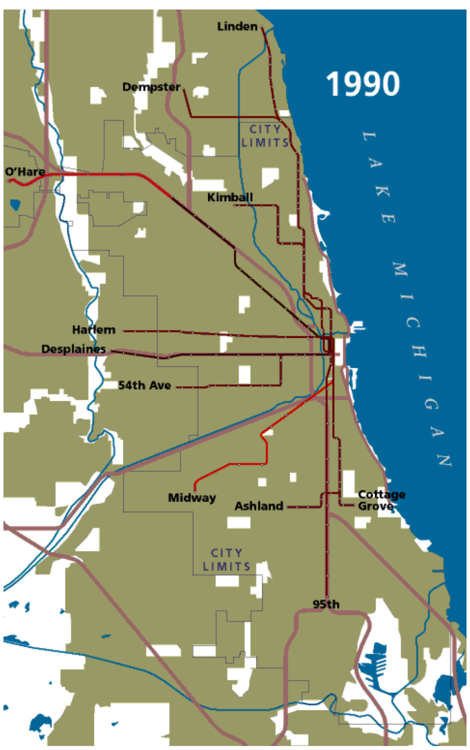
The opportunity cost of land in the downtown is clearly extremely high, and not all of Chicago's downtown freight facilities of yesteryear would be relevant today (for instance, transfer freight terminals that were intended as warehousing for break bulk cargoes are no longer required). However, it is not clear that rail freight options were considered at the time when the cityscape was being dramatically altered – during the transition from an industrial-based economy focusing on warehouses and factories to a service-based economy focusing on office towers. The Chicago example thus illustrates the economic importance of revisiting options for rail freight today.



Chicago 1920



Chicago 1970



Chicago 1990

2.6 TECHNOLOGY TRENDS

This section identifies examples of technology trends affecting the feasibility and cost-effectiveness of both rail and truck to serve freight movements. Technology trends clearly have great significance for the determination of economic feasibility of truck to rail freight diversion. Diversion feasibility is accordingly discussed in detail in the next chapter of this report, so the overview provided here is merely intended to illustrate the existence of long-term technology shifts that are coincident with shifts in economic, freight and business location patterns.

2.6.1 Intermodalism - On the macro level, transportation technology has changed relatively little in the past twenty years. Although legislation has forced truck manufacturers to produce more fuel-efficient and less polluting vehicles, and size limits expanded, the basic form of the truck has not changed. The ocean-going container cube standard, at 20' × 8' × 8½' (and the double-length 40' types), has also remained unchanged. Operations of trailer-on-flatcar trains, pioneered by the Chesapeake & Ohio in the 1950s, and later pushed into production phase by the New York Central, have remained largely unchanged since the advent of stack trains in the 1980's. The 'intermodal' revolution is more of an evolution than a revolution, in the sense that the traffic mix on the railroad evolved from one dominated by carload traffic to one becoming dominated by intermodal traffic.

2.6.2 Motor Carriage - There has been a variety of "extensions" to truck size and weight standards, which have modified the economics of trucking and shipping in the background. Domestic trailers and containers, for traffic in the United States, were progressively extended from 40' to 45', 48', and finally to 53' at the beginning of the 1990's. Progressive changes in highway design standards have allowed these longer trailers to run without causing safety problems. The hi-cube containers have also made an impact, extending the height from 8½' to 9½'. The newer domestic trailers with low-profile wheels, low floor, 9½' minimum height and 53' length, could replace ocean-going containers on a two-for-three basis. This has contributed to increased transloading activities at West Coast ports for light density imports that 'cube-out' before they 'weigh-out'.

Driven by changes in highway standards, many states allowed double and triple trailers to operate. Increases in tractor diesel engine performance have allowed higher tractive effort, thus making it possible for a single tractor to tow multiple trailers at acceptable operating speeds. Engine improvements also boosted fuel efficiency and prolonged operating life. Although these changes have been incremental, they expanded competitiveness and market reach for trucks as operating costs were reduced. Costs and business capture have been further improved by the substantial gains in equipment utilization and service quality afforded by control technology. Two-way mobile voice and data communication, global positioning systems, truck monitoring devices, optical readers, and information software have made assets in the field more productive, and more responsive to customer requirements.

2.6.3 Railroads - In general, railroad technology improvement in the last twenty years has been focused on: (1) larger/longer equipment or consists; (2) lower operating and maintenance costs, including signaling; (3) the double-stack innovation; (4) the auto-rack innovation; and (5) safety improvements. To understand the philosophy 'bigger is better', one simply needs to examine a list of equipment that has increased in size in the past twenty years: the boxcar, the coal hopper, the grain hopper, the articulated flatcar, the locomotive horsepower, and the length of train. The only piece of equipment that has not evolved much in this manner is the plain gondola car.

Lower operating and maintenance costs have come from a variety of sources. The elimination of the caboose and of crew positions, and the use of the remote-controlled locomotives, have allowed railroads to compete for freight at even lower costs. Changes in network and operating practices have also decreased the railroad's cost base – by cutting maintenance of way, concentrating trains on increasingly fewer core lines, and by eliminating intermediate classification yards while focusing on long-haul through traffic. The incremental improvements in both maintenance of way equipment and the components (such as concrete ties and Pandrol fasteners) have allowed railroads to achieve higher axle loads, higher tonnages, lower costs, and less downtime. Signaling improvements have allowed many towers to close while centralized dispatching evolved to deal with trains with increasingly tighter headways. As a result, railroads have become capable of handling large loads more efficiently while becoming less efficient at handling smaller loads. This has allowed them to conquer certain dense traffic markets while continuing to cede loose-car traffic to trucks.

The double-stack and auto-rack innovations permitted the carriers to make more effective use of a great rail asset: the ability to carry heavy, consolidated loads with efficiency. Double-stack trains almost halved the cost of intermodal operations, making it much more competitive with road-based transport – to the extent that the majority of marine import freight today travels by train. The three-level auto-racks made much more effective use of train capacity while protecting the cargo (compared to finished autos carried on flatcars). Since 1980, railroads have also developed a safer operating environment, due to incremental improvements in tank car design. Development of new types of couplers, defect detectors, and fiber-optic network have both reduced the instances of failures and enhanced the railroad's ability to detect problems.

2.6.4 Marine - Technological changes in marine shipping have been dominated by the quest to build increasingly larger ships. As the volume of containers being shipped throughout the world increased, the generation of very large 'Panamax' class ships - the largest that could fit through the Panama Canal – was surpassed, and it became economical to construct super-size vessels and routes without dependence on the Panama passage. In the meantime, clearance-restricted routes, such as the St Lawrence Seaway, became less important as railroads replaced ships in those trade lanes. On the whole, propulsion and loading/unloading technologies have not changed a great deal in the shipping industry. There have been incremental improvements in coatings and engines, and environmental regulations have forced changes from single to double hull, separate ballast and cargo tanks, but all of the 'breakthrough' technologies proposed, including nuclear propulsion, 'fastship', and hovercraft, have received all but limited niche acceptance. Navigation has greatly benefited since global positioning systems were developed and satellite communication improved. This has made it cheaper to transmit information about shipments and increase safety by allowing advance notice of dangers.

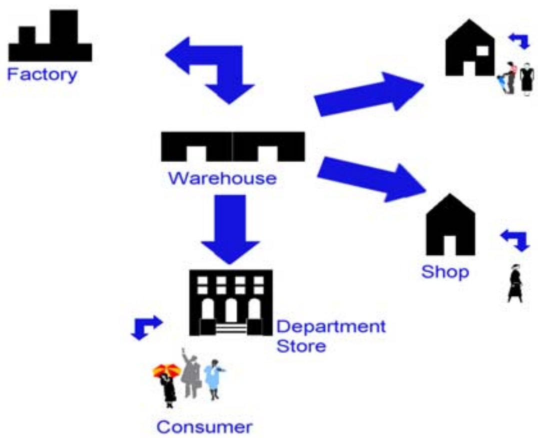
2.6.5 Commodities - While the technology of sea transport has not changed a great deal over the past twenty years, technologies behind the commodities that are being shipped have undergone fundamental transition. The advanced technology and high degrees of automation, along with the high level of wealth generated by technological innovations at the turn of the 21^{st} Century, have allowed many everyday items to migrate from the durable to the disposable category. Greater information technology and data processing capability have allowed a much greater degree of customization than in the past.

Technology-driven economies, rather than manufacturing-driven economies, have a tendency towards generating non-material products such as intellectual property, software, banking, medical and legal services, and highly customized products in small batches such as scientific instruments, created to order in smaller production facilities. This has contributed to a regeneration of cities and higher degrees of congestion, as it is now possible to be productive without consuming great tracts of land area to set up mass-production plants.

For the freight industry, this has meant trends towards: (a) disposable goods, with higher use rates and more shipments; (b) greater customization, with more seasonal product categories; (c) non-material or made-to-order products, with smaller shipment sizes; and (d) miniaturized goods, with high cost per unit volume, higher logistics costs and higher speeds required.

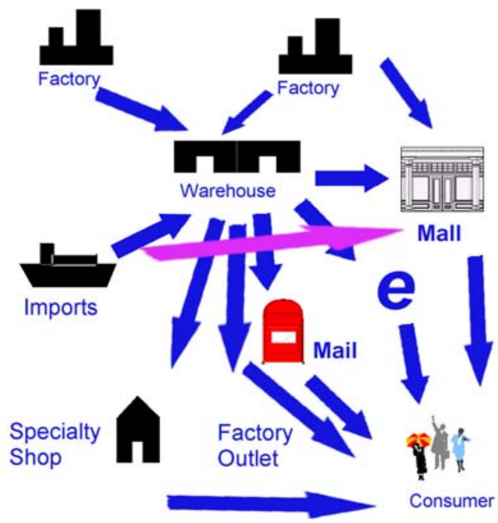
Although some goods are still sold with methods similar to those of twenty years ago (e.g. fresh fruit or coal), others have migrated to the Internet and mail-order market, resulting in more small packages than before. Goods distribution and supply chains have become based more on a "totally-connected network" than a "hub-and-spoke network." Consumer-oriented pull logistics have come to dominate over production-oriented push logistics. The net result is that consolidation of freight is increasingly more difficult due to decreasing package sizes and increasing complexity of network.

Push Logistics



Push Logistics offer less customization and simpler logistics chains with hub and spoke networks.

Pull Logistics



Pull logistics provide multiple channels to shop and many different products, resulting in a totally connected network

2.6.6 Economy - New technologies such as radio frequency and computer directed storage and handling systems, satellite supported ground positioning systems (GPS) for tracking and expediting shipments, and use of the Internet to connect trading partners and customers are being widely used to create more effective and efficient distribution of raw material and goods.

Internet-based catalogues offer everything ranging from consumer electronics, luxury goods, sports goods, freshly produced foods, prescription medicines, and replacement parts. Customers are expecting overnight deliveries of this Internet based e-commerce. This is leading to either a network of market-based distribution centers filled with inventory, or fewer fulfillment hubs requiring much less inventory, where overnight delivery is possible.

The movement towards globalization with the emerging markets, cheap supply sources, new trading partners, and increasing industry competitiveness is compelling enterprises to develop new strategies to track orders and react to changes in real time in the handling and transporting of materials, as they move across the supply chain from originating suppliers to end customers.

Summation: Together, all of the technology changes in transportation, products and trade shift the calculation of economic feasibility for truck-to-rail freight diversion. The factors to be considered in these calculations are discussed further in the next chapter.

Chapter 3: Road-to-Rail Diversion Constraints & Impacts (Task 3)

3.1 INTRODUCTION

For railways to produce material relief for the congested roads of the nation, the rail system must capture highway traffic. Therefore in many ways, diversion of traffic from road to rail is the heart of the issue that forms the subject of this research. This chapter examines the constraints to diversion, the conditions that favor it, and the impacts when it occurs. Its chief objective is to assist planners in coming to a realistic judgment of the market and operating conditions, that shape and show the probable payoff from rail solutions to congestion.

Analysis of diversion options becomes quite complex when it takes in the interaction of factors and motivations at the level of individual shipments. The purpose of this chapter is to reduce those factors to broad, true outlines that offer a compass to planners, by which they can navigate the forest from amid the trees. In a sense, diversion can be brought down to a simple proposition: good, low cost service wins business from competitors, and the obstacles and advantages for rail in delivering this are what have to be understood. An evaluation in practice will not play out simply, yet this perspective is important for testing whether a result makes sense: diversion analysis is competitive analysis, and strongly competitive service should succeed.

Since the goal throughout this research is reduced congestion, and greater effective capacity for the highway system, then preservation of rail traffic is important, because it prevents additional, often heavily laden volume from being introduced to the highways and further eroding their performance. It means that the problem of pickup and delivery is important, because these trip-end services occur more frequently in urban areas. If they must operate by truck instead of direct rail, then there will be limited rail relief in urban areas, which are among the most congested. Lastly, as volume delay functions demonstrate, incremental traffic has a greater detrimental effect on system performance in already congested networks. This implies that as freight traffic on the roadways continues to build, the value of diversion to rail grows greater.

This chapter moves through seven additional sections, beginning with a presentation of basic customer motivations, then builds toward an understanding of the barriers and opportunities for diversion, and concludes with a review of diversion's effects.

- Section 3.2 – *Shipper Needs*. Understanding of modal preference starts from the foundation of customer needs. Their portrayal in this section ranges from service, cost, and other requirements to carrier selection. The market positions of modes are indicated, and the discussion introduces the concepts of equivalence, conversion, and categorical distinctions in service.

- Section 3.3 – *Structural Factors*. Important limitations to rail are posed by the conditions of access, and the addressable extent of the highway market. The characteristics of truck fleets are described as modal competitors and intermodal partners, and the challenge of interoperability as well as the urban problem are highlighted in this section.

- Section 3.4 – *Market Segmentation*. Recognition of the differential nature of market sectors helps to uncover diversion opportunities, and to verify their realism. Markets are considered in this section from the demand and supply sides, in retail and wholesale aspects. A freight rail typology and market benchmarks are presented, and the discussion concludes with a framework for market segmentation, useful as a basis for diversion evaluation.

- Section 3.5 – *Barriers to Diversion*. Drawing together and extending conclusions from the preceding sections, nine obstacles to railroad diversion of highway freight are identified, under the two broad categories of market viability and institutional readiness. In addition, the issues of citizen acceptance and competitive account are stressed as important and related barriers in the public sphere.

- Section 3.6 – *Levers for Diversion*. The public sector has methods at its disposal to encourage rail usage without short-changing shipper needs. Five types of policy lever are proffered this section, from the obvious option of financing to the uncommon option of pursuing a market strategy.

- Section 3.7 – *Diversion Opportunities*. The prospects for highway diversion are different for the railcar and the intermodal businesses, while the short-haul freight market is large, significant for congestion relief, and difficult to approach. This section considers the singular qualities of opportunity in each of these areas, employing a number of case examples and distinguishing prospects of national magnitude from those with local promise.

- Section 3.8 – *Impacts of Diversion*. Modal diversion alters the locational impact of freight, creating new traffic concentrations on rail lines and around transload facilities, yet improving mobility for other traffic left on the roads. The marginal effects of diversion in economic and social dimensions are reviewed in this section, including congestion, economic development, environmental, safety, and community consequences.

This chapter develops methods for rail projects to be evaluated in their market and operational contexts, and shows barrier conditions to be appreciated and engaged. Because diversion impacts should add up as net benefits, it suggests some ways that realistic projects can be justified. Together with the accompanying chapter treatments of trends and model approaches, it begins to demonstrate how rail solutions to roadway congestion can be appraised, and how supporting assessment tools should be constructed.

3.2 SHIPPER NEEDS

Purchasers of freight transportation are motivated by a series of factors in their selection of providers. Chiefly they are concerned with performance specifications and value, within the overall context of the logistics of their business and its contribution to customer satisfaction. These factors are variously described as purchasing criteria or selection requirements, but are most simply called shipper needs (although the purchasers of transportation may be receivers or managers of freight, and not properly shippers at all). Adopting simple terms for this discussion, the two primary needs of shippers are service and cost.

3.2.1 Service – Service fundamentally means the reliability with which goods are picked up and delivered as scheduled or expected, and the transit time or speed of that process. Reliability can be understood as the variability of performance versus a standard, which typically is an appointment time and a tolerance range around it. An example of a reliability measurement would be “95% of deliveries on time”, where ‘on time’ means within one hour of the appointed moment. Precision arises as an aspect of service when the tolerance range narrows, down to fifteen-minute windows around appointments, or with financial guarantees for a fixed, daily deadline. Service on the pickup end also entails equipment capacity to collect the shipment, and the turnaround time for equipment to cycle back. Examples would be the railcar supply during the harvest season, or the availability of trucks around big retail distribution centers, and it is routine for shippers to require commitments of equipment from their freight carriers. Finally, frequency of service effectively is a facet of transit time, because it adds to the hours elapsed between the point when a shipment is ready for pickup, and the point when it can be delivered. In irregular route systems (like significant parts of the US truckload business), frequency is a direct function of equipment supply, but in regular route operations the availability, number, and timing of departures is a major determinant of effective service. In railroading, departures correspond to the number of trains running per day and per week; in other planned route networks the departures might be planes (in air freight) or linehaul trucks (in LTL and small package trucking). It’s worth noting in these systems that departures have a high fixed cost component that tends to depress service frequency, and creates a temptation to consolidate departures, thereby reducing costs but downgrading performance.

Two additional points should be made about service. First, it is measured door-to-door, which means from the shipper’s door to the door of the receiver. This is a salient point for railroading in the context of highway relief, because in the commonplace absence of direct rail access to the customer facility, goods must be transloaded and drayed, and this can[2] add to time and cost. Furthermore, the railroad and the drayage truck performing pickup and/or delivery normally are not under common operating control, implying that door-to-door service performance depends on the cooperation of independent agents.

[2] For customers with direct rail access, the switching of cars between the rail yard and their facilities also consumes time and expense.

This issue of cooperation affecting service also exists for interline handoffs between the major rail systems prevailing today in the eastern US, the western US, Mexico and Canada.

Second, there is a common misperception that the speed of transit is not especially important so long as deliveries are predictable. Reliability or predictability is the most crucial feature of service, and shippers may exist who value it to the exclusion of transit time, but speed of transit is an essential factor in modern logistics:

- There is a well-documented movement in industrial management to reduce the cash-to-cash cycle time of business, which refers to the time between the purchase of inputs or merchandise, and the point when goods are sold and paid for. Time compression is sought in every aspect of the cycle, implying that speed is important everywhere. One core motivation for this trend is market responsiveness, whereby the productive capacity of a supply chain reacts swiftly and flexibly to local activity at the points of sale. Adoption of low inventory, high speed logistics systems is key to this capability. In a large survey of freight shippers released by Morgan Stanley Equity Research, the number one reason that shippers had not shifted more truck freight to rail intermodal was slow transit, followed closely by unpredictability of service.[3]

- Truck lines form an important intermediate customer group for rail intermodal services, providing both the pickup and delivery operations and the retail marketing to shippers. In market research conducted for the Virginia I-81 corridor, motor carriers made the significance of transit time performance quite clear. For fixed route truck lines that have published schedules, rail must meet or improve the schedule or it cannot be used; for irregular route truck lines, the standard of comparison is the over-the-road speed of a single driver, and the utility of rail is diminished if it cannot match or improve upon the standard. An additional finding in this research was that transit time performance behaved as a step function measured in whole or half days. Speed improvements are significant when they cross this threshold, but are not very meaningful in smaller increments. Coupled with the fact that speed is evaluated door-to-door, this finding points up a competitive hindrance to rail in short distance lanes, which will be explored further on in this chapter.

3.2.2 Cost – Cost considered narrowly is the price charged by the carrier for the shipment, but more broadly and substantially it is the total set of costs attendant to doing business with the carrier and mode. Like service, it must be totaled door-to-door, and include any separate charges for pickup, delivery, and transfer. Costs are compared by unit shipped – per piece or per pound, for example – and thus are sensitive to the loading capacity of transport equipment and to the size of the shipment. Comparisons also have to be aligned by miles traveled (commonly called length of haul), first because distance is a primary and obvious driver of transportation costs, and second because of the changing proportion of pickup and delivery to linehaul costs, as miles lengthen. Pickup and

[3] "Freight Pulse Survey: Second Round Insights", 1/9/02, Morgan Stanley Equity Research.

delivery tend to be time and therefore asset intensive; railroads in particular find their comparative advantage lies in the efficiency of linehaul.

Total logistics cost is the most comprehensive way to view the sum of the expenses attached to doing business with a carrier or mode. The term 'logistics' especially brings in the inventory carrying costs associated with the lot sizes, transit time, and service reliability offered by the carrier. The inventory itself expands into the building space, the staff, and the administrative expense required to support it. Provided the value of the goods shipped is known, the inventory financing charges for lot sizes and transit time are calculable; however, the cost of some of the other elements can be difficult to measure, notably for analysts (like public planners) who are not privy to shipper's internal information. From a practical standpoint, there are two observations to make about logistics cost and its effect on carrier selection and diversion:

- Low inventory logistics are a manifestation of a deeper business process. When just-in-time practices were introduced to industry, they were focused not so much on stock reduction as on eliminating the process failures that inventory covered over. As the evolution of supply chain strategies has turned the focus to market responsiveness, the value of that strategy to business overwhelms other considerations,[4] and logistics practices are engineered to execute it. Shippers in this sense are seeking the right transportation products in terms of service performance and carrying capacity; while transportation costs matter, additional logistics factors have been obviated by the performance standard. In other words, if a transportation product imposes significant inventory burdens on the logistics system, it can't meet the engineering requirements and doesn't qualify for purchase.

- Apart from rates, the logistics cost differences between carriers is largely a function of modal technology. Motor carriers certainly compete on service, but they are broadly substitutable one for another in terms of their logistics effects. The logistical implications of rail carload service can be significantly different from motor carriage, on the other hand, and are an impediment to diversion. Even so, the class of railroad service that competes most aggressively with highway transportation and is most likely to produce congestion relief is the intermodal product, which strives to emulate truck performance and offers the shipper equivalent loading characteristics. As the rail product becomes substitutable for all-highway service, supply chain effects start to become immaterial, and total logistics costs collapse to the difference in transportation costs.

Transportation costs are structurally dependent on modal technology, and are fundamentally influenced by two forms of volume efficiency: consolidation economics, and economies of density. Consolidation denotes the ability to combine shipments into

[4] The "International Trade Flow Study" by the Fleet Management Department of TTX Corporation (9/03) describes retail importers stopping, stripping, and transloading international containers for the purpose of delaying a decision about the final destination for goods. This is done so as to react most optimally to point of sale information from stores. Market considerations in a case like this completely offset the added logistics expense.

larger lots by grouping or unitizing them, or by accumulating them to travel together. It can be performed by the shipper in tendering larger amounts of freight, or by the carrier or intermediary in combining freight from many shippers into quantities that will fill a truck, or make up a block of cars on a train.

Density refers to the concentration of market volume in time and space. Its major components are:

- *Balance* – the ratio of delivering (inbound) shipments to originating (outbound shipments in an area;
- *Proximity* – the distance between delivering and originating shipments, or the interval distance between sequential deliveries or pickups in a chain;
- *Vector* – the direction of volume, often characterized as a lane;
- *Confluence* – the joining of vector volumes in common, arterial sections of a network. Vector and confluence are critical to railroading, because its unit of production – the train – depends on directional traffic concentration;
- *Frequency* – the timing of volume, as it determines the immediate relationships of balance, proximity, vector and confluence in a spatial zone.

Consolidation and density both are concerned with the organization and dynamics of traffic flow, and in turn are determinants of transportation asset utilization. Utilization measures the productive work of assets – facilities, right of way, and especially mobile equipment – in terms like revenue per day, cycle time, and loaded to empty proportions, and it keenly affects return on investment. A strong positive relationship usually exists between density and utilization on the one side, and service performance on the other, such that quality and efficiency can be mutually reinforcing attributes. Because of this, the advantage of density can be thought of as conferring a service economy. Finally, carriers can control utilization by a variety of means; an important one is management of the dispersion of assets across geographic territory, where less concentration is detrimental. This is equivalent to the military principle, under which the effectiveness of armies is related to the ratio of the force they exert, to the space in which they operate.

3.2.3 Other Needs – Beyond the two primary requirements, shippers consider a series of additional factors in carrier selection: geographic coverage, affecting lane service and the ability to single-source; relationship, including customer communication and incumbency; and ease of doing business. Three of the most prominent are visibility, risk elimination, and specialization, which are discussed below. The relative significance of these factors varies with the shipper's industry, and can rise to the importance of service and cost in some cases. The chemical industry, for example, values risk elimination highly, while shippers of produce care about the equipment and knowledge specialization that delivers their products fresh and unbruised to the market.

- *Visibility* – The movement to low inventory, market responsive supply chains has caused the visibility of product inside the system to become vital. The objective ideally is to be able to locate and affect any item in real time anywhere in the chain: at the factory, the warehouse, the store, or aboard the freight carrier. The traditional role of inventory as a guarantee of goods to customers has been transferred to information systems, transportation systems, and integrated supplier management. Shipment tracking historically was a carrier support function for service assurance; under fast cycle logistics, it makes a crucial contribution to total supply chain management. Development and adoption of a range of mobile communications tracking technologies have created the ability to follow and direct the movement of power units; trailers, containers, or cars; and the goods inside them. A carrier who provides visibility to a customer offers a combination of technology (transponders, cellular devices, bar codes and radio tags are examples as this is written), data processing and communication systems (currently including web-based platforms for shippers to tap carrier data), and operational controls, all combining to produce actionable information about goods in transit.

- *Risk Elimination* – The components of risk are safety, claims, and environmental protection; equipment maintenance; insurance; security procedures; and the stability of finances and labor. They are directed at four issues: a) the safe handling of goods, including hazardous goods, and the ability to respond and make recompense in the event of incidents or loss; b) the protection[5] of goods from theft, vandalism, and violence, and of the transportation system from highjack and terrorism; c) the safe conduct of transportation, and the avoidance of accidents harming people and property; and d) the dependability of the carrier as a going concern, so that shipments tendered and logistics programs built around the company can be expected to proceed without disruption.

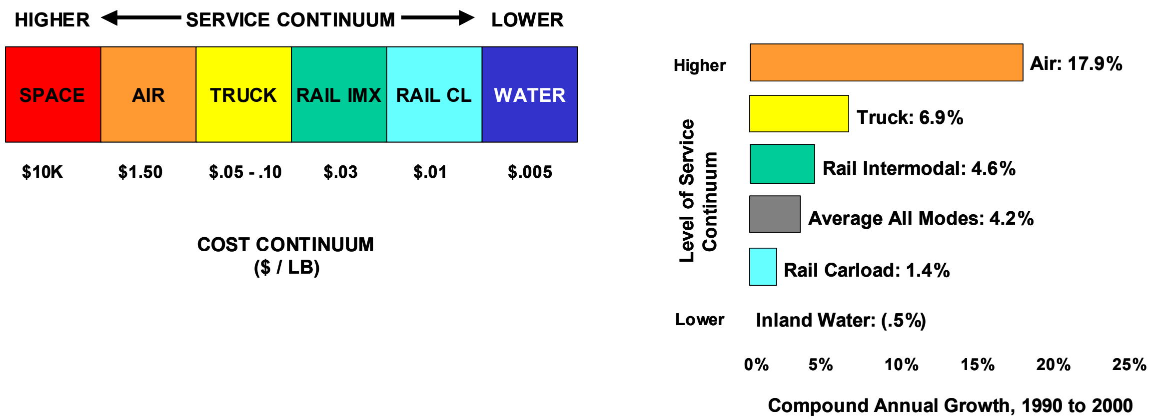
- *Specialization* – Expertise in the shipper's business is helpful to the client in many industrial segments, and is critical in some. Specialized equipment is a prerequisite in numerous areas: temperature controlled goods, automobiles, apparel, and heavy machinery are examples. Equipment (specialized or not) may be dedicated to a shipper, or an entire operation may be contracted, including motive power and on-site staff. Training or simply experience in product handling and plant procedures turn carrier personnel into approximate extensions of the shipper's staff. Where dedicated or specially trained work forces are used, the carrier may assume logistics functions such as preparing store-ready merchandise with tagging and displays. Specialization in these instances crosses over into out-sourcing and third party logistics.

3.2.4 Carrier Selection – Freight modes offer a characteristic mix of service and transportation cost advantages, and can be arrayed in a continuum as shown in the first chart of the accompanying **Figure 3-1**. Individual carriers and operations may perform above or below the tendency of their mode, but it generally holds that motor carriage offers superior service to railroading and earns a higher price, while the intermodal product for rail is the closest to truck performance. The importance of service is borne

[5] It is worth noting in this context that railroads maintain private police forces that are licensed and armed as peace officers.

out by modal growth rates in the 1990's, which directly correspond to position along the continuum (seen in the second chart of the accompanying **Figure 3-1**). These illustrations suggest the fronts of modal competition, and the areas of the market where traffic diversion is most apt to take place: intermodal versus highway, highway versus air, barge versus carload rail. Two points should be acknowledged about this profile:

Figure 3-1



- Shippers may employ a portfolio of carriers and modes, according to the span of their logistics requirements, geographic exigencies, and movements in their markets. Their needs therefore may fall into several sets, and require a diversity of solution.

- Freight carriers or companies seek to transfer the portfolio function from shippers to themselves, by utilizing multiple modes beyond the one they may be known for. A current expression for this is mode neutrality, indicating that carriers market certain performance specifications to shippers, while trying to reserve to themselves the responsibility for deciding the method of accomplishment. Of course, the selection of modes and sub-modes matters to the execution. In practice, some specifications are synonymous with a particular mode, and some shippers will penetrate the veil of neutrality if they are concerned for the risks that a mode may pose, or want to assure themselves a share of a cost advantage.

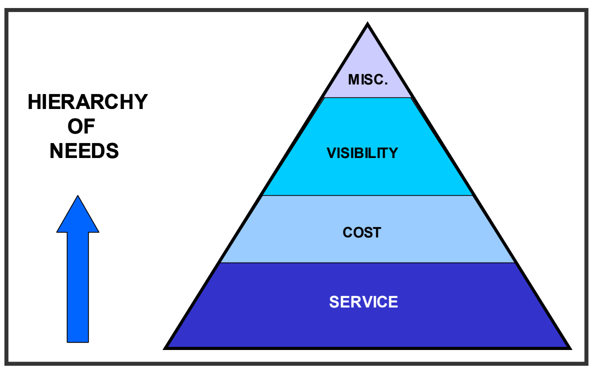
Shippers consistently rank their needs as service first and cost second. Numerous studies through the years[6] demonstrate this, and typically stress reliability or on-time delivery as the foremost feature, followed by transit time. Priorities after the cost feature fluctuate by industry group, as noted above, and of course individual shippers may deviate from the norms. Freight carriers nevertheless react with cynicism to the primary ranking of

[6] One particular reference is a 1996 paper "Shipper Carrier Decision Making: Post Deregulation Quality Factors" by Professor Bud LaLonde, formerly of Ohio State University. LaLonde in turn references the findings of Michael McGiniss and others. A 1997 shipper survey by Cahners Publishing is another of many sources (Logistics Management magazine, September 1997, "The High Rollers", page 72.) Private research by the authors for railroads, motor carriers, and public agencies from the 1980's through 2003 show the same thing.

service, because their competitive experience is that shippers care chiefly about cost.[7] Understanding this apparent discrepancy is useful, because it points up dynamics that influence analysis of diversion.

Figure 3-2 presents the prioritization of shipper needs in the terms of Maslow's hierarchy. Abraham Maslow was an American psychologist who posited a theory of human needs, under which basic requirements like food and shelter had precedence over emotional requirements like social esteem, but each level of the hierarchy formed a threshold below the next. This meant that, so long as more fundamental requirements were being met, the focus and object of behavior would move up to higher levels of need, and the basic needs would recede as motivations unless they were threatened. Clear examples were available from the Second World War, when the survival needs of middle class citizens rose strongly to the fore, then fell back behind social concerns after the conflict ended.

Figure 3-2



As an interpretation of shipper behavior, the hierarchy places service at the level of basic needs.[8] Because the first job of the shipper is to satisfy such needs, normally they have already done so, and the focus of their behavior has moved up to cost. In competitive markets cost is so often malleable (and shippers work hard at improving their power over it), that even when shippers are seeking to satisfy higher-level demands, cost is rarely a wholly resolved need and doesn't drop out of the picture. This explains the carrier perception that customers care chiefly for price. The precedence of service is evident from the vigorous and early steps shippers take to respond to the threat of a strike or the collapse of a carrier: traffic is diverted to more stable, even more costly alternatives, until

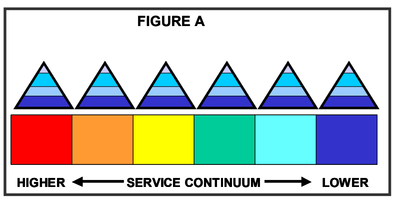
[7] This is the author's long-standing experience.

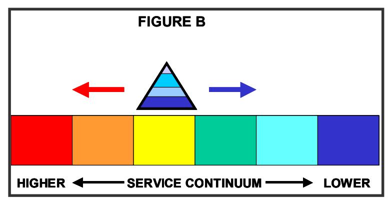
[8] This interpretation is principally the author's conclusion from observation of behavior. Others have drawn the same conclusion, however, nor is application of the hierarchy unique. LaLonde states, quoting McGiniss, "performance and quality requirements are constraints to be satisfied before rates become a significant issue in logistics service provider selection."

the disruption is ended.[9] Service disruption is not the normal state of affairs, of course, and in the condition of normalcy service needs stand as satisfied.

However, the modal differences function as *categorical* distinctions in service – meaningful and plain – and shippers manifestly do observe these distinctions in their modal portfolios. Interpreting this in terms of the Maslow model, shipper satisfaction at the basic level of service is touched by disruption or carrier failure, or by categorical differences such as the several modal technologies produce. The service positions of modes, then, can be conceived as a series of hierarchies along the continuum (Figure A), or as a shifting of the hierarchy across its line (Figure B) in **Figure 3-3**. To summarize, shippers slot their carriers into logistical roles according to their categorical levels of service, and within those roles in an everyday way, carriers principally compete on cost.

Figure 3-3





The upshot of this is to render service as a step function in the dimension of reliability, as well as in the dimension of transit time. This is reinforced by two factors:

- Reliability entails a measure of trust. For that reason, a carrier who has proven reliable wins loyalty and is not easily abandoned, except for another who is equivalently trusted. Therefore, there is a certain amount of resistance to shifting of carriers over issues of reliability: the prevailing sense of satisfaction has to be disproven or disrupted, and shippers take time to change their position.

- Carrier performance in the aspect of reliability is not finely measured, because of the structure of business relationships. Shippers typically select the carrier, pay freight charges, and are held responsible for delivery failures – but they do not directly observe delivery.[10] Instead, they depend on customer complaints and exception reporting, on statistical shipment sampling or tracking of urgent shipments, and on carrier-generated performance reports (which allow slippage through tactics like resetting appointments). Hence, shippers 'know' carrier performance, but not precisely and not with complete data, and the implication is that shippers will not be sensitive to small gradients of reliability due to the imprecision of measurement. Prominent exceptions include cases where shippers control their inbound freight and so have direct data on performance (some of the large retail chains do this),[11] and

[9] The West Coast port strike of 2002 and the UPS strike in the mid-90's are well-reported examples.
[10] These issues were explored in research for the Virginia I-81 market study, detailed in the Task 2 case reports.
[11] Even here, information quality is mixed. A study of major retailers by the Soleus Group (reported in trafficWORLD, 2/2/04, page 16, "Retailers in the Dark") reveals that less than 70% of truck lines are able

cases where a carrier purchases contract linehaul transportation (such as a truck line buying intermodal service from a railroad).

Carriers within modes consequently are operating, and are perceived to be operating, all on the same plateau of the step function. Clear product differentiation in such circumstances is difficult – and this is what carriers report. To the extent differentiation exists, it is usually related to a cost advantage derived from network service economies, or to a transit time advantage produced either by the service economies or by specialization.[12] Railroads competing with motor carriers are a step behind and contend as an inferior good: shippers have to be offered a substantial risk premium to offset service deficiencies, provided they can utilize rail service at all.

For the purpose of diverting highway traffic sufficiently to affect congestion, rail services must climb to the step that motor carriers occupy. Small gradients in speed and reliability will not matter much, but equivalent performance is a categorical change in the railroad product proposition. Equivalence is achieved today in market segments that play to traditional railroad strengths, and is rewarded with market share. Intermodal rail, to use an obvious example, holds a commanding position for long haul transportation of containerized goods in dense intercity lanes. In these conditions, density supports dedicated trainload operations, and linehaul distance offsets inefficiencies in pickup and delivery; the result is that rail performs as well as a truck, with a lower cost.

Railroads are not likely to improve on truck performance and don't really need to; when the service plateau is reached, the shipper's objective turns to cost, and advantages in cost will win business. The objective is *equivalence*, and since motor carriage already can be equaled by rail some circumstances, the core question in traffic diversion is, how broadly can equivalence be produced?

A final point on the value of parity is that it is an effective way to win motor carriers as allies of railroads, and through them to transform product equivalence into significant modal market share gains. Truck lines need cost superiority for their competition with one another, and some view intermodal linehaul as one method to obtain it, so long as a) the rail product matches their competitor's performance over the road; b) rail linehaul blends smoothly into their fleet operation; and c) rail usage can be translated into sustainable advantage. This last provision can be satisfied through a number of means: specialized equipment, knowledge of how to utilize railroads productively, train ownership, yard and slot priority, price preference, and pickup and delivery costs. Motor carriers have to develop trust in the railroad, but once they acquire it, their existing relationships with shippers help to reduce the resistance to change, and accelerate the diversion of traffic. Equivalence in this way is an instrument of *conversion*, in the sense of persuading opponents to cross over to a position of support.

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to provide electronic shipment updates to retail customers, and 50% of those who can have accuracy problems.

[12] Carriers commonly complain of commoditization in their markets and struggle to separate themselves from their brethren. Examples of transit time differentiation are regional LTL lines who use network density and labor flexibility to lengthen the distance limit on overnight service, and truckload lines specializing in team driver operations.

3.3 STRUCTURAL FACTORS

3.3.1 Access - Railroad sidings as a feature of industrial facilities have been declining for decades. Many businesses that possessed them have paved them over, or allowed them to fall into disrepair, and new industrial development for generations has been widely heedless of access to the rail system. Meanwhile, the long-term rationalization of the railroad network has caused it to shrink away from many areas that it once closely served, and left it far smaller than the highway system. A network whose major development ended early in the 20th Century has adapted to shifts in economic geography only through contraction, not growth.

The trends reflected in these conditions were explored in a previous chapter of this study. To illustrate the consequences for traffic diversion, the research team analyzed a commercial database of American businesses, consisting of all manufacturing establishments with twenty or more employees. Establishment addresses were geocoded to prepare them for cartographic examination. This process successfully coded 61% of the establishments, or about 100,000 businesses; additional effort could have raised the proportion captured, but with no evident bias to the coding failures, the result was an adequate sample for analytic purposes. Finally, the coded establishments were checked for their proximity to rail lines, using a cut off of 500 yards (about a quarter mile) from the current, active network. This process found that just 34% of manufacturing businesses were within the cutoff distance, representing perhaps 35% of shipping volume. This assessment is not fine enough to identify the presence or absence of sidings,[13] but it is safe to say that a number of these businesses near the network will not possess an active or indeed any spur. The conclusion suggested by this exercise is that at least two-thirds, and perhaps four-fifths of US manufacturing sites have no on-line access to the railroad system.

The upshot is that most shippers require pick up and delivery at their facility to be handled by a truck, and utilization of rail service is predicated on transloading between modes. There are two primary types of transload and many subtypes:

- *Conventional Intermodal* involves the transfer of freight-carrying <u>equipment</u> – truck trailers or containers – between a rail and a road unit. The rail unit usually is some variant of a platform like a flat car, and the road unit is either a truck tractor to which a trailer may be hitched, or a tractor with trailing chassis, onto which containers may be placed. In most cases the equipment is designed or outfitted to permit transfer via a lift or crane, and thus is specialized for the rail environment in ways unnecessary for

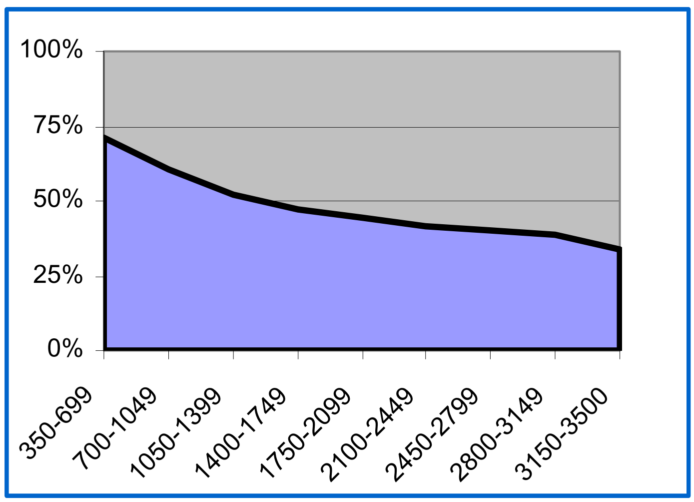
[13] In other words, the GIS network doesn't capture sidings. The 500-yard figure is a reasonable limit, and it is imposed as the crow flies, so that track distance may be greater and still fall within the cutoff. Longer sidings exist (some stretch a couple of miles), but they require large traffic volumes to sustain them, and topographical problems grow with distance. When the Mercedes auto plant opened in Alabama, its siding was perhaps half a mile long, and track construction required major investment by the State for highway bridging.

road operation. Subtypes includes bi-modal equipment (where the rail unit instead of a platform is a set of steel wheels swapped onto a modified trailer), Expressway-style equipment (where the rail car is a roll-on, roll-off platform that accepts standard, non-specialized highway trailers), and arrangements where tractors together with trailers ride on the rail platform (seen in some circumstances in Europe, but not currently in North America).

- *Carload Transfer* involves the transloading of goods between an ordinary rail car and a standard highway trailer. Subtypes include bulk transfer (such as the transloading of liquids via hose from railroad tank cars to tank trailers), break-bulk (such as the movement of metals via outdoor or indoor crane, from rail flatcars or gondolas to flatbed trailers), and finished automobiles (which are driven via ramp from railroad auto racks onto highway car trailers). This also is a form of intermodal transportation in the pure sense of the word, but for ease of reference, we will limit the term 'intermodal' to the transfer of equipment not goods.

Provision of rail access via transloading requires networks of on-rail facilities equipped to conduct the various forms of transfer, and trucking operations at each facility suited to handle the intermodal units or goods. The full spectrum of transload business demands multiple networks with distinct operations and few efficiencies of combination, and they need management and information support systems as well. Access costs are a major contributor to door-to-door transportation expense, and are the primary component of cost at shorter distances. The Exhibit "Intermodal Access Costs by Mile Block" demonstrates this for intermodal service. Extracted from the Virginia I-81 study and reproduced from the Task 2 case study, it displays lift costs plus pickup and delivery drayage as a percentage of total expense, by mileage door-to-door. As distance drops to 350 miles (the shortest haul examined in the study), access costs climb to 75% of the total. Two important implications should be drawn from this:

Figure 3-4 Intermodal Access Costs by Mile Block (2-End Dray)



- Given the importance of access cost, the requirement for transload and drayage at one end or both ends of a freight shipment becomes an essential consideration. Direct loading to rail in shipside or auto plant environments, for example, produces one-end drays that improve the economics for those shipments, and clearly single-end drays matter to the viability of short-haul rail. The carload transfer business is most often a one-end, destination dray.

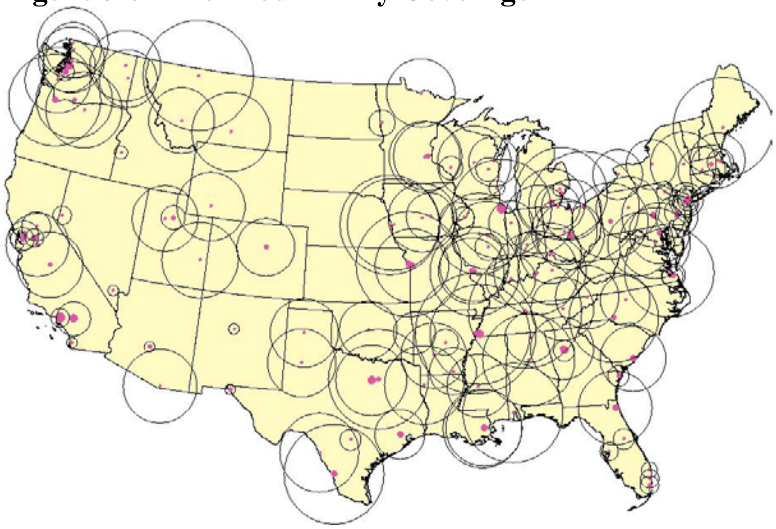
- The composition of access costs emerges as a critical factor. The absence of cranes and the heavy pavement to support them are an advantage to ramp-style terminals. The high rates of empty return associated with local intermodal drayage drive up its cost. An advantage to intermodal services with network motor carriers can be better load balance, produced by the situation of intermodal inside a larger trucking operation, and by the interchangeability of equipment.

The significance of access expense also points up a public planning policy lever. If public investment in terminal connections and facilities reduces transload expense, it improves the capability of rail to attract traffic. An experiment conducted for the Virginia I-81 project tested the influence of a diesel fuel tax credit aimed at intermodal drayage. The result was a boost in diversion from highway to rail, especially at shorter lengths of haul.

The effectiveness of the intermodal system at producing access is shown partially in the accompanying map "Intermodal Dray Coverage". It displays the dray radius[14] within which 80% of pickup and delivery activity occurs, for rail facilities that handle at least 1,000 annual units. Larger facilities appear as larger dots; the underlying data are drawn from TRANSEARCH, and reflect operations both of local draymen and network motor carriers. The map suggests reasonably thorough coverage of urban markets, and of territory as a whole in the East. Even so, there are gaps - notably in the Southwest and along the Gulf - and large portions of the less populated West are not served. Dray distances tend to be longer where there are fewer terminals or population is less concentrated, and at the East/West rail gateways along the Mississippi, where railroads will dray instead of interlining with one another. An important caveat to this display is that it does not capture the lanes where these terminals do and do not offer service. A full picture of traffic coverage addresses the questions of whether shippers can be reached by a terminal, and whether the railroad runs trains to the right destination markets. The map (**Figure 3-5**) shows the first, not the second.

[14] Radii for a given lane really have an elliptical, not circular shape, with most of the coverage area extending beyond the terminal and extending in the lane direction of travel. The reason is that a shipment is less likely to backtrack to a terminal and more likely to use one that lays enroute, because the former adds to cost and time versus an all-highway route, and the latter does not. Circles nevertheless are a reasonable display of coverage for the total collection of lanes that a terminal serves.

Figure 3-5 Intermodal Dray Coverage



A final and major implication of the conditions of access is the *urban problem*. As shown by the FHWA maps reproduced in the previous chapter of this report, congestion at root is an urban challenge, expanding through time from metropolitan districts into the roads between adjacent city pairs. The marginal public cost of heavy truck operation is materially higher as well on urban versus rural roads, for pavement, environmental, and particularly congestion elements.[15] Nevertheless, if railroad access is to be primarily via truck drayage, then it is precisely the urban areas that railways will find most difficult to relieve. Benefits from highway diversion will accrue to the regions through which the rail linehaul travels, but pickup and delivery will be consigned as before to the road.

The urban problem as an instance of access limitation is one of the chief obstacles to solving road congestion with rail diversion. While it is difficult, still it is neither a one-dimensional nor wholly intractable problem, as the following considerations demonstrate:

- Through truck traffic can be a substantial contributor to urban highway congestion in some segments, and is substitutable by linehaul rail. Moreover, as congestion threatens to grow well beyond city limits, its appearance on intercity routes can be headed off, at least in part, by rail alternatives.

- Direct rail access continues to exist, and can be exploited or extended in some circumstances. The competitiveness of carload service probably does not justify broad expectations for diversion (this is discussed further below), and this is the normal form for direct rail service to shipper doors. However, there are pockets of traffic where carload works and can work well, notably in dedicated train operations where service quality improves. Single-end drays are an important example of direct rail usage in the intermodal sector; port cities encouraging on or near dock rail, and factories capable of loading to rail at or beside their property, keep appreciable volumes of truck traffic off city streets. Capabilities of this sort can be developed, negotiated, or possibly zoned by city planners.

[15] 1997 Federal Highway Cost Allocation Study (FHWA)

- Proximal rail access is an attempt to establish or retain transload facilities so as to hold down drayage distances (and truck VMT). The previous chapter highlighted the national trend for railroad terminals to move to the urban periphery, where land is cheaper and more plentiful, the neighborhoods sometimes more accommodating and the roads less congested. This trend results in central business districts losing close-in rail service; a twin terminal strategy like that recommended in the Chicago Rail Futures Study (described in the chapter for Task 2) offers a resolution. In this approach, the peripheral terminal becomes a hub for suburban and exurban shipments, and builds shuttle trains for a downtown facility. Plentiful freight traffic in the Chicago market supplies density to justify the shuttle and the second terminal; in a smaller city, a public and/or share use facility could consolidate traffic, or underwrite costs with congestion tolls. A virtue of the ramp-style intermodal technology is that terminals are less costly and need less land, so it may be well suited for multiple facilities and central business district locations.

- Trans-urban corridors are a fourth way for rail to target city trucks. Motivations for existing examples[16] include line rationalization and reduction of road/rail interference, but they also diminish rail-based truck drayage, and conceivably could be directed toward cross-town truck traffic streams. An instance of the latter is the Chicago Transit Authority (CTA) air package express[17] scheme, described in the accompanying inset box. While this service is still in the planning stages and the associated volumes are light, it removes some of the most time-sensitive trucks from the city's most clogged roadways at the most valuable times of day. Here, as elsewhere, the support and conversion of the truck operators is essential to the prospects for success.

[16] The Kansas City Flyover and the Alameda Corridor presented in the Task 2 case studies are some, as are aspects of the proposed Chicago CREATE project.
[17] The CDOT/CTA-sponsored study was led by Reebie Associates, one of the authors of this NCHRP Report.

Case Study 1: The Chicago Transit Authority Air Package Express

In 2003, The City of Chicago Department of Transportation, with the Chicago Transit Authority (CTA), launched a market study to determine the demand for scheduled rail freight service between a downtown terminal and the two major Chicago airports, O'Hare and Midway. The goal was to tap spare capacity in dedicated baggage cars aboard the Airport Express transit service to carry freight, thereby by-passing the region's congested roadway network. The study found that the large integrated package express companies (such as UPS, FedEx, USPS, etc.) operating out of O'Hare see significant benefits to using the proposed service to reduce the need for large scale trucking along urban freeways during peak travel hours. Initially, the primary interest would be to use the rail service as a 'fallback' mode for when delivery deadlines are jeopardized as a result of severe congestion on the Kennedy Expressway. Progressively, as logistics chains are re-engineered to take advantage of the reliable service and the region's roadways become even more congested, the rail freight solution could become the least cost mode and an effective means to maintaining a high-quality service into the Chicago downtown. The primary contribution of rail freight in this case is to leverage the schedule reliability associated with a dedicated right-of-way transit service to allow a later last-pickup and a more efficient sorting at airport cargo facilities. If recurring highway congestion prevents reasonable package delivery windows from being met, the package express firm will suffer, but the productivity of downtown firms would also decrease, and Chicago will become less competitive for businesses relative to the suburbs and other cities.

The Chicago Express case demonstrates several important concepts in applying rail freight solutions to roadway congestion. Firstly, the direct benefit of removing trucks from highways may be marginal, and contributes relatively little to easing congestion that is predominantly attributed to commuting automobiles that demonstrate high time-of-day demand peaking and poor utilization of highway capacity. The entire Chicago Express scheme could remove about 20 trucks per hour in total, against a background of approximately 4,800 peak-direction vehicles that could theoretically move along the highway. However, the impacts of such schemes may be far more important than the marginally diminished congestion that motorists may experience as a result. The Chicago Express scheme attacks freight congestion in an area that is most leveraged: small packages are highly time-sensitive, urban corridors are highly congested, and removal of peak-hour vehicles has the highest value. The net contribution to the Chicago economy due to expedited freight packages may be substantial. Although such schemes may not have the system-wide impacts associated with the Kansas City Flyover and the Alameda Corridor, its significance for the City of Chicago cannot be understated. Since congestion occurs mainly in dense urban areas, intra-urban schemes such as this could be as effective as large-scale highway or railroad capacity expansion to provide for time-critical freight needs. Infrastructure investment in rail freight could allow rail to become competitive in commodities that require a higher level of service, and the efficiencies associated with rail transport may provide significant benefits to regional economies over other options, such as continued expansion of highway networks to accommodate peak-period traffic. An Urban Intermodal Network constituted from dilapidated branch lines and underutilized city yards could conceivably reduce both congestion and intermodal drayage times by minimizing truck moves through congested urban street network and funneling intermodal traffic to the intermodal 'terminals' located in suburban and rural areas more efficiently.

3.3.2 Addressable Market – Five hundred miles is the rule of thumb limit for the distance a truck can travel overnight in the US; originally it reflected the typical performance of a rested single driver on good roads over a ten-hour shift. Like any rule of thumb, it is not always and everywhere true. The hours of service regulations introduced by the US Department of Transportation in 2004 lengthened the driving shift to eleven hours, but straitened the definition of off-duty time. The effect is that a pure linehaul driver (like LTL carriers use, or truckload operators when pickup and delivery is a quick 'drop and hook') can take the overnight distance out to 550 miles and more; conversely, a driver tied up waiting for pickup or delivery, or physically loading and unloading trailers, can travel less far. Driver teams can manage a longer distance if they get an early start; distances are shorter when drivers are not fresh, or run many miles empty before starting off with a load.

Table 3-1 Length of Haul Distribution by Trucking Segment

LENGTH OF HAUL DISTRIBUTION BY TRUCKING SEGMENT (% of Loaded Trucks)											Source: TRANSEARCH
	All	Fleet Operation			Trailer Type						
Distance	Truck	Truckload	LTL	Private	Dry Van	Reefer	Flatbed	Bulk	Tank	Auto	Livestock
200 Miles & Under	74%	71%	55%	78%	75%	39%	61%	85%	70%	27%	52%
500 Miles & Under	91%	87%	75%	95%	92%	71%	85%	92%	92%	51%	68%
Over 500 Miles	9%	13%	25%	5%	8%	29%	15%	8%	8%	49%	32%
Proportion by Segment:		47%	1%	51%	69%	2%	5%	10%	14%	0%	0%
Proportion 200 Miles & Under:		45%	1%	54%	70%	1%	4%	11%	14%	0%	0%
Proportion Over 200 Miles:		53%	2%	44%	66%	4%	7%	6%	17%	0%	0%
Proportion Over 500 Miles:		69%	4%	27%	64%	6%	9%	9%	13%	0%	0%

The outcome of all this is that 500 miles probably remains an adequate measure for overnight distance over the road. In the most common business arrangement, shippers tender freight at the conclusion of the day and want to receive at the beginning, so the overnight distance describes the transportation service standard between the end of the work day and start of the next. Ninety-one percent of truck freight shipping falls within this limit, as the accompanying **Table 3-1** "Length of Haul Distribution by Trucking Segment" demonstrates, and some three-quarters of it lie within 200 miles.[18] Interestingly, 44% of all rail freight tonnage also moves within 500 miles, and 22% within 200 miles; however, rail transit times typically are much longer than overnight.[19] In intermodal services, which are the chief alternative when direct rail access is absent, and are the most substitutable for truck transportation, just 14% of rail tonnage is below

[18] The table is derived from Reebie Associates' TRANSEARCH database. TRANSEARCH coverage does not extend to some portions of local truck activity, which would raise the proportion at the shortest distances.

[19] The figures are from the 2002 Surface Transportation Board (STB) Carload Waybill Sample. The miles are rail miles, which are approximately 10% circuitous (longer) than highway miles, so the tonnage proportions on a highway mile basis would be somewhat less. The sample also is subject to rebilling error, which causes overstatement of short distance rail volume and understatement of long distance. It is nevertheless true that rail traffic outside of the intermodal business has a significant short haul component. The Table 'Rail Volume by Rail Miles and Class of Operation' appearing later in this chapter, presents a detailed mileage distribution.

500 miles and perhaps 2% is below 200.[20] For service reasons, and for reasons of access and costs that were explored above, it is difficult for rail to address the distance segment of the freight market where most of the truck traffic lies. This explains the acute interest among public planners in short-haul rail, and that subject is treated in detail further on in this report. Of course, greater inroads by rail into the medium and long distance markets still would reduce freight highway traffic by an appreciable amount, and matter to congestion in many localities. However, there are meaningful ways that these markets, too, are not being addressed by prevalent rail technology and practice.

Fifty-four percent of intermodal unit volume in 2003 was international containers ultimately tied to international trade, according to figures from the Intermodal Association of North America (IANA).[21] This proportion has climbed from 51% in 2000, and international units accounted for 73% of the intermodal volume growth during this period. Truck tonnage on US highways, on the other hand, is 95% domestic, and of the part that is international trade, about 40% is NAFTA traffic.[22] While rail intermodal has done a very good job in absorbing the transportation burden of US foreign trade, it has not been aggressively addressing the domestic highway market.

Domestic intermodal unit volume grew 8% from 2000 to 2003, compared to 22% for international units, again according to IANA. All of this growth was in domestic containers, since the trailer traffic dropped by 9%. Trailers accounted for only 20% of the intermodal business in 2003, down from 25% three years previously. The significance of these shifts is this: the domestic container is another specialized piece of intermodal equipment. It is designed to capture the cost saving of container stacking in linehaul train service; while the longer 53' units (which not all are)[23] have the same carrying capacity as a standard highway trailer, they have to be matched to and mounted on wheeled chasses to function over the road. The added expense, maintenance and management of a separate chassis fleet renders containers an inferior option for highway operations, and motor carriers normally don't deploy them. In consequence, the standard truck equipment seen on the road is not compatible with the principal type of intermodal service.

Highway trailers can be and are handled intermodally, but weight penalty require modification to suit the lift devices that transfer trailers onto railcars. Again, there is a need for specialized equipment. Moreover, and returning to information about trucking segments in the Table, there are significant portions of trailer activity that cannot be outfitted for intermodal lift: the box-type equipment (dry vans and refrigerated units) can

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[20] These percentages derive from the Carload Waybill Sample, which does not capture traffic that is local to shortline railroads. For the intermodal business this will not miss much, but there will be an under-statement of short distance carload traffic.
[21] From IANA's "Intermodal Market Trends & Statistics", fourth quarter publications for the corresponding years.
[22] Based on a Reebie Associates analysis conducted for the American Association of State Highway and Transportation Officials (AASHTO), using 1998 FHWA Freight Analysis Framework tonnage data, further adjusted for the international portion of intermodal dray. The international contribution to truck tonnage may have risen since then.
[23] International containers also appear in domestic service, but their smaller size (40' is the most common length) limit their utility against the standard 53' highway trailers.

be adapted, but 30% of truck traffic in medium and long haul lanes is flatbeds, tanks, and bulk trailers that cannot. Although there are alternatives – the isotainer, for instance, is a tank rigged for handling as a container – the equipment is even more specialized and less efficient. As a result, intermodal usage imposes a barrier of customized equipment, and even then there are important segments of the market it does not really address. One solution is the ramp-style intermodal railcar that accommodates *any* style of highway trailer, without modification; while these cars see very limited service today, they substantially enlarge the addressable market for intermodal rail.

The Table additionally points up the distinct characteristics of truck fleets:

- The private carriage of shippers and distributors that works mainly as a cost center in support of customer service and logistics strategy, and is heavily short distance;

- The much lower volume LTL segment that consolidates and distributes small shipments through terminal networks, runs full-load linehaul on regular routes between terminals, and is split between regional and long-haul service (although regional has grown more);

- The fragmented full truckload group, whose for-hire members range from national irregular route network carriers, through small regional lines and draymen, to the freelance independent contractors (owner/operators), and is the principal form of long-haul motor carriage but also figures prominently in regional and local markets.

The various segments also intermingle: truckload carriers make multiple stop pickups and deliveries and contract for LTL linehaul, while some LTL operators avoid terminals. The private fleet group is particularly fluid; it will add or subtract traffic with common carriers according to how its flows balance, and it will outsource operations entirely to commercial fleets, whose dedicated carriage adopts the functions of the private truck line.

The characteristics of truck fleets are pertinent for at least three reasons. First, to the extent that the intermodal customers are motor carriers whose linehaul is to be converted to rail, the nature of their business influences the requirements for operational integration. For example, LTL volume is concentrated in nightly departures with a fixed schedule to which the railroad must conform; truckload volume is spread during the day and has greater need for more frequent trains. Second, the traffic capture experience of railroads differs by segment. Private fleet business typically is difficult for railroads to attract, yet the Canadian Pacific has had success through its Expressway service; alternately, the outsourcing of private traffic to commercial truck lines can produce greater opportunity for rail participation.[24] Third, utilization of intermodal services requires trucking capacity to be in place at the pickup and delivery ends. For an independent contractor with one or a handful of trucks, this is out of the question, unless the load is (improbably) interchanged with another operator. The equipment and driver deployment of regional and private fleets is similarly sparse, so that railroads cannot convert these loads and must

[24] These conclusions come from conversations by researchers with railroad officers, and from direct observation.

win them away from their current carrier. One way this can be done,[25] however, is truck-to-truck diversion: when large network carriers capture business from smaller operators, the deployment obstacle is reduced and the traffic becomes rail-convertible. From this perspective, defragmentation of the trucking industry is desirable for rail.

Another, more subtle aspect of compatibility is concerned with the integration of rail with highway operations. Because intermodal services are dependent on trucks, they should be understood as a variant form of motor carriage, as much as they are a variant of rail, and they need to be effective as such. American intermodal trucking falls into two broad categories:[26]

- Intermodal marketing companies (IMCs), who are specialists in rail-based services, historically depended on equipment owned by other parties, and provide pickup and delivery as draymen; and,

- Network motor carriers, who offer road-based services, own their equipment, and perform intermodal pickup and delivery as a subset of their larger operation.

Inevitably there are ways these distinctions become blurred, but both categories need density to be efficient: loads must be balanced, and assets must be deployed in proximity to traffic sources. High rates of empty return are typical for rail-based services (as they are for most local trucking); for cost and performance reasons, this tends to keep equipment deployment near the ramp, and more remote business isn't handled. Road-based operations have greater loading options, and the balance advantage of an irregular route, non-local, multimodal system. Equipment deployment tends to be more ubiquitous and so closer to more shippers, and empty return rates probably are better; it is certainly true that the serving radius from an intermodal ramp is longer with road-based than with rail-based operations.[27] This profile may contribute to the trend among IMCs to develop highway business: an IANA survey found rail and highway loads nearly equal among respondent IMCs in 2003, with the latter growing and the former not.[28] Highway operations also boost the feasibility of the extended length, enroute dray. While the normal intermodal dray is under 100 miles, extended drays are run like a highway load, traveling hundreds of road miles toward the delivery point, then intercepting and using rail ramps along the way with little out-of-route[29] mileage. The service area of intermodal ramps is orders of magnitude longer for the lanes that lie enroute.

Compatibility of equipment between intermodal and over-the-road *operations* becomes important, because the blending of highway with rail networks creates greater drayage

[25] The obstacle also is eliminated when the tractor and driver travel by rail with the load, as some European services allow.
[26] American railroads for the most part do not supply intermodal trucking services. Currently, the most prominent exception is the Norfolk Southern Triple Crown division, which nevertheless accounts for a minority of NS intermodal business.
[27] Internal analysis by Reebie Associates from primary sources found the road-based intermodal serving radius to be 50% larger than the rail-based radius.
[28] IMC revenue still was two-to-one in favor of intermodal business. Source: IANA, op cit.
[29] Out-of-route mileage is deviation from the normal highway route of operation, and is an inefficiency because of the added cost and time of extra, circuitous travel distance.

efficiency and wider rail access. The stress on the word 'operations' is significant in distinction from 'environment': the specialized equipment that dominates the intermodal rail environment all functions on the road, yet it is not the equipment of choice for carriers in the highway network. In consequence, the specialized units are leashed to the railway network, and fleet balance[30] must be produced inside a system that is far smaller than the roadway and has many fewer balancing flows. Utilization of intermodal services thereby is constrained and the size of the addressable market again is reduced;[31] conversely, free flow of equipment between railroad and highway operations substantially releases this constraint.

These considerations can be summarized as the issue of *interoperability* between highway and rail, and it is another of the key barriers to traffic diversion. Equipment compatibility restrains the integration of networks, narrows the breadth of access, and limits the size of the market railroad solutions can target, with the result that intermodal as a class of truck operation is less effective. Thus, there are strictures upon the segments of the highway freight market that rail is able, or else currently designed to address. They are due to the emphasis on international container trains and the problem of interoperability, the character of truck fleets, and to the effect of transloading on serviceable distance. The question of design is made more difficult by the limits that also exist on railroad capacity and capital, coupled with the fixed cost of train starts. The fact is that a container stack train can carry more revenue-producing boxes than a trailer train simply because of its second tier, and so usually produces a better return per unit of capacity, capital, and train commitment. Stack trains then are favored for a good reason. However, railroad decisions about the market they prefer to address tend to institutionalize their preference in technology and methods of operation that are not the best suited to the domestic freight market. While the many containers hauled by rail should be appreciated as relief of the roads, they also denote an *institutional* barrier to diversion of the common highway trailer tied up in most of the traffic jams of the country.[32]

[30] These issues are prominent in the thinking of major network motor carriers working with rail: the carriers restrict their rail usage to assure fleet balance, and they press their rail partners for expansion of the high performance intermodal network to enlarge their options.

[31] Fleet balance is the way equipment is resupplied to a shipper after it departs with a load. Simplistically, the unit can come straight back empty, or reloaded with a different shipment, or it can work its way back through triangulation, or a more complex irregular route loading pattern.

[32] This barrier may be undermined even now. A 2003 study by the railroad equipment cooperative TTX (TTX op cit) documents a trend toward container stripping at West Coast ports. This signifies that containerized import goods are being transloaded and remixed with domestic product into highway trailers, and it reflects an effort by retail chains to defer selection of the final destination of consumer goods, in order to respond to point-of-sale information. On the one hand, this development should stimulate a new and concentrated demand for trailer services; on the other, railroads probably will prefer to respond with domestic containers and rail-modified trailer equipment. While a net effect that encourages introduction of intermodal trains that are more compatible with the domestic market seems unlikely, still, a new opportunity to pierce institutional barriers may have arisen.

3.4 MARKET SEGMENTATION

Market segmentation is a basic approach to understanding buying behavior, establishing the differential requirements of customers, and determining where a product or service would or could find its best appeal. Buying behavior and service appeal, in a competitive context, lie at the core of diversion dynamics for any kind of business. The question becomes, what is a practical way to employ segmentation to describe the barriers and opportunities, for the shifting of freight business between highway and rail.

3.4.1 Demand Side – To this point, market and diversion issues have been discussed in terms of shipper needs and trucking characteristics. These can be called the retail and the wholesale perspectives:

- *Retail* encompasses shipper supply chain factors, such as industrial, commodity, and geographic composition; time performance requirements; and the configuration of customer orders, because it is a determinant of the size, frequency, and volume of shipments.

- *Wholesale* takes in the service requirements, equipment specifications, and operational features of the carriers of goods, who may tender their loads to railroads: parcel, LTL, and full load truck lines, independent contractors, private operators, steamship companies, and intermediaries.

The retail perspective is a traditional level for market research and would seem to be basic for diversion analysis. However, information about its components is not systematically available from transportation sources, and can be fragmented so as to be heteroskedastic for analytic purposes. This doesn't demean its value and there are ways to use it,[33] but there are other methods that more readily produce planning guidance.

Use of the wholesale perspective is one. It is informed and shaped by the retail (because wholesale needs incorporate and respond to retail needs), captures aspects of service and shipment size through summary dimensions like equipment types, and it is the wholesale level at which major railroads for the most part try to do business. For example, temperature-controlled equipment (which includes refrigerated vans, or "reefers") describes a segment of the market that tenders mainly full loads outside of the local sphere, can be adapted for intermodal loading, but has stringent service and monitoring requirements that are challenging for railroads to meet. Shippers in this market are not all alike – frozen goods and produce are more sensitive than chilled foods, and differ from chemicals that need temperature protection – but they are broadly alike, and this forms a constructive way to distinguish a sector of the market. The wholesale level also is quite effective for the competitive analysis that is essential for diversion estimation, because in a number of instances the wholesale customer is both a potential client and a modal rival, so that the client's needs from the railroad reflect the rival's performance characteristics.

[33] The treatment of diversion modeling, below, shows one.

3.4.2 Supply Side – These are demand-side factors. There are benefits, too, from examining the supply side. The chief of these is that it gets at the operating economics that are critical, both to the qualities of service and to the transportation costs on which customers are acutely focused. A primary analysis starts from division of rail operations into the three classes used elsewhere in this report: unit train, carload or 'loose car', and intermodal services. The Chart "Rail Freight Typology" (**Figure 3-6**) lays out these classes and shows how they differ in the dimensions of markets and economics. (The Chart identifies differences in public benefits as well, which will not be taken up here but will be returned to later in this research). Like any set of generalizations, some elements of the typology will be found arguable by some observers; it is intended, however, as an overview of the major railroad business groups, and it is functional as such.

Figure 3-6 Rail Freight Typology

RAIL FREIGHT TYPOLOGY				
DIMENSION	**ELEMENT**	**UNIT TRAIN**	**CARLOAD**	**INTERMODAL**
Markets	Commodities	Coal, grain, minerals	Chemicals, forest, bulk food, metals, waste, auto parts	Merchandise, automobiles
	Competitive dynamic	Rail dominion	Eroded dominion Network access issue	Competitive, divertable
	Intermodality	Water; truck gathering	Truck (bulk transfer, breakbulk)	Marine & truck
	Service requirement	Equipment turnaround	Equipment supply	Speed & reliability
	Captivity	Some	Some	Little or none
	ASPECT	**UNIT TRAIN**	**CARLOAD**	**INTERMODAL**
Economics	High empty return	☑	☑	No (but imbalance affects)
	Private/Sequestered equipment	☑ (not grain)	☑	Box, not car
	Heavy, periodic eqpt. demand	☑	No	International marine
	Long haul	Mixed	Mixed	☑
	High lane density	☑	No	☑
	Heavy axle loads	☑	☑	No
	Serves commodity business	☑	Usually	No (but transport a commodity)
	Operational	Door-to-door Non-stop	Door-to-door Intermediate switch & interchange	Ramp-to-ramp Intermediate mixing & interchange
	Capital	Self-funded Traditional Baseload (sine qua non)	Mainly unfunded	Under-funded New Baseload
	BENEFIT	**UNIT TRAIN**	**CARLOAD**	**INTERMODAL**
Public Benefits	Bridges & pavements *(heavy axle loads)*	☑	☑	No
	Congestion & capacity	Avoided traffic	No (but rail is door-to-door)	Avoidable traffic (highway relief)
	Private maintenance & security *(pertinent if public investment)*	☑	☑	☑
	Economic development	Cost of production Viability of plant	Production costs Rural communication	Supply chain efficiency
	Defense	☑	minor	☑
	Emissions	☑	☑	☑
	Fuel efficiency *(today, a national security benefit)*	☑	☑	☑
	Safety *(truck perception; freight separation)*	Avoided trucks	Hazmats; positive record	Avoidable trucks

- The Unit Train business handles high volume bulks like coal and grain in trainload quantities. Dedicated operations make time performance fairly good, and the emphasis of service principally is the turnaround time of equipment to keep shippers resupplied. Dense, non-stop, door-to-door transportation in imbalanced lanes conforms to railroad strengths, and this is the traditional baseload of the industry.

- The Carload group carries industrial goods, chiefly for further processing, in mixed train consists that require intermediate switches (which is essentially a kind of hubbing). Shippers who can use this service typically are focused on equipment supply and low cost transportation for higher lading weights, because performance can be slow and erratic: in a 2004 anecdote, a metals shipper reported to a researcher carload transit between seven and forty days over a 1,400 mile haul (truck transit would consistently be three days).[34] The time and cost challenges of handling non-unitized, loose cars has caused this historical traffic of the railroads to contract steadily, as heavy manufacturing also has diminished in the American economy.

Table 3-2 Rail Volume by Rail Miles and Class of Operation

RAIL VOLUME BY RAIL MILES & CLASS OF OPERATION								
Source: 2002 CWS; no rebill adjustment								
TONNAGE (000's)	TOTAL	UNIT TRAIN ≥ 50 CARS	CARLOAD < 50 CARS	INTER-MODAL	TOTAL	UNIT TRAIN ≥ 30 CARS	CARLOAD < 30 CARS	INTER-MODAL
All Tons	2,090,835	982,644	935,778	172,413	2,090,835	1,061,617	856,805	172,413
% of Tons	100%	47%	45%	8%	100%	51%	41%	8%
< 100 Miles	260,929	149,343	109,187	2,399	260,929	174,449	84,082	2,399
% of Tons	12%	15%	12%	1%	12%	16%	10%	1%
< 200 Miles	456,647	240,722	212,331	3,594	456,647	282,738	170,315	3,594
% of Tons	22%	24%	23%	2%	22%	27%	20%	2%
< 500 Miles	927,566	443,100	460,476	23,990	927,566	508,278	395,298	23,990
% of Tons	44%	45%	49%	14%	44%	48%	46%	14%
> 500 Miles	1,163,269	539,544	475,302	148,422	1,163,269	553,339	461,507	148,422
% of Tons	56%	55%	51%	86%	56%	52%	54%	86%
UNITS (000's):								
All Units	33,366	9,187	12,641	11,537	33,366	10,014	11,814	11,537
% of Units	100%	28%	38%	35%	100%	30%	35%	35%

- The Intermodal business[35] moves consumer goods and general merchandise, half of it imports and exports, primarily in solid trains with some intermediate hubbing. Service is among the railroad's best, and although it is mostly slower than highway, on premium trains or in well-developed lanes like Los Angeles – Chicago, it is fully the equivalent of over-the-road. Intermodal trains run in a smaller, more concentrated network than carload traffic, but in these markets they are at the front of modal competition between highway and rail. The American Association of Railroads expects[36] the Intermodal business became the top source of Class I revenue in 2003, surpassing coal and in some ways rendering itself the new baseload of the industry.

[34] Train speeds are another measure. The manifest trains that bear loose car traffic are regularly the slowest, and intermodal trains the fastest class of service, with unit trains lying in between. Railroads publish such statistics, but one citation showing this pattern is trafficWORLD, 3/8/04, page 30, where there is a table of comparative speeds on the Union Pacific.
[35] Finished automobiles have been grouped with conventional intermodal here, while carload transfer business has been classified with carload.
[36] Reported on the AAR website. Expectations will be updated with facts when they are released.

The **Table 3-2** "Rail Volume by Rail Miles & Class of Operation" shows the relative magnitudes of the three business groups in physical terms. Using a minimum block size of fifty cars to define a unit train, the carload and the unit train groups are about even in volume and account for most of the tonnage, with the light-loading intermodal much smaller. However, substituting unit volume to adjust for load factors makes the three groups roughly equal in size at around one-third of the traffic each, with the carload somewhat the larger and unit trains somewhat the smaller. The Table depicts in addition the length of haul profile of the groups, displaying substantial short-haul activity for carload and unit train yet not for intermodal, as mentioned before. (Applying the units instead of the tonnage measure has no effect on the distance distribution of the three operating classes.) It is important to notice the way the traffic split changes when the definition of a unit train is reduced to thirty or more cars from fifty: the unitized business climbs to become clearly the tonnage leader. This underscores how consequential car blocks are to railroad traffic, especially under 500 miles where 80% of the definitional shift occurs. Below the thirty-car threshold are smaller groups of five, ten, and twenty, all of them aiding operating economics and forming major constituents of trains. Loose cars in this sense are not entirely loose.

There are two further points in this context:

- The size of trains is variable. They have a heavy fixed cost component for crew, power, and marshalling, so there is a potent reason to run them large, up to the limits of siding lengths (sidings allow trains to pass one another). However, solid blocks improve the marshalling (pickup, delivery, hubbing and interchange) costs of trains, and keep smaller ones viable. Capacity is another consideration. When track space is constrained, consolidation of traffic into fewer, bigger trains uses less of it.

- Car blocks normally are multiple cars moving under a single bill from one shipper to one receiver. In the conventional intermodal and carload transfer business, it is different, because transloading performs a kind of consolidation function, allowing blocks to derive from multiple shippers grouped around single *geographic* origin and destination points. This is the same benefit small package and LTL truck lines obtain from consolidating intercity freight at terminals, which in turn permits rail to participate in the small shipment market through terminal linehaul transportation.

Car blocks signify lane density, and lane density both augments and trades off with distance in its competitive influence. This is demonstrated in the matrix **Table 3-3** "Modal Market Share by Lane Density & Distance", which presents the progression of market share for conventional intermodal rail, as highway miles lengthen and lane volumes grow. The market here is defined as over-the-road dry van trucking, that being the wholesale sector where the standard intermodal product competes; it is also the largest sector of the trucking market accounting for two-thirds of the volume, as was shown in an earlier part of this chapter. Lanes are origin-destination pairs of Business Economic Areas (BEA) metropolitan markets,[37] this being a pragmatic way to reflect the

[37] The federal Bureau of Economic Analysis divides the nation into 172 metropolitan areas, based on the economic relationships of counties and covering all of the geographic territory of the fifty United States.

consolidation effect of terminals within the definition of an economic region. Two additional technical factors affect the table: a) it excludes truck volume outbound from wholesalers and distribution centers, because this is regional and local traffic for which rail intermodal does not compete – if included, over-the-road (OTR) market share below 500 miles would go up; and b) an attempt has been made to correct for rebilling in railroad statistics, which diminishes intermodal (IMX) tonnage and locates more of it in long-haul lanes.

Table 3-3 Modal Market Share by Lane Density and Distance

MODAL MARKET SHARE BY LANE DENSITY & DISTANCE
RAIL INTERMODAL (IMX) Vs OVER-THE-ROAD (OTR) DRY VAN TRUCK

Source: TRANSEARCH 2000

HIGHWAY MILES	LANE DENSITY (Annual Tons [000] by IMX+OTR) < 100		100 - 400		> 400		Total	
	IMX	OTR	IMX	OTR	IMX	OTR	IMX	OTR
1-100	0.1%	99.9%	0.1%	99.9%	0.4%	99.6%	0.4%	99.6%
100 - 299	0.3%	99.7%	1.1%	98.9%	1.4%	98.6%	1.3%	98.7%
300 - 499	0.8%	99.2%	2.3%	97.7%	3.6%	96.4%	3.0%	97.0%
500 - 699	1.3%	98.7%	5.8%	94.2%	11.1%	88.9%	6.6%	93.4%
700 - 999	1.3%	98.7%	8.3%	91.7%	27.2%	72.8%	12.6%	87.4%
1000 - 1499	2.6%	97.4%	8.7%	91.3%	28.1%	71.9%	11.4%	88.6%
>1500	7.3%	92.7%	24.8%	75.2%	62.0%	38.0%	37.1%	62.9%
Total	2.4%	97.6%	6.6%	93.4%	8.2%	91.8%	7.0%	93.0%
Total > 500	3.0%	97.0%	10.8%	89.2%	33.8%	66.2%	16.8%	83.2%
Total < 500	0.6%	99.4%	1.5%	98.5%	1.5%	98.5%	1.4%	98.6%

MARKET SHARE KEY:
OTR TRUCK ≥ 80% BOTH < 80% IMX RAIL ≥ 80%

The matrix displays intermodal market share clearly and consistently climbing with distance and lane density. It rises as mileage rises within each category of density, it rises as lane volume rises within each category of distance, and the combined influence of these elements (the diagonal vector of the table) generates the strongest gains. This share pattern is a direct result of service economies: railroad service performance and unit costs both improve as the linehaul component overtakes pickup and delivery in the transportation mix, and as the railroad production function is satisfied with train-lot quantities. Over-the-road trucking shares the economies, but less strongly, and the competitive balance moves in the direction of rail. The same relationship holds for other equipment types, and it has held historically:

- Matrix analyses for flatbed and bulk equipment showed an equivalent pattern, although the progression was less pronounced and rail share was greater in cells where short distance unit trains operate.[38]

[38] These were 1996 Reebie Associates analyses conducted for the FHWA Truck Size & Weight study, comparing non-intermodal rail to over-the-road trucking in these equipment groups.

- A version of the dry van/intermodal matrix prepared[39] five years earlier exhibited a like progression, and higher market shares. The railroad service disruptions of the latter 1990's, combined with vigorous economic growth that rail was not positioned to enjoy, drove intermodal market shares downward in the intervening years.

As a method of market segmentation, the intermodal matrix reflects a hybrid of demand and supply-side features. Equipment type captures demand at the wholesale level, in the market sector where intermodal principally operates. Distance and density are supply elements in that they embed, and in a sense are proxies for, service and cost characteristics of the intermodal product, which are the properties that customers care most for. They are demand elements as well, because they are descriptions of market activity, just as equipment type has a supply-side facet through its connection to technology. Market share introduces a competitive dynamic that is critical to the understanding of diversion and its opportunities, and is helpful as a depiction of competitive fronts. The upper left half of the matrix can be understood as a truck domain, and the lower right corner as something of one for rail. For rail to improve its penetration and produce relief to highways, it must be able to exploit business in its own domain with capacity and additional services, and it must be able to push across the matrix vertically and horizontally for smaller gains, and diagonally for larger ones, with new classes of product. The location of push is the front. For intermodal in the latter 90's, the line was rolled backward, but for the rail business as a whole, it has been on the intermodal front that traffic gains have been made.

A final supply-side factor with telling influence on the competitiveness of rail is access. The conditions of access, and the forms of drayage and transfer when access is not rail direct, are determinants of service, cost, and the addressable market. These points were explored earlier in this chapter; suffice it to say here that pickup, delivery, and transfer are major ingredients, and sometimes the principal ingredient, of door-to-door performance. Their demand-side implications are straightforward and profound.

In summary, the freight market can be segmented in three primary dimensions that are both meaningful, and broadly measurable for the question of rail relief to roadways. They are the classes of rail operation, the conditions of access, and economic geography, by which is meant the combination of wholesale trucking characteristics with geographic service economies that was condensed in the competitive matrix. The **Table 3-4** "Dimensions for Market Segmentation" recapitulates these classes. They utilize supply and demand-side features, and in the former there are demand elements also signified or embedded. They are not the only productive method for segmenting freight markets, but they are usually a relevant method, and treat questions about business conditions that need to be answered.

[39] For Reebie Associates internal research.

Table 3-4 Dimensions for Market Segmentation

RAIL OPERATION	ACCESS CONDITIONS	ECONOMIC GEOGRAPHY
▪ Intermodal ▪ Unit Train ▪ Carload	▪ Drayage • Rail Direct • 1-End, 2-End Dray ▪ Transload • Unitized Lift, Ramp • Bulk Transfer • Break-bulk	▪ Distance ▪ Lane Density ▪ Equipment Type ▪ Competitive Modal Share

For diversion estimation in particular, segmented market shares offer benchmarks by which to categorize susceptible traffic, or can be developed further into predictive models. Data for this can be assembled from sources like the Carload Waybill Sample, public information like the federal Commodity Flow Survey, commercial databases, traffic surveys, and even planning model trip tables if they are robust enough. Equipment types can be observed directly, found in some data sources, or extrapolated from industry or commodity information using bridge tables, or with carrier cooperation. The differentiated comprehension of markets produced in this way supplies a basis for understanding the significance of barriers to diversion, and the opportunities to reduce them.

3.5 BARRIERS TO DIVERSION

The diversion of freight traffic from highway to rail is restrained by a series of obstacles. Several have been developed in the course of this chapter's discussion, and the ground has been laid to identify others. They can be encapsulated in nine kinds of barrier, under the general categories of market viability and institutional readiness.[40] The nine are all in some fashion business issues; in addition, there are public issues inhibiting modal shift. Both types will be recounted in this section, bringing focus to the key points, and utilizing but not repeating treatments that are offered elsewhere in this report.

3.5.1 Market Viability - Market viability factors affect the acceptability, competitiveness, and logistical efficiency of rail service for the customers. The major diversion barriers are four, and reflect on the immediate practicality of projects for planners:

- *Equivalence* is the comparability of the door-to-door rail product to over-the-road alternatives, and its suitability to the requirements of supply chains. Encompassed are the thresholds of service performance and delivered cost, the typical yet not universal position of rail as an inferior good, and the service windows of shippers in the context

[40] Like any reduction of complicated issues to a classification scheme, there are other ways to parse the material. The approach here aims to cover the essential items fairly completely, and to organize them succinctly for planning use.

of distance, which can allow or disallow rail operation. An example of the last is the common customer expectation for overnight service in the shorter lengths of haul, where complex staging operations simply take too long.

- *Access Limitation* determines the character of door-to-door service as direct rail or as transload, and the presence of a single or two-end dray. It introduces the need and specifications for transfer facilities, the efficiency and circuity of pickup and delivery, the time and cost penalties associated with these elements, and the urban problem, by which rail may not physically reach into the congestion on metropolitan roadways.

- *Interoperability* is the faculty of rail, in the conditions of transload, to interchange smoothly with motor carriage. It embraces particularly the compatibility of equipment, the domestic appeal of service, the breadth of the addressable market, and the integration of rail in the operating networks of truck lines.

- *Density* shapes the frequency of service and the productivity of assets, but its primary aspect for railroad functions is the vector and confluence of market volume. This characteristic supports or will not support trainload operations, requires or avoids intermediate staging, and permits or may prohibit the production of service economics, all with profound effects on competitive performance and the sustainability of service.

3.5.2 Institutional Readiness – Institutional readiness describes the capability of railroads in physical, financial, and organizational terms to attract and retain additional volume from highways. There are five prominent barriers to diversion:

- *Capacity* is the magnitude of line, terminal, and siding infrastructure for the physical and functional accommodation of train operations, including factors like signaling, clearances, and weight limits. It is a tangled consideration in networks, and it has become a significant hindrance to railroad growth, after the great attenuation of the system in the second half of the 20th Century. Labor, power, and carrying stock also are components of capacity. The effective value of the latter is a consequence of turnaround cycles, which in turn are interrelated with service and the flow across infrastructure. Labor output is affected by regulation and bargaining agreements, and manpower shortages are common in much of the freight industry.

    - An instructive example of the intricate nature of capacity and its interference with diversion comes from the Union Pacific in 2004. A premium intermodal train for a major motor carrier, designed to produce highly competitive four-day transcontinental service, created system congestion and delays for other trains. Limitations of track, siding, signaling and labor capacity, coupled with the need to create headroom (a clear lane) for the much faster intermodal train, created cascading disruption for other operations that lasted weeks.[41]

[41] "Freight Car Congestion Worrying Union Pacific", The New York Times, 3/31/04.

- *Capital* is the constraint of funds for investment in capacity and new services, which leaves railroad networks undersized and divertible traffic on the roads. Because capital rationing pushes internal hurdle rates to high levels, there are important consequences for retention of operations and prioritization of projects: viable opportunities and services are neglected or dropped because profitable traffic isn't profitable enough. In the exceptionally capital-intensive industry that railroading is, constraint of funds is a major barrier to new initiatives and a strong influence on carrier behavior.

- *Institutional Commitment* is the in-place investment of financial and human resources in a course of action or way of doing business. It causes change to be encumbered, and new ways of operating to face higher asset costs and fewer network benefits than continuance of the old. Partly, it manifests the business franchise that companies build up through the years, with their customer relationships, and interlinked traffic and asset deployments; and partly, it depicts the engrained implications of capacity and capital restraints. The latter is exemplified by the railroad's general preference for stack trains in intermodal service, because of their superior revenue per foot of train and track, and per dollar of train start (among other motivations), even though there are drawbacks for the domestic market.

- *Institutional Structure* acts as a barrier when company and industry organization cause the railroad network to function in balkanized segments, instead of an integrated whole. Private studies[42] have shown railroad market share to be materially higher in territory where carriers offer single-line service, than in interline areas. Railroads commonly cite single-line operation as a fundamental argument in support of merger applications, pointing to service and efficiency benefits and the effects of network expansion. There are motivational aspects as well: two railroads interchanging traffic in a given lane have shorter hauls than if they could handle the traffic themselves, plus they face less productivity from linehaul, and an obligation to divide the profit contribution. This produces the under-served markets of the so-called watershed areas, that straddle the territories of two rail systems,[43] and it has an influence on the opportunities and relationships between shortline and Class I railroads.

    - The Alameda Corridor offers another perspective on the motivational component. There, the local authority purchased the right of way to be upgraded, *and* it bought out all of the competing routes, so as to assure that the user railroads would not favor their own track ahead of the public facility.

- *Sustained Performance* is a crossover issue between the categories of viability and readiness. If a railroad can introduce but not maintain competitive service, or if it

[42] The authors of this report conducted such studies in the mid-90's, and are aware of others also done privately that produced the same conclusion.
[43] The lane between Nashville TN and Dallas TX is one of many examples. The 660-mile total distance is a haul length where railroads are active, yet the lane crosses between the service regions of eastern and western rail systems. With a 210 mile run in the east and 450 miles in the west, the business opportunity is less appealing to both carriers.

withdraws service in favor of another use for its assets, then traffic diversions are lost. Moreover, because utilization of service builds and matures through time (following a typical product life cycle curve), traffic shifts do not reach their peak for an extended period after a competitive operation has opened. Sustained performance touches on market viability in that the projected demand for a service may not materialize, causing its discontinuation as a modal alternative. It has been categorized as an institutional issue, however, because of the significance of carrier behavior and choice in the matter, reflected in an essential inability to perform as required, or in organizational dynamics and economic incentives that produce the same result.

- Start-up risk is a specific and important instance of this barrier at work. Departments of operations frequently are cost centers for railroads and other freight carriers alike. Start-up services impose most of their costs long before they generate most of their revenue, and there is professional skepticism among the parties responsible for expenses about expected returns. Transportation services most often are produced daily during the work week, traffic activity rarely is consistent day to day, and train starts – like scheduled linehaul in other modes, and as noted above – have a high fixed cost. There is a powerful *daily* incentive in operating departments to hold linehaul departures for more volume, or to consolidate them, and this normally means a penalty for on-time performance. Intermittent service then interferes with the retention of new business, there is more reason to withhold departures, and in time the service is killed entirely for lack of volume. Obviously this is a vicious cycle, and it can be undone with discipline and financing, but it is a frequent problem in freight transportation, not just at the lane level, but company wide when there is an organizational movement to raise performance.[44] In a sense, a train that only runs when it has sufficient volume will cease to run at all,[45] and while it is hardly irrational to control costs, operating expenses in new ventures essentially work as investments, though they are not accounted for as such. This means that the ventures may have to run at a loss until they earn customer confidence and attract adequate business, and during this period the operator is assuming a risk.

3.5.3 Public Obstacles – Public obstacles to the use and support of freight rail, and thus of its ability to capture new traffic, are treated in other chapters of this report and for the most part, will not be rehearsed here. Nevertheless, there are two public barriers that shall be cited now for emphasis, because they exacerbate the challenges of readiness and viability that have been under discussion in this section.

- *Public Acceptance* is the first of these. For almost any kind of freight, the reluctance to accept traffic in populated districts seems to be widespread, and there is a

[44] Private conversations with railroad officials trying to institute scheduled operations confirm this; scheduling confronts precisely this issue.
[45] The practice of running linehaul departures on schedule, whether full or not, was called "positive pull" by the air freight firm Federal Express in the early 80's. The term implied that volume would follow service. What it meant organizationally was that profit responsibility moved from the operations to the marketing group, who then had to keep the planes loaded.

preference for out of sight, out of mind. Citizens want fewer trucks on the road but not more trains, and the construction of new lines as well as new facilities face local in addition to environmental concerns,[46] with delays stretching into years. As an earlier chapter noted, this has caused some railroads to view facility capacity as fixed. The crucial difficulty is that this not only prevents acceptance of substantial new volumes, it also spurs the process by which the railroad traffic mix is culled for only the most profitable traffic over lofty hurdle rates. The public and the carrier financial interest are not necessarily aligned in these conditions.

- *Competitive Account* is the second barrier. Diversion is a two-sided process because it involves competitive interaction, and competition is about *relative* position. The great decline of the American railroad business traces more than anything to the advent of the interstate highway system, and it remains true today that roadway investment has a downside for the viability of rail. While the competitive result of rail projects can be mitigated by the ability of motor carriers to use rail for their own benefit, the reciprocal case may be a weaker one. With some exceptions, public road projects do not take account of their consequences to rail – and with many of them the consequences may be subtle, but they are also cumulative. Whether it is improbable or not that this behavior ever will change, the failure to take competitive account of highway project effects is an entrenched barrier to modal diversion.

3.6 LEVERS FOR DIVERSION

The countering case to barriers to diversion is the levers that may aid it. This section will consider the public levers, leaving the private – productivity programs, service strategy, technology deployment, and others – to the railroads. The topic of levers, because it is a creative subject where new approaches may flourish, will be taken up again in the later stages of this research. This initial treatment should be understood as an introduction of the subject, and not as definitive.

In light of the narrative in the preceding section, the most obvious lever is the *two-sided character* of diversion. Actions or inaction that influence the efficiency or service quality of motor carriage have an effect on the competitive balance with rail. It is not in the public interest to interfere with the performance of truck transportation when it is the way the vast majority of goods travels to market, including a large number that travel part of the distance by air, water, or rail. Conversely, there are initiatives that on balance may be judged to be in the public interest, that nevertheless impose a penalty on truck lines. Tolling of roads is an example of this; another is the 2004 update to the federal hours of service regulations for truck drivers. This update was designed to improve road safety, but it also reduced labor productivity for some classes of truck shipments, with a benefit perhaps for rail. It is worth noting for the objective of this research that a laissez-faire

[46] The break-up of Conrail saw great resistance to higher train volume through Cleveland, OH. In the I-81 study referenced before, the authors observed that construction of certain new and better routes was ruled out by the state, because of citizen resistance in well-heeled rural areas.

approach to congestion relief gives an advantage to rail, when the bottlenecks affect linehaul transportation, and that rail-based reduction of roadway congestion is of help to the trucks that do not divert.

Public financing is another obvious mechanism, suited to the equally plain purpose of removing capital and capacity constraint. The issues surrounding its use are presented sufficiently well elsewhere; in this consideration of levers, there are four points to underscore:

- Funds can be used to elicit a quid pro quo from the recipient, naturally enough. Therefore, financing agreements can be linked to steps that reduce the barriers of interoperability and institutional commitment, and thus widen the market to which publicly backed rail services may appeal.

- Similarly, public financing changes the internal priorities of railroads, and can be utilized to move projects of benefit to citizens – such as congestion reduction – to the top of the list for action.

- Funding tactics may be aimed at particular elements in the competitive economic equation, in order to encourage a given class of service. Financing of terminal projects and drayage equipment, for example, or tax benefits for dray operators, would tackle the main components of door-to-door cost in short distance transload lanes.

- Start-up risk can be mitigated with limited-duration operating subsidies, protected by performance and marketing covenants. Alternately, to avoid public absorption of operating expense, a combination of project-related equipment financing, and tax credits for fuel and possibly labor, could be applied to accomplish the same objective.

Market strategy is a lever not normally associated with the public sector, which nevertheless can be part of comprehensive statewide and regional plans. DOTs who support the pursuit of bulk traffic by their shortline railways are keeping the heaviest trucks off the roads and shortlines healthy, but they also are pursuing a vertical market strategy that specializes in bulk industry. A strategy favoring intermodal diversion is support of the enlargement of the breadth and depth of terminal coverage throughout a geographic region, because of its repercussions for the load availability experienced by motor carriers, and their consideration of rail alternatives.

Prior to the advent of fast stack train service from the west coast to the interior of the country, those lanes were a long haul truck market.[47] When stack trains arrived, the traffic they captured substantially reduced the number of loads available to motor carriers delivering on the coast, to return their trucks inland. Regional work could be found, but a truck that came from Chicago could not get back to Chicago, nor to anywhere close. The difficulty was not that the railroad took all of the business, rather that it took enough of it

[47] This is a first-hand account by the author, who ran a truck operation during this period, spanning the late 1980's and early 1990's.

for the remaining loads to be fewer and further between. This resulted in trucks laying over longer while they awaited their next load, and traveling a greater distance to find one. The coastal geography – with mountains and rural areas for hundreds of miles eastward – acted like a peninsula to trap the fleets along the Pacific. Layovers and empty miles meant declining utilization, and coupled with rates dropping toward the railroad price points, the business was no longer profitable. Many motor carriers withdrew from the west coast market, ceding it to the railroads, and to the first truckload lines to seriously adopt intermodal as a strategic alternative. Trucks flowed and still flow over the road, especially for time sensitive traffic like California produce, yet the railroads effectively took the market and they have it still.

This history is instructive about geographic market strategy. The critical ingredients were good quality rail service, its coverage of all the important lanes (which weren't many), and the peninsular conditions that prevented truck lines from easily finding their loads elsewhere. These conditions can be reproduced in open geography by a terminal network whose coverage areas densely overlap, provided service levels are competitive and extend to enough of the major lanes. The competitive dynamic is that reduction of a significant portion of available market loads, and elimination of nearby alternatives, disturbs truck utilization to the point that rail options have to be considered. The effect will be strongest in the most concentrated part of the network, motor carriers can be allies in bringing it about, and it isn't necessary to serve all lanes in order to have a noticeable influence on load availability. As a public strategy to encourage rail traffic, the key elements are the number, serving radii, and overlap of terminals (which may have to be determined from gate surveys, because railroads often don't know), and the proportion of large lanes these terminals operate with competitive service. The lever is public investment in terminals and other capacity. Since the diversion effect is produced regionally, the strategy works best with multi-state coordination, although geographic barriers can fortify it.

Manipulation of density can be undertaken from vectors and points. Inland ports and forward distribution programs transfer the location from which traffic is dispersed, from a gateway or production region to a spot closer to the consuming markets. The lane from that production or gateway region to the new dispersal center consolidates traffic into a dense vector, which may support trainload operations and non-stop service. Both kinds of program are active in the public (and private) sector; the Port Inland Distribution Network sponsored by the Port Authority of New York and New Jersey is one of many examples.

Point density, which affects pickup and delivery efficiency, is produced overtly by public terminals or land development concepts like the freight village; however, purposeful city planning and zoning can lead with a lighter hand to a comparable result. The operative dynamic is concentration of multiple shippers in a geographic pocket. The pocket then may become served with good access routes, and with rail spurs or facilities, and the proximity of shippers improves the cost and quality of direct or drayage service.[48]

[48] An example of this strategy as pursued by railroads is the "logistics hub", described in a trafficWORLD article "Logistics Hubs' Promise", 4/5/04, page 21.

Finally, the *intrinsic appeal* of railroading as a separated right-of-way, can be wielded more aggressively to attract public support to rail projects. On the theory that citizen objections to freight are rooted in the visceral experience of driving alongside heavy trucks, the more segregated and less visible rail mode is an answer. A policy approach that routinely sought grade separation as a way to reinforce the segregation of rail, and then emphasized the railroad's sequestered character as an additional benefit in projects that might be motivated by economic competitiveness or congestion relief, could foster a public consensus in regular support of freight rail programs. Such a receptive environment could smooth and simplify the production of diversions by making programs easier to pursue, and faster to accomplish.

3.7 DIVERSION OPPORTUNITIES

This chapter began with an examination of shipper needs and structural factors, developing from there a segmentation scheme to evaluate rail projects in their market and operational contexts, and then summarizing diversion barriers that had emerged or could be drawn from the discussion. The barriers indicated conditions to be met and issues to be considered and solved, in order for rail projects to warrant pursuit because of their viability and institutional soundness. Next, the chapter identified levers at hand for public planners, by which barriers could be reduced and circumstances fostered that would favor diversion.

There remains to review the opportunities that may exist for diversion, and to classify them for planning purposes. Railroads typically approach this in terms of markets, lanes, and corridors, which is the terrain that terminals can cover and where trains will run. Public agencies are oriented to the elements of infrastructure, reflecting their mandate and the objects that congestion afflicts and railways may relieve. They can be defined as five types:

- Facilities and districts, like bridges and ports;
- Urban corridors, such as prime arteries;
- Citywide networks, or the urban grid;
- Intercity corridors, like interstate highways; and,
- Regional networks, such as statewide or multi-state systems.

Four of the five types appeared as categories of rail project in the Task 2 case studies, but they work equally well as classifications of congested roadways and road-dependent structures. The fifth – regional networks – is broader in scope than recent rail projects really have been, and it also points up the need for comprehensive, coordinated strategies in pursuit of road relief. While state rail plans do establish programs with more of a territory-wide purpose, the key consideration is that harmonized initiatives at multiple levels – facilities, cities, corridors – not only are mutually reinforcing, they can produce cumulative effects: within networks, within markets by changing load availability, and upon fronts of competition. In this way regional networks are a kind of meta-category, because individual projects in fulfillment of broader strategy may accomplish more than sensible, yet stand-alone initiatives.

For the mitigation of congestion on these classes of infrastructure, the questions are what sets of traffic can be removed (or prevented from appearing), and what forms of rail service will yield results. Traffic can be considered simply as originated/terminated or overhead, meaning freight that derives from the locale of the infrastructure, or freight between external points that passes through. It can be further categorized or grouped in four ways, by utilizing variations of density as a way to uncover diversion options:

- *Lane volume* is the basic form of traffic concentration. Sufficient volume between an origin and destination may support train block or direct train operation, each representing a step up in competitive service performance.

- *Confluent volume* is intermediate or combinant concentration, supporting train operation where the strands of a network come together and before they part. This is produced inside the rail system by the way traffic is marshaled and directed, or in the highway system by the dispatch routes of trucks. In the latter case, confluent volume can be intercepted in train or train block lots, provided efficient shipper door service is available through interoperability with motor carriage, or through equivalence in direct rail.

- *End point density* is concentration produced at the start or finish of a series of routes, by a common path prior to dispersion, or by funneling into a termination point. Examples might include all of the truck traffic leaving Houston for the Northeast, or all of the highway freight destined to South Florida. It can be generated by physical or network geography, or by logistics strategies like forward distribution, and it supports train or train block operation through the juncture where traffic is dispersed. Like confluence, end point concentration may be divertible, provided efficient service is available to the shipper door.

- *Hub or terminal concentration* is produced by logistical staging. One important type is truck traffic resulting from railroad systems. This occurs at some rail-to-rail interchanges, where cross-town drayage substitutes for direct rail connection; at territorial gateways, where trucks instead of a connecting railroad carry shipments to and from the network border; and at end point terminals, where dray trucks debouching from rail may travel an extra distance, because of the remote location of the transload facility. These cases are highly divertible to a continuous or extended rail haul, on the grounds that the business already supports train operations. On the other hand, there can be numerous difficulties in keeping the traffic on rail; for example, volume may be staged at the point of dispersion; land or land use obstacles may be prohibitive; or institutional structures may be impractical to overcome. Truck concentration at hubs and terminals can be created by other modes (such as ship lines, or the motor carriers themselves), by facilities (like an inland port), and by shippers (at distribution centers). While this can present a significant business prospect for rail, it won't always present one. Block or train lot volume typically exists either on the inbound or outbound side of the facility, but not on both, and in instances like a motor carrier hub, the rail opportunity may not be larger than single shipments that are fanned out in multiple directions.

In each of these four groups, volume enroute to market either offers density, or is brought together to offer it, and this improves the likelihood that effective rail service will be possible. Concentrated traffic sections may be shorter than the total lengths of haul and may consolidate multiple lanes, but diversions remain dependent on door-to-door performance. Enlarging this perspective to the full dimensions of market segmentation – moving from density to the wider scope of economic geography, and examining the conditions of access – then begins to reveal the traffic that rail might remove from infrastructure, and provides a foundation for analysis and evaluation with market participants. From this the questions of viability and readiness, and of appropriate levers to use, start to be answerable.

Rail operations are the remaining dimension of market segmentation, and have different abilities to yield traffic results. The general opportunity for railcar and intermodal services to capture highway business is discussed next, along with treatment of the special circumstances for short haul rail.

3.7.1 Railcar – In the ten years from 1990 to 2000, railroad coal tonnage grew at a compound rate exceeding 2%, intermodal tonnage rose at a rate close to 5%, intercity trucking expanded at a pace of almost 7%, and growth in the rest of the rail business was under 1% annually.[49] Clearly the carload traffic[50] was losing market share; this is the customary business of the Class I railroad industry, and it has been in long-term decline. It is also the mainstay of shortline railways and principally transports heavy loading goods that are damaging to pavements, and slow moving in the traffic stream, if they should divert to highways. The AASHTO Freight Rail Bottom Line Report estimates that the national road network annually avoids 20 billion truck miles traveled due to the existence of carload service, and 25 billion miles due to unit trains.[51]

Concerned that the carload business might cease to be financially supportable, a 2004 Federal Railroad Administration report evaluated the potential for scheduled train operations to keep the loose car segment viable.[52] The report found that utilization benefits and the associated cost savings would meet this objective and retain the traffic on rail. Nevertheless, according to railroad officers interviewed for the study, the service improvements brought by scheduling would not win significant new traffic from highways. The most optimistic of a range of opinions was that carload growth might come close to the GDP expansion rate in some lanes – in other words, the business would expand far more than it has in decades, but it would not gain market share.

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[49] Source: TRANSEARCH

[50] A breakout of unit train versus carload volume isn't readily available for 1990; railcar tonnage excluding coal acts as a proxy.

[51] Table 2, page 26 of the cited report.

[52] Comprehensive train scheduling is a relatively new practice among Class I railroads in the first years of the 21st Century. It had been used prior to this overseas, and on at least one US regional railroad, The FRA report is titled "Scheduled Railroading and the Viability of Carload Service"; citations here derive from a press article in trafficWORLD, 4/5/04, page 24.

Setting aside the merits of these findings, the position that the carload sector is not a major venue for diversion is consistent with the Class I outlook from other contexts. Railroad merger applications during the 1990's claimed carload gains from their combinations, yet never as the primary source of traffic new to rail; for that, they looked to intermodal. In another perspective, a railroad executive who had reviewed company marketing plans for a generation concluded that carload prospects always held some promise, but for an engine of corporate growth or a meaningful alternative for highway planners, it was the wrong candidate.[53]

It isn't necessary to determine the future of the carload sector for the purposes of this report. It is possible that scheduled operations may do more than seems anticipated, or that different yard technology may aid them, or that they may be spurred by combination with some other development. It is nonetheless true that the sector has important handicaps: marshalling is costly and time consuming, the historical business base is a shrinking part of the economy, and direct access continues to diminish. Transloading works, yet it is somewhat less efficient than the unitized intermodal: intermodal lift at \$30-\$35 per box translates to \$2.00-\$2.50 per ton, versus \$5-\$6 per ton for carload goods like steel and chemicals, and the vans used for intermodal dray have better reloading options than flatbeds or tank trailers.[54] At the high volume end where large unit trains operate, railroads vigorously pursue and invest in the business, and can be counted on to do so; while sidings, line extensions, and other access requirements may attract public support, the utility of rail should be apparent.

Rail retention of carload traffic is of clear benefit to the congested highway system, in urban districts as well as on intercity routes, and it is necessary to take this into competitive account during development of public road programs and policies. As loose cars segue into unit trains, the importance of retention intensifies, and since rail can do well with trainload volumes of carload goods if access is solved, repeating shipment lots starting from 2,000-3,000 tons apiece in a lane can become opportunities. Most substantially, the local outlook for diversion will vary from the national. If carload prospects seem underwhelming on the grand scale, their effect on an urban heavy truck corridor can be penetrating and deep. The shortline rail industry plainly has been successful at diverting or withholding bulk and other freight from congested urban areas and inadequate rural roads, and its influence primarily is on specific and local infrastructure. Three examples follow:

- The New Hampshire Northcoast (Conway Branch) operation hauls aggregates from Ossipee, NH to the Boston Sand & Gravel transloading terminal in Somerville, MA, a distance of 100 miles.[55] In addition to removing an estimated 100 aggregate trucks per day from the parallel I-93 and I-95, the carrier also delivers plastic and propane to

[53] From a private conversation with a researcher.
[54] Transload costs come from 2004 quotations obtained in the Pittsburgh and Houston markets. Vans are the most versatile equipment and have the lowest empty return ratios – though ratios still may be high in local markets.
[55] Blanchard (2003) http://www.rblanchard.com/resources/texts/NE%20Railroads%2030900.html

Rochester, NH as needed. The line carries 8,950 carloads annually[56] and benefits the region in two distinct ways: removal of heavy trucks improves air quality and reduces congestion; and lower cost of transportation allows New Hampshire quarries to be competitive in the Boston metropolitan area, lowering construction costs.

- Many short lines carry seasonal bulk traffic (particularly grain) in the Midwest. One such carrier is the Iowa Interstate Railroad, owned by Railroad Development Corporation. The 687-mile regional carries 6.1 million tons per year,[57] or approximately 75,000 carloads. The IAIS transports grain, steel, scrap, intermodal, chemicals and forest products. In addition to handling 'bridge' traffic that substitutes for barges in the winter, or providing access for bulk customers, IAIS switches many industries along its route, including major customers at Newton, Iowa City, Cedar Rapids, and Rock Island.[58] Although the bridge traffic is an important source of revenue, chairman Posner claims, "our bread and butter really is serving private-siding customers with a local freight schedule. A lot of IAIS' traffic originates or terminates on branch lines served by short trains."[59] This type of operation can be very effective in removing trucks from local roads, and in the right circumstances may generate substantial profit.

- On the West Coast, a 2003 study[60] found that the 372-mile, 10,700 carloads per annum, grain-hauling system known as the Palouse River and Coulee City Railroad (PCC), is highly susceptible to abandonment in private ownership. However, the PCC saves shippers $2.2 million per year, in addition to keeping 29,000 heavy trucks off county roadways - creating a benefit of $4.2 million per year in avoided highway damage. By all standards, this is a very light density line. However, even at this level of density, substantial diversions and resulting benefits are generated.

The core advantage of a shortline railroad is its low cost function, gained from a combination of inexpensive equipment, flexible labor agreements, and light track. Recent studies[61] have demonstrated some lines can operate with significantly less than 50 loaded cars per mile per year. Shortlines operable at low traffic densities are able to compete for seasonal traffic, or to focus on a single bulk commodity, or even a single shipper. This kind of adaptability can be a powerful answer to particular traffic problems, so that reviving disused but intact shortline railroads, or increasing traffic volumes on existing ones, in a local setting may be highly productive for roadway relief.

3.7.2 Intermodal – Standing on the front line of modal competition with the highway, the railroad intermodal business faces aggressive and routine rate pressure, and is

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[56] ANRP (2004) http://www.atlanticnortheast.com/regn/railroads.html
[57] RRDC (2002) http://www.rrdc.com/company_overview.html
[58] Atkinson (2001) http://www.drgw.net/iais/railguide/operations.html
[59] Posner (2003) http://www.rrdc.com/spch_london_rsa_2003_pg_1.html
[60] Tolliver (2003) http://www.wsdot.wa.gov/rail/plans/pdf/grainhauling_rpt.pdf
[61] "The Experience with New Small and Regional Railroads, 1997-2001" JF Due, et al, Transportation Journal, Volume 42 Issue 1, pages 5-19, 2002.

sometimes perceived as questionably profitable. At Conrail in the 1990's[62], however, standard costing formulae were modified to unburden this business of expense allocations for features that Intermodal did not require – heavyweight track, and certain yards and branch line networks would be examples. The restated Intermodal financial picture was then found to be one of the more profitable operations on the railroad, and thereafter earned a higher priority for capital usage.

There is rich and ample opportunity for railroad expansion in the intermodal sector, more than the carriers have resources to pursue.[63] If Intermodal did no more than recover the ten points in long-haul, dry van market share that it lost during the service disruptions of the latter 1990's,[64] it would take six million trucks off the road. In the 800-mile, dense and mature traffic lane between Chicago and New York, Intermodal carries 25% of the *total* traffic (intermodal plus all truck types combined); if it achieved such penetration across the board in long-haul, medium and high density lanes, fourteen million trucks would come off intercity roads.

The Virginia I-81 study[65] utilized alternative technology to resolve the problem of interoperability, and called for major, corridor-wide public investment to improve capacity, terminal coverage, and track speeds. The study found that 15% of I-81 AADTT (average annual daily truck traffic) in Virginia could be diverted to Intermodal over three to five years, and 29% in the longer term. However, the majority of I-81 truck traffic is overhead to Virginia and therefore longer haul; the rail services proposed for development did not address traffic shorter than 350 miles. Even so, employing interoperable technology and applying the same distance-sensitive diversion rates to national traffic, Intermodal would attract 9 million highway loads in the medium term, and 27 million loads when services reached maturity. The latter represents two to three percent of current nationwide truck volume, but a three-fold increase in intermodal activity, and would require considerable new capacity in lines, terminals, systems, equipment, and crews.

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[62] The source of this anecdote is a former Conrail executive who was on the scene at the time. There do not appear to be any published accounts.

[63] This at any rate was the opinion of one Intermodal officer who talked to researchers, and was speaking just of *immediate* opportunities.

[64] Alluded to earlier, internal Reebie Associates reports show Intermodal with 30% of the 1995 dry van business over 500 miles, versus 17% five years later. The numbers are not entirely comparable because of corrections for rebills in the later and not the earlier figures, but share losses in the ten-point range are reasonable. Because of merger-related service disorders during this time frame, Intermodal grew only moderately, while the economy expanded with vigor and logistics requirements became more stringent, so that the volume went to trucks. Traffic data here and elsewhere in this section are from TRANSEARCH, and the term 'long-haul' means beyond 500 miles.

[65] Referenced in the Task 2 case studies.

These are illustrations of possibilities. They focus mainly on longer distances, and they still leave dray trucks on the road. While short-haul options are reviewed in the next section, for the purposes of congestion reduction and roadway relief, the long-haul opportunities nevertheless have impact. **Table 3-5** "Length of Haul Distribution: Truck VMT" offers a different perspective on highway volumes: where three-quarters of truck trips are concentrated under 200 miles, just one-quarter of truck VMT (vehicle miles traveled) falls in this bracket. This profile comes from TRANSEARCH, and even allowing that this data source does not capture all local truck activity, it is plain that rail reduction of medium and long-haul truck traffic has real repercussions for road demand. The consequences for highway relief are clearer than the consequences for congestion: rural roads will account for a greater proportion of truck VMT than they will for over-capacity road miles. Diversion of through trucks certainly matters for congestion mitigation, but interior cities will derive more benefit than a metropolis like Los Angeles or Miami situated in a kind of geographic corner, and for all of them the urban problem looms large.

Table 3-5 Length of Haul Distribution: Truck VMT

LENGTH OF HAUL DISTRIBUTION: TRUCK VMT (Loads & Empties) Source: TRANSEARCH	
Distance	All Truck VMT
200 Miles & Under	25%
500 Miles & Under	53%
Over 500 Miles	47%

It was stated earlier in this chapter that the core question in traffic diversion was, how broadly could equivalence be produced? In fact this is a two-fold question, because it is not only a matter of comparable product performance between rail and over-the-road services, and of interoperability. It is also a matter of the breadth of deployment, and breadth requires capacity and capital beyond what is available as this is written. Public investment to moderate the capital intensity of railroading can lift the limits on possible opportunity, and modify the markets to which rail services are introduced. The bottom line for traffic diversion lies in the two-fold nature of this core question: can the product be good enough, and can enough of it come to market?

3.7.3 Short-Haul Rail – Three out of four loaded truck trips travel within 200 miles, and nine out of ten within 500 miles. The short-haul market draws the attention of planners because the truck volume is found there, and because diversion of short city and intercity trips will relieve congestion where it is most common, and where highways are most costly. The distance definition of short-haul varies. To some interpreters, it is the twenty miles of the Alameda corridor; to others, it is many times longer. This chapter will use 500 miles for inclusiveness, and on the grounds that it is the overnight distance for a truck. Within this, it will distinguish local traffic up to 200 miles (which is the out-and-back distance for a truck in a work day), and regional traffic from 200 to 500 miles.

As observed before, approximately one-fourth of the carload and unit train business is local, and another fourth is regional. The intermodal business is entirely different: only a bit over ten percent is regional, and the local activity is minor. There is an assortment of caveats with these numbers, of course: rebills overstate the short-haul tonnage, shortline traffic is underrepresented, and Alameda Corridor volume is long haul because it is an end-point shuttle feeding inland trains. The obvious reason for the distinction in length of haul profiles is access: intermodal by definition is a transloaded operation, whereas railcar traffic enjoys direct access to a significant degree. A second reason is service: the majority of short-haul railcar activity is in train blocks or unit trains, implying that it is sensitive to equipment capacity and can be handled through the rail network with relative expedition. Moreover, after decades of traffic erosion, it is safe to conclude that the remnant railcar business can tolerate the service it receives, and disappears slowly because better alternatives (or industrial changes) are slow to arise. The general merchandise market where Intermodal competes doesn't travel by rail because it requires better door-to-door service, it encounters important barriers of interoperability, and its volume is comparatively fragmented on a per-shipment basis.

These are explanations of the status quo. Since the objective of this course of research is diversion, the true interest is in new traffic opportunities, and there the profile alters. Whereas Intermodal retains the difficulties that depress its participation in short-haul markets, the railcar sector loses its advantages: access for new customers becomes much more of an issue, block volumes have to be sought, and service has to stand up to incumbent competition. The biggest obstacle for both sectors is the time factor. Regional overnight truck transit is eleven hours or less; local transit is four to five hours, and can be same day delivery. High speed rail operations don't help much, because there isn't enough distance over which to gain time – freight rail usually benefits from higher speed when it can run for twenty-four hours straight through. Delivery windows are vital: customers who can accept next afternoon or evening receipt are much more serviceable by rail, and yet this is not the normal pattern of business. Finally, complexity of operation is the enemy of transit time, and of reliability. Solid trains that can be quickly assembled may be successful if yards and main lines are uncongested; conversely, marshalling requirements and scheduling conflicts bring delays and service failures.

The second major obstacle is the relative profitability of traffic. The Florida East Coast Railroad (FEC) is a regional line offering corridor services between Jacksonville and Miami.[66] Multiple intermodal trains operate daily on the 350-mile lane along the Florida coast, supporting local service but especially providing interchange at Jacksonville to motor carriers and Class I railroads traveling further into the continental US Railcar business includes unit trains of stone and cement; in one operation, two to three million tons of rock are brought 200 miles from south Florida to Cocoa, then transloaded and drayed fifty miles to construction sites around Orlando. Traffic of this kind is attractive to the FEC for at least two reasons. First, the peninsular structure and economic geography of Florida makes for famously imbalanced traffic, and channels it into dense lanes. These features play to the strengths of railroading, they keep rate levels high, and they discourage motor carriers from committing their own assets to the territory. Second, as a regional network in isolated geography, the FEC is not considering other prospects.

[66] The information presented comes from the Florida East Coast web site, and from the Freight Goods and Services Mobility Plan of MetroPlan Orlando (the MPO for Orlando, FL region).

Profit contribution is a function of margin and quantity, and in freight transportation the quantity is composed of shipment volume and distance. Shipments of equivalent size and margin are more attractive to carriers at longer distance, and when the efficiency of linehaul is factored in, there is sound reason for railroads to prefer long-haul business. Even so, the decisive element for Class I railroads in considering traffic opportunities is the rationing of capacity and capital. The business prospects for these carriers are not seriously limited by the size of the market, but rather by what they can act upon. In most cases, the profit contribution from short-haul traffic is lower than from long-haul, causing assets to migrate from one to the other, and depriving the regional and local business of any exclusive investment. Class I choices will continue to favor the long distance options unless the ground rules are changed by new resources.

The motivations for shortline railroads stand in contrast. On light-density networks, the non-traffic related maintenance-renewal burden (such as corrosion, weather, and degradation) dominates the capital requirements, and the shortline business model therefore has tended to focus on generating traffic to build up traffic density.[67] This is a different and more accepting regimen than asset rationing, although it is unclear what happens when capacity is tapped out. As to business mix, opinions differ as to whether interchange traffic or local, single-line traffic is the primary money generator on a shortline. For a carrier that is not a switching road (whose rates are tied to the serving Class I's), the dollars generated from interchange traffic can depend mainly on negotiating ability with larger carriers over revenue splits, and on Class I strategy with respect to shortlines and carload shippers. The local traffic, on the other hand, is entirely under shortline control, and has various cost advantages over interchange business - more intensive equipment utilization is possible, for instance, and much reduced management overhead - so that the lower revenue per car in local lanes still is very attractive. Shortlines also can extend their role as low cost carriers to contract for trackage rights, and operate over secondary Class I right-of-way, turning interchange into single-line business. Where the Class I track space is not constrained, such tactics may be productive and generate additional profits for the smaller railroad. Shortline strategy directed at single-line opportunities thus can be effective at combating local congestion, since goods may be moved in volume, and at lower rates than interchange traffic. A prominent[68] example is the Nittany & Bald Eagle division of the North Shore Railroad Company, which operates a dozen-car shuttle train twice daily on an eight-mile run, bearing 1.1 million tons of stone annually and keeping trucks in the tens of thousands off central Pennsylvania roads.

[67] There had been much research into the economics of shortline railroads, most of it treating the cost aspect of the business. References include "Success and Failure of Newly Formed Railroad Companies", John Due and Carrie Meyer for US DOT, 1988; "Short-Line Railroads Performance", Michael Babcock et al, Transportation Quarterly, 49.2, (1995), pages 73-86; "Financial and Demographic Conditions Associated with Local and Regional Railroad Service Failures", Eric Wolfe, Transportation Quarterly, 43.1, (1989), pages 3-28.

[68] Prominent because it earned an American Short Line and Regional Railroad Association 2003 marketing award. The information is from the North Shore web site.

Figure 3-6 Expressway

Class I Railroad officials discussed short-haul operations in Intermodal at the Transportation Research Board meeting at Washington, DC, in January of 2003.[69] Only two of the active examples cited actually were under 500 miles, but the success factors identified were notable: routes were single-line and not circuitous, drayage requirements were significantly curtailed, traffic was concentrated, volume was balanced by the lane or network, terminals were efficient and well situated, and trains were fast, reliable, and sufficiently frequent. One highlighted service was the CP Rail Expressway, which is believed to carry two to three percent of the truck volume on the continuous corridor from Montreal to Toronto (330 miles), and then on to Detroit (230 miles). Using ramp-style intermodal technology, Expressway is highly interoperable with motor carrier fleets, and its twice-daily departures in each direction produce dependable overnight service. The mature potential of the operation was estimated at 12-15% of corridor volume without capacity expansion, and with expansion, one out of three trucks was projected to be divertible. All rail officials including CP Rail's stressed the necessity of high (or excess) capacity corridors for short distance intermodal operations, not because the services specifically required it, but because the short-haul profit contribution would not justify right-of-way investment, barring public support.

The local and independent intermodal corridor service of Northwest Container is described in the inset box. This company has stepped outside of pure freight carriage in order to boost financial returns, and uses a management approach comparable to truck lines to drive out utilization inefficiency. As a business model, this firm represents a homegrown version of open access, and is reminiscent of the efficient regional players in the trucking industry, who construct an effective set of operating economies within disciplined territorial bounds. The operation is analogous to a shortline taking on Class I trackage rights, in that both produce some control of train service, and yet neither one ever escapes the problem of capacity. Northwest Container is able to acquire a contract train because its payment is competitive with other uses for the Class I track; if high volume, long-haul corridor service began to consume track space, the Northwest train slot (or its financial feasibility) might be jeopardized. Moreover, as a case study in short-haul highway relief, Northwest Container is instructive for what it does not do as well as for what it does. In the view of this company, conventional intermodal service is not competitive for the truly local domestic market.

Thus, the two major barriers of time factors and relative profitability remain in place. Shortlines and purchased transportation can be effective, but eventually they will reach

[69] Points are taken from notes at the session by the author of this chapter, and from subsequent interviews in Canada.

capacity constraints, and must deal with the limits of geography and density (and be helped by industrial development programs). Short-haul rail plainly does work in niches, perhaps including trans-urban corridors like the Chicago Airport Express, and it certainly can function as an end-point service feeding longer haul traffic. Nevertheless, without public investment to change the profit comparison, short distance rail is not likely to succeed as a broad alternative to road congestion, and with public investment, the predicament of time performance may be intractable in very many instances, or require unconventional technology or exceptional innovation. The truck VMT distribution suggested that road relief reached through the regional and long-haul markets can have a material result for congestion. In the local and urban markets, there are strategies to employ that will touch the problem, but there is also a dilemma.

Case Study 2: Northwest Container Services [70]

The core operation of Northwest Container Services is a daily stack train supplied to the international trade, between the Portland, OR market and the seaports at Seattle and Tacoma, WA. Containers drayed through a Portland terminal are railed 170 miles to Seattle piers. Trains run north and south five to six days a week, bearing 110-140 units and removing 60,000 trucks annually from the crowded I-5 highway corridor. The company claims 99% on-time performance against container-ship cutoff times, and backs up rail with over-the road service if necessary. Northwest owns the terminal and the railroad wellcars used in the operation, and purchases dedicated trainload service from the Union Pacific, who provides track (including maintenance and signaling), power, and crews. The firm is Oregon-based and privately held, receives no public funds and is neither a railroad nor a motor carrier.

The economic geography of the Pacific Northwest supports this operation by creating a north/south funnel for freight in a strong foreign trade basin. The call pattern of container ships

[70] Information presented here is taken from an on-site interview by the author with executives of the company. Conclusions about success factors are those of the author, unless specifically attributed to Northwest.

has rendered Seattle/Tacoma a major load center port, and has placed Portland in a feeder role, so that there is heavy traffic between the two. Containers are in ample supply because of trade imbalances, and those bearing the region's forest products load above interstate highway weight limits, which rail is able to accommodate. These natural advantages help to establish a niche market, and stack train economics paired with a single-end dray help rail to contend for it, but the critical factor for this short-haul corridor is the service window of the ship lines. Sailing schedules create slack time at either the origin or destination of every load, covering for the terminal handling and dray delays attendant to rail, and allowing it compete against four-hour highway drive times in a way the domestic market does not allow. Rail intermodal can meet the ship schedule without being as fast as a truck door-to-door, and according to the company, this is the key reason Northwest has stayed out of the domestic business.

Beyond these market factors, the company succeeds for three critical reasons:

- A high degree of operational control is created by asset ownership and train purchase. The Union Pacific can change the time of train departures, but it does not decide whether a train will run. This is strengthened by local, hands-on staff, motor carrier alliances, and good customer relationships, so that Northwest knows the full logistics detail for any load.

- The Northwest approach to managing train utilization is comparable to truck line tactics. Customer service representatives book loads and work with customers on individual container schedules, in order to keep trains full. The company also builds up inventories of loaded containers and uses them to balance trains.

- Northwest markets a full service transportation package, which has two important advantages. First, the product is a turnkey *set* of services, which together make it easier to do business intermodally. The firm inspects and maintains equipment, handles logistics, and offers complete container yard functions, with chasses, repair, storage, and pre-tripping. Second, the profitability of the operation derives from the *cumulative* contribution of the set of services, each of which has thin margins; the company believes that the rail service alone would be insufficient to sustain itself.

3.8 SOCIAL AND ECONOMIC IMPACTS OF DIVERSION

Modal diversion changes the location and technology of freight carriage. This implies that its social and economic impacts mainly are incremental, modifying an incumbent body of traffic rather than introducing a fresh influence[71] to a region. Diversion brings more volume to rail routes and rail facilities, where the relatively favorable rail emissions profile, for example, may still mean more total emissions in the vicinity. Diversion reduces traffic on highway routes, providing a better operating environment for trucks that remain on the road, and safer, faster travel for passenger vehicles. Given the service characteristics and network density of the US rail system, most opportunities for diversion from highway to rail will require transloading of freight; thus, trucks performing pickup and delivery will stay on the road, and will acquire new patterns of traffic concentration. Analysis of the effects of modal shift thus requires a careful examination of the complete logistics chain, for direct and indirect impacts.

The societal impacts of diversion of freight from highway to rail can be classified into four areas: shipper related; direct highway; direct rail system; and indirect or collateral effects. In addition, there are four main drivers of negative social externalities for freight movements: (1) physical volume; (2) traffic distribution, in space and in time; (3) load characteristics; and (4) operating profile. These underlying variables related to the way freight flows, combine to place a burden on the host community through their collateral impacts, resulting in effects such as accident risk, noise, vibrations, visual quality impacts, detriment to community cohesion, impact on property values, and vehicle pollution such as particulates and nitrous oxides. Beyond their negative consequences, freight flows reflect economic vitality and generate economic benefits. As freight is produced or consumed, value is being added in supply chains and gross regional product is augmented.

Diversion produces a new net result from these varying influences, transferred in location and transformed in the method of operation. This section reviews the classes of incremental impact and the factors that affect them. It closes with an overview of diversion models, concluding the subject matter of this chapter and opening the subject of the next, where analytic tools for evaluation of rail opportunities are considered in detail. Methods for quantifying the societal impacts of diversion are taken up in that next chapter as well, along with numerous applied examples, but a last point is worth making here. Societal impacts are important for more than a responsible accounting of project consequences; they are part of the justification for supporting rail projects in the first place. The goal of mitigating road congestion moves closer to accomplishment when relevant projects also can be shown to support economic competitiveness, or to dampen citizen's safety concerns, or to aid the quality of life.

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[71] Due to the configuration of the rail network and the way it is operated, traffic diversion of long-haul shipments sometimes moves the route of travel into a new region of the country, in contrast to the highway route.

3.8.1 Forms of Incremental Impact – The ways in which freight transportation affects a community are many of the same ways that modal diversion affects it marginally: through economic development and competitiveness, safety and security, congestion, and quality of life. In each category, however, there are circumstances and implications that are particular to the character of modes, so that the ramifications are complex and diversions involve trade-offs. Truck traffic removed from the highway, for example, shrinks the highway's maintenance requirements by eliminating some of its costliest vehicles, and the burden is moved to the private maintenance budgets of the railroad right-of way. On the one hand, the added traffic may strain railway capacity and cause it to seek public support for expansion. On the other hand, capital injection may be a one-time expense, while maintenance costs are permanent and ongoing, and the latter might be recovered from shippers through freight rates, instead of through the general funds of DOTs. The major forms of impact and some of their multiple facets are:

- *Economic Development and Competitiveness:* A primary benefit of more efficient transportation systems is enhanced economic productivity, development and competitiveness. In various periods during US history, evolution in transportation technology from canals to railroads to interstate highways allowed much of the interior to be developed through improved accessibility. Today, as the transportation system continues to evolve, the focus has turned to using intermodal networks and choosing an appropriate mode for each flow, allowing transportation costs to be diminished and the accessibility benefits of a multimodal freight transportation system to better realize its potential.

  Freight transportation upgrades raise the productivity of businesses in a region in one or more of the following ways:

  - Reducing the cost of shipping;
  - Reducing the time-variability of shipping (thereby improving supply chain performance);
  - Reducing the time for shipping (also improving supply chain performance); and,
  - Reducing the risk associated with shipping (thereby avoiding cargo loss and damage).

  Diversion from truck to rail normally will reduce transportation costs at the expense of a longer journey time. In highway-congested areas, rail can have lower time-variability, although rail typically is less dependable; in rail-congested areas, highway drayage is often offered as a by-pass route. For low-valued bulk commodities that divert to rail, the net effect of time and expense will be lower total logistics costs, and in some instances, a rail-connected distribution center may be replacing a local processing site. For rail intermodal, in lanes where it offers genuine truck-equivalence, transit time will match the highway and overall service performance will be competitive. In these cases, total costs will be lower because rail will reduce the transportation component, and equivalence will render the logistical effects immaterial – but there will be no logistical gain. Cost reductions produced in these ways have impact by generating a direct benefit to the shipper's business and a trickle-down benefit to the rest of the regional economy, leading to increased economic competitiveness. In the aspect of loss and damage, rail haulage changes the nature of risks associated with these factors, as is discussed below.

- *Safety and Perceived Safety:* When truck freight activity is replaced by rail freight activity, risks in rail accidents are substituted for risks in highway accidents. The risks are different in nature and cause different problems, although both can be mitigated effectively with appropriate safety programs. The highway is an open environment; other than driver licensing programs and DOT inspections, there is little centralized control over the movement and condition of driver and vehicles. It is also a shared facility – accident involving trucks usually result in many more fatalities than auto-only accidents; disruption caused by truck accidents can inconvenience many autos. However, compared to rail accidents, even major truck accidents seem non-catastrophic. Routine railroad incidents usually result in lesser consequences than a comparable incident involving a truck, because of the design of railcars, but a major rail incident can result in the evacuation of a neighborhood or an entire town. When railcars fail, damage to freight, equipment and the environment tend to be much more severe simply because of the much greater equipment capacity.

  In the chemicals sector, replacing truck flows of bulk dangerous chemicals with rail improves safety in transit and loading. Tank railcars, by design, allow a more controlled discharge process and have a smaller likelihood of spills per volume of liquid transported (Ensuring Railroad Tank Car Safety, TRB Special Report 243). The safety benefit extends beyond the terminals. Diversion also changes the risk exposure profile, shifting the spill risk from public highways and main streets to private railroads. Tank cars in addition are engineered to much higher standards and are usually not ruptured in derailments. In general, conversion of bulk chemical flows from truck to rail is considered a safety improvement, especially in the public perception because of its obvious effect in removing large chemical tankers from the highways.

  Evaluation of safety benefits is based on risk assessment and risk mitigation. Risk assessment involves identifying accidents that may potentially occur and estimating the likelihood of their occurrence. Probabilities are generally calculated by taking an average over a number of past years. Risk mitigation means to devise a scheme that can reduce the probabilities of accidents occurring, or given that the accident will occur, how their severity and public impact could be reduced. Relating to chemicals transportation safety, this might mean making funding available for training of operating and emergency-response personnel. In the context of rail freight solutions, rail diversion might be explicitly stated as a mitigation strategy that could reduce the probability of spills and highway accidents. In some cases, for highly hazardous commodities, the cost of delay associated with rail shipments could be budgeted as a risk mitigation item, which the government, or a particular shipper, could commit to as a part of a deal to reduce unacceptable levels of risk.

- *Security Impacts:* Rail and highway transport plainly present different security risk exposures. However, the extent and direction of these impacts are not well understood. Rail operations, by design, occur in a loosely supervised environment where ensuring cargo accountability is more difficult; in instances where direct rail service is not available, transloading will be required, which is inherently less secure than a single truck movement. However, trucks are more mobile, and it is far easier to disrupt truck operations than train operations. Hijacking a train is practically impossible, while thieves and others sometimes intercept truck shipments. Railcars also tend to carry far larger quantities, but it may be easier to keep track of one unit-train or block of cars, versus hundreds of truck movements. Thus, diversion to rail will change the security risk profile, creating different types of risks. It is not clear which mode will be more secure, but it is possible to mitigate the risks associated with both modes through staff training, advanced technology, and other security enhancements.

- *Quality-of-Life Effects:* There are many quality-of-life impacts associated with freight traffic moving by rail; some of these are found in Weisbrod and Vary (2001, NCHRP Report 456):

  - Pollution: Particulate Matters, NO_X, Volatile Organic Compounds, and CO;
  - Noise and Vibrations;
  - Visual Quality;
  - Community Cohesion;
  - Property Values.

  Rail carriage generates less air pollution per unit of freight than motor carriage. Diversion to direct rail shipments produces a fairly straightforward benefit in this respect. Transloaded rail is more complicated, because while emissions are lower during linehaul, trucks performing pickup and delivery concentrate around terminals instead of being dispersed, and can drive circuitous loaded miles, and additional empty miles by comparison to an all-highway operation. The net result normally is positive, but it is dependent on linehaul distance, and thus is lessened in shorter lengths of haul. Whether direct or transloaded rail is the recipient of diverted freight, the travel route almost always is different and will affect new zones, while the smaller rail network may tend to channel traffic volume to a greater degree than highways.

  Noise and vibrations relate mainly to residential neighborhoods, and are particularly prevalent where interstate corridors or railroad corridors run adjacent to highly developed urban areas. Visual quality is difficult to assess. Transportation facilities generate visual impacts in proportion with their size. Diversion to rail normally would not solve this problem; it merely changes the location where such cosmetic problems occur.

The adverse effect of transportation arteries on community cohesion is well documented in the literature.[72] The issues relate mostly to the existence of infrastructure, but also to an extent their operations. A new bulk traffic generator, such as a transload facility, could aversely affect formerly cohesive small towns along the route of the new freight movement. The town may have to trade off potential for economic development against drayage congestion or grade crossing traffic, when deciding whether or not to allow new facilities to be constructed. Property values may change, attracting commercial interests but harming the residential; similarly, removal of freight traffic from roadways can be an adverse development for businesses that serve it, yet may make the facility more benign for dwellings in the area.

- *Congestion:* Trucks are slower in acceleration and deceleration than automobiles, and are both larger vehicles and possessed of a larger footprint in highway capacity. Volume delay curves show that incremental trucks contribute disproportionately to deterioration in highway levels of service, and imply that small amounts of diversion have extra leverage in their impacts. As they did for emissions, the conditions of access matter for congestion effects, with diversion to transloaded rail offering less benefit and possibly introducing new issues. Road-rail interaction at grade crossings grows with diversion unless it is explicitly headed off in project plans. Finally, undiverted trucks operate in less congested, more efficient conditions, making them more difficult to capture as rail services mature.

  The consequences of diversion for congestion also are two-sided. Although an interstate lane nominally carries 1,200 vehicles per hour,[73] at super saturation the capacity can be much lower. Removal of perhaps, thirty heavy vehicles per hour, each with a passenger-car-equivalent (PCE) of 3.0-4.0 during the rush contributes ten percent more capacity to a single lane. This impact can be significant if the roadway does not attract additional traffic as a result of its decreased impedance.

  On the rail side, removal of thirty trucks per hour translates to about 240 boxcars per day – perhaps two to three merchandise trains, and a somewhat larger number of intermodal trains, depending on the equipment profile. The impact of this on rail system congestion varies, depending on the system. Most rail lines can support one additional train per day without great difficulty, but if the yards or lines are already running near capacity, the incremental traffic removes any delay recovery margin, which can lead to a gridlock of rail systems.

  Rail congestion can have additional impacts on abutters. If existing trains are lengthened, the gate downtime at grade crossings could increase. Yard congestion potentially leads to more yard movements, which produce more noise. If a significant amount of traffic is diverted, formerly quiet mainlines could become quite busy, increasing risks for trespassers and others.

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72 For example, see Community Impact Assessment Website at: http://www.ciatrans.net/ciahome.shtml.
73 Highway Capacity Manual – NCHRP 350

3.8.2 Factors Affecting Incremental Impact – The burdens and benefits that diverted freight flows produce for a host community have several determinants. Some are inherent characteristics of the freight, and are dependent on the economic geography of the area, and thus not easily changed – diversion will tend to reduce congestion on some highways and increase congestion on the railroads and near transload centers. Others could change over time or be modified by operational design. The prominent factors are:

- Volume of freight diverted;
- Persistence of traffic diverted;
- Economic value of flow;
- Operational profile of modes;
- Local conditions.

The influence of volume is obvious, since the externalities generated by freight movements are proportional to the number of discrete equipment movements that take place. It is modified by operational profiles in ways that this chapter previously has described: by modal loading characteristics, network geography, routing and consolidation, and access. Transloading, for example, replaces trucks operating over a variety of routes - thereby spreading the congestive effect through a wide area – with routes consolidated around rail terminals. The smaller rail network with its need for trainload volume favors traffic concentration even as it relieves the highway, so that externalities also become concentrated. Communities that will tolerate small and gradual growth around existing rail facilities – particularly when such growth is attained by increased terminal utilization without major construction or property taking – will react differently to the substantial new volumes and infrastructure, that material reduction in road congestion may entail.

The local considerations this points up are manifold. Heavy truck traffic through residential neighborhoods, on narrow streets, near schools and other public gathering places tends to get more attention than that traveling on the interstate highway system. Rail solutions may relieve these situations (as with direct rail service to ports), or they may create them. On some interstates, where trucks make up a proportion of total traffic that becomes meaningful to motorists, diversion of freight can develop political urgency, but its rerouting can meet resistance. The diversity and conflict of the local conditions that surround freight traffic – social justice concerns, jurisdictional layers and turf, residential versus employment interests – can exceed what railroads have the ability or the stakeholder mandate to balance. As such conditions shape the impact of diversion, their effect may be to stifle it, simply because the conflicts are too troublesome to reconcile.

The persistence and economic value of flow bear on the impact of diversion from a number of angles:

- *Persistence of Traffic:* Some traffic is a short-term, one-off movement of a single significant shipment – for example, a large transformer, space-shuttle parts, or tent rigging and scaffolding for a special event. Some traffic is of a one-off nature, but occurs over a number of months due to the volume of material that requires shipping – such as a large construction project, or the decommissioning of a nuclear plant. The remainder of traffic is broadly continuous and cyclical – a flow expected to continue for an indefinite amount of time, fluctuating depending on marketing, seasonality and other periodic factors, like the movement of grain after harvest, movement of ores for processing, coal going to power plants, imported apparel moving to stores, and manufactured parts or products moving from factories to the consumer.

The environmental damage done by large volumes moving in a short period or small volumes moving throughout the year might be the same, yet the public perception of the problem is likely to differ, and therefore evaluation of potential impacts of diversion should account for this perception factor. Since setting up rail access requires substantial infrastructure investment, traffic that could be ongoing is more likely to succeed than one-off moves, making rail diversion better suited to traffic that is sufficiently persistent to be considered consistently problematic. Investment could be effective for peak level traffic that is highly seasonal, such as grain gathering, or construction traffic that is concentrated in the summer months, as well as steady if cyclical traffic such as container flows from large ports.

- *Economic Value of Flow:* Different commodities correspond to distinct industries and supply chains, with characteristic job densities, job features, and economic relationships. These variables in turn determine to what extent transportation infrastructure investments produce local development (or indeed, how diversion to slower modes or how lack of suitable capacity will retard local economic progress). Value of goods also is related to the risk of transportation failure: if a single truckload of seasonal goods does not arrive on time due to road or rail congestion, loss of revenues from a single one-day delay can be significant - perishable goods may perish, fashionable goods may miss a day of their ephemeral market. Diversion from road to rail may increase such risk, since rail disruptions affect full trainloads of goods. An open question is the degree to which current logistics and supply-chain processes can be re-engineered to take advantage of rail; where this happens, it changes the influence of rail services. Private enterprises undertake such evaluations on their own and public planners may not be privy to them, but dialogue could be revealing.

3.8.3 Modal Diversion Models - Modal diversion of freight traffic follows from an induction of shift in the competitive balance. Typically this comes about through a change in the available door-to-door service or cost, or through the lifting of a constraint. The shift will be greater if the change is structural, such as a rise in input costs, a technological advance for service, or an expansion of network. More commonly, though, the change is the introduction of a grade of transportation that is offered in other markets but is new to the one in question, or that sometimes represents a new generation of product offering. Assessment of the diversion prospects for a project or program should examine first its competitive dynamics, and the durability of the modal advantage it ought to produce. It should next consider the barriers to diversion, as they are relevant to the case, and how satisfactorily they will be answered. Projects that make sense in basic ways can then be subjected to deeper analysis.

This chapter has reviewed the use of market segmentation, traffic benchmarking, and classification of opportunities to commence such analysis. Diversion models are tools for further and detailed assessment, at the level of individual lanes and commodity, equipment, or industry groups. The latter function as a way to generalize retail or wholesale customer needs, and the former to isolate and differentiate competitive performance, with volume reckoned in both dimensions. Three types of models in active use focus on logistics cost, market share, and customer preference. They are designed to construct quantitative estimates of traffic swings, and all of them in some form call for market data, establishment of algorithms, and the contrasting of rival transportation products.

- *Total Logistics Cost* models aim to compare the comprehensive costs of modal choice alternatives, including direct transportation expense, and inventory dollars associated with modal lot sizes and service profiles. The models assume that customers rationally select the lowest cost option, and they require extensive information about logistical factors in transportation and industry to produce this comparison. They can be deterministic in that shipments become assigned to one mode or another, while retaining stochastic features to treat inventory risk and carrier performance, or they can allow for probability in the modal choice itself. The US Federal Highway Administration has employed a model of this type in its truck size and weight studies.

- *Market Share* models develop a statistical correlation between modal performance factors and traffic capture, then project traffic swings when relative performance changes. The correlation is derived from historical traffic patterns and in that sense is experiential, reflecting the results of carrier behavior as embedded in share. Performance factors typically include comparative transportation but not total logistics costs, first because transportation costs by themselves produce strong correlations, and second because logistics burdens can be regarded as accounted for, or 'discounted' in historical capture rates. The models assume that experience is a rational basis for projection, they require historical information for their preparation, and they produce probable shifts in share from the alteration of competitive position. A model of this type has been employed by Class I railroads in a number of merger applications.[74]

- *Stated Preference* models are developed from structured interviews with transportation purchasers. Through an extended set of forced choice comparisons by which the buyer makes trade-offs between performance characteristics, the process seeks to reveal decision points for mode shift. Statistical analysis of interview results can then be applied to project probable traffic diversions in response to changes in competitive service offerings. The models assume that statements replicate decision conditions and behavior, they require a program of interviews for their preparation, and they can be targeted to retail or wholesale participants. Models of this type have

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[74] One of the authors of this report provided the model referred to here.

been employed for customer research at some railroads, and for public rail initiatives like the New York Cross Harbor major investment study.

It is important to realize that freight flow is not a constant. In some circumstances, the traffic will evaporate due to factors outside the transportation arena – for example, local labor rates or exhaustion of natural resources may force certain industries to relocate out of the region, however much the transportation costs are minimized. For very high volume flows and modest investment, it is possible to set up rail flows that pay back the initial investment within a short period. For more ambitious schemes, a more general local economic assessment is required, to ascertain whether the target flows will remain for the foreseeable future.

Summation: This chapter has considered how shipper needs, structural factors, and competitive position delimit the expansion of rail freight, and how barriers of market viability and institutional readiness encumber its path. It has described how market analysis techniques can point toward promising segments where diversion challenges might be overcome, how public levers can prod the advance of highway relief, and where real opportunities are more and less likely to lie. It has summarized the effects of diversion when it occurs – and these effects in turn may form the justification for programs that produce it. Railroad solutions clearly can be a method to reduce road congestion, and just as clearly have their own limitations and consequences. The following chapter examines conditions and tools that can be guides for planners, who must decide when rail options belong among their strategies.

Chapter 4: Analytic Tools to Assess Decision Choices (Task 5)

4.1 OVERVIEW

This Task 5 report examines options for development of a public investment decision-making model that can be applied for evaluating rail and intermodal freight solutions to highway congestion. The remainder of this report is organized in four sections:

- Section 4.2 – *Key Factors to be Addressed*. This section highlights findings from prior tasks concerning needs, opportunities and decision factors to be considered in developing freight solutions to reduce highway congestion;
- Section 4.3 – *Applicable Analysis Models*. This section examines and reviews the wide range of analytic tools and models that can potentially be relevant for evaluating those needs, opportunities and solutions;
- Section 4.4 – *Process of Matching Analysis to Rail Initiatives*. This section identifies how different types of analytic approaches need to be applied for evaluating different kinds of transportation solutions; and
- Section 4.5 – *Outline of a Conceptual Framework*. This section outlines a conceptual framework for a decision-making approach that can identify appropriate and cost-effective forms of rail and intermodal freight system solutions. It focuses specifically on evaluation of the potential of public investments to reduce highway congestion and other related surface transportation problems, taking into account both public policy considerations and requirements for public/private cooperation.

It is important to note that the conceptual framework is outlined in this report, but will be further developed into a full model design later (in Task 9), after completion of further research on best practices in public-private partnerships (in Task 8).

4.2 KEY FACTORS TO BE ADDRESSED

Overview: The premise of this study is that there is a need for rail freight solutions to roadway congestion, and also a need for a new framework to help guide public sector decision-making for those solutions. This makes it important to ensure that (a) we first have a reasonable explanation of how and when such solutions are necessary, and (b) we can identify the types of key factors that have to be considered in such a decision-making system.

This section extracts lessons learned from the previously-submitted review of literature (Task 1), review of case study examples (Task 2), review of transport, land use and technology trends (Task 4), and review of policies and practices (Task 7). It discusses four sets of factors:

- Types of situations where multi-modal freight planning is most needed;
- Types of rail freight initiatives;
- Types of key public and private decision-makers; and
- Types of factors and applicable models for evaluating rail freight initiatives.

4.2.1 Multi-Modal Freight Planning. In order to systematically evaluate rail freight solutions to road congestion, it is first necessary to identify the types of situations where multi-modal freight planning is even required. Clearly, there can be some cases where existing or anticipated future roadway congestion can be adequately and appropriately addressed by "single mode" traffic planning solutions. These may include situations where road or highway capacity expansion, improvement to intersections, enhanced traffic control measures, and/or real-time monitoring and response systems can be appropriate technical solutions. The need for multi-modal planning, as opposed to single-mode planning, requires technical evaluation of transportation needs and solutions.

Generally, *multi-modal* planning becomes necessary when either: (a) transportation system investment needs transcend individual modes, or (b) solutions to single mode needs become infeasible, but can be addressed by encouraging shifts to alternative modal solutions. (This can apply to both freight and passenger needs.) In other words, multi-modal planning is most needed in situations where existing planning processes are too narrowly focused and therefore fail to identify the best options. These include situations where prior planning has been concentrated on single modes (e.g. highways), but intermodal and multi-modal transportation options offer superior performance. Sometimes, multi-modal solutions are constrained by institutional or regulatory hurdles (e.g. land availability, road access or zoning) that could be relieved through public policy.

Freight system planning can be viewed as one element of multi-modal planning, but it has traditionally been given less attention in public planning processes because major elements of freight systems are privately owned, with planning decisions made by many different private carriers and companies that use freight transportation. Many freight transportation decisions, with the notable exceptions of the provision of highway and port capacity, are made in the private sector by railroads, trucking and barge companies that seek to maximize their profits. For the most part, these freight transportation companies are engaged with specific modes, are not heavily involved with public agencies, and are not directly concerned with public benefits and costs.

The intersection or confluence of *multi-modal* and *freight system* planning is most needed in situations where existing planning processes are too narrow in scope and therefore cannot uncover the best options. These include situations where:

- Prior planning has been focused on single modes, e.g. highways.

- Private sector decisions do not take into account externalities that would, if considered from a public perspective, lead to different decisions.

- Intermodal and multi-modal transportation options offer superior performance, but cannot be implemented because of constraints that could be relieved through public policy (e.g. lack of land, inadequate road access or zoning).

- Private sector firms reject proposals with beneficial public benefits because their return on investment would be less than their cost of capital, or less than alternative uses for scarce funds.

In this context, the Task 4 documentation of transport and land use trends is important in that it lays out data on already ongoing trends, providing empirical support for the case that there are very large surface transportation investment requirements affecting passenger and freight travel across multiple modes. In terms of aggregate national needs, the report showed that traffic growth is exceeding population growth, and that freight ton-miles is growing most rapidly. It also showed the confluence of technological changes in industry production and distribution processes, increasing global markets, and changes in urban land development patterns have together supported the increasing reliance on trucking and further exacerbated urban congestion. Yet the review of technological change (in Task 4), along with the case studies (in Task 2), together support the case that new freight tracking and shipping technologies could support increasing investment in rail freight as part of a *multi-modal, freight system* planning process to reduce traffic congestion.

Together, the literature review, analysis of trends and case studies lead us to identify five types of situations where rail freight could be part of a multi-modal solution to road congestion. These are where:

- *Severe congestion seems to require very extensive investment in highways*. This includes situations where there are congested highways with high truck volumes, and where one approach would be to add highway capacity, but another would be to divert a significant portion of the truck traffic to rail. It also includes situations where there is local congestion related to delays at grade crossings - for example, where grade separation is beneficial for highway and railway users together, yet there are insufficient benefits to either group to support investment.

- *Over-reliance on trucks leads to very severe local problems*. This includes situations where truck traffic moving to and from ports causes severe congestion along the major access routes. For example, better rail service might divert some portion of traffic off certain streets, but it may be possible to justify public support for a shuttle operation that would move much or all truck traffic off the streets. It also includes situations where truck traffic serving local industry (or agriculture or mines) is growing, causing rapidly escalating maintenance costs for and congestion on local street networks. This is the classic light density line problem, where traffic that seems to be too little to justify rail may cause substantial problems for the public if the railroad leaves.

- *Problems with the network structure currently restrict the roles of rail*. This includes situations where railroads plan to add intermodal terminal capacity at the outskirts of metropolitan areas because of the availability of cheap land and the ability to consolidate operations, with the likely impact of increasing local truck miles within the region. In these cases, multi-modal planning might suggest multiple sites within the region, and public participation might help find better sites that would reduce truck traffic. It also includes situations where rail freight operations leave little capacity for commuter operations, stalling efforts to increase commuter service as a way to reduce highway congestion or as an alternative to expanding highway capacity. In these cases, railroads may not have the incentive to increase capacity, or they may be unable to increase capacity because of the cost or the availability of land, or the complexity of dealing with local governments.

- *Problems with the rail network structure restrict the performance of highways*. This includes situations where rail facilities block logical development of the metropolitan area or disrupt the flow of local street traffic. In these cases, multi-modal planning might be able to restructure the rail and highway facilities to the benefit of both rail and highway users.

- *Freight users are too small or too scattered for efficient use of rail or lack access to the network*. This includes situations where public loans or grants may assist companies in constructing sidings and gaining access to the rail network. It also includes situations where there could be opportunities for using regional warehouses or distribution centers that would allow greater use of rail.

In each of these five types of situations, there is a logical reason to believe that investments to promote rail could in fact lead to improvement in the greater transportation system. The next part summarizes the types of investments that should be considered.

4.2.2 Types of Rail Freight Initiatives - When a process of multi-modal planning identifies rail freight among the technically viable solutions, then a second step is to identify possible sector actions (initiatives) that could be taken to address them. We can view these actions or initiatives in the context of both broad strategies and specific solutions to implement them. At this juncture, we do not distinguish public and private roles, nor identify institutional issues that may hinder them. Rather, we focus on identifying the types of actions that potentially could make rail freight part of a viable solution to roadway congestion.

The literature review (in Task 1) identified a variety of different ways to improve railroad performance and various ways of categorizing rail improvement issues and related initiatives to address them. This led to a classification of six common *strategies to improve the performance of rail systems*. These six strategies, and associated types of solutions to implement them, are as follows:

(1) *Reconfigure to "rationalize" the center city rail network*: The major urban rail networks were largely established long ago, often reflecting land use patterns and

transportation technologies of the nineteenth century; they have not evolved to serve the land use patterns and transport demands of the 21st century.

Solutions include: (a) improve rail access to ports and other prime freight generators, (b) increase the capacity available for commuter rail, (c) consolidate rail terminal facilities so as to reduce rail costs and enable redevelopment of certain yards, and (d) improve rail and highway access to rail/truck intermodal terminals.

Ways to improve rail and highway access to intermodal terminals include (1) increase rail clearances to allow access for multi-level automobile cars, double-stack container trains, or other kinds of longer or higher cars to reach intermodal terminals or distribution centers, (2) enhance highway clearances to allow safer, more efficient access to rail/truck intermodal facilities, (3) provide more direct or less disruptive highway connections to intermodal facilities, (4) upgrade rail lines to make them suitable for through as well as local traffic, (5) improve rail clearances (height, width, and length restrictions), and (5) increase line capacity.

(2) *Reduce conflicts among rail and highway traffic flows*: Rail-highway grade crossings and at-grade rail crossings lead to congestion on both the rail and the highway networks.

Solutions include: (a) increase capacity to allow better service for rail passenger service (and thereby increase the ability of commuter rail to reduce highway congestion), (b) increase capacity to allow intermodal, general merchandise, and bulk trains to operate with fewer delays on high density rail lines, and (c) reduce delays and risks associated with rail/highway grade crossings.

Ways to reduce delays at grade crossings include: (1) improve protection at crossings, (2) better enforcement, (3) reduce rail operations during rush hour, (4) close grade crossings with low highway traffic, (5) invest in grade separation for crossings with high rail or highway traffic, and (6) change rail routing so as to reduce conflicts and alleviate highway congestion.

(3) *Increase use of rail/truck intermodal transportation*: Many kinds of freight can move in containers or trailers that can be handled by rail or truck, thereby reducing truck-miles on highways.

Solutions include: (a) improve rail access to ports and other prime freight generators, (b) increase the capacity available for commuter rail, (c) consolidate rail terminal facilities so as to reduce rail costs and enable redevelopment of certain yards, (d) improve rail and highway access to rail/truck intermodal terminals, and (e) promote non-standard technologies, such as Expressway-style equipment or the RoadRailer, to minimize terminal requirements and make intermodal more attractive for shorter distances.

(4) *Improve direct rail service to industry*: Some customers would ship more by rail rather than by truck if they had better access to good rail service.

Solutions include: (a) provide improved rail service to industrial parks and major potential rail customers, (b) provide sidings and support yards for potential rail customers, and (c) include investment in rail infrastructure in economic development planning.

(5) *Expand rail capacity*: The rail industry has increased the standard maximum weight for rail cars from 263,000 to 286,000 pounds, allowing some efficiencies in transport costs, but only if the track structure is able to bear the heavier cars.

Solutions include: (a) Upgrade track structure to allow higher axle load limits, (b) upgrade bridges to allow higher weight limits, (c) provide assistance to shortlines and regional railroads for upgrading their tracks and bridges to handle traffic commonly carried by Class I railroads.

(6) *Upgrade intermodal terminals*: As business locations and growth patterns have dispersed over time (discussed in the Task 4 trends report), accessibility to some rail loading facilities has become diminished, resulting in less use of those intermodal terminals.

Solutions include (a) improve terminal locations, (b) minimize local truck-miles by providing dispersed terminal facilities, (c) serve new industrial areas by locating facilities on the perimeter of the metropolitan area, (d) develop facilities with better highway access, (e) expand capacity to handle growth, and (f) achieve economies of scale in terminal operations by consolidating terminal operations.

These six types of strategies illustrate the range of rail freight initiatives that can be taken in theory, to improve the system in order to address the problems identified in the prior section. The Task 2 report also provided specific examples of actual initiatives that have been taken to promote greater use of rail freight. These initiatives were grouped within four types of project setting: inter-city corridor, urban corridor, metropolitan, and shipper or other related facility. Within any of these settings, many distinct options will be available to promote greater use of rail, which is why we retain the broader classification approach from Task 1.

4.2.3 Types of Public Sector Initiatives – For many elements of the six types of strategies, automatic implementation by private railroads cannot be expected. Rather, they require some sort of public sector support or intervention. Accordingly, it is important to identify the range of programs or strategies that public agencies can use to try to maintain, improve or promote the use of rail.

Many of these potential public roles deal with rail finances and industrial development issues, rather than with particular kinds of investments in rail technologies. In general, they revolve around the fact that public benefits and private sector profitability do not always coincide for freight rail systems and services. This creates a case for public support of rail facilities and services, when there is a clear public benefit (such as traffic congestion reduction) exceeding the private benefit to rail property owners and rail service operators. Some examples include:

(1) *Light density rail line programs*: For private rail operators, light density freight lines are often money losers. This makes it difficult for them to justify major new investment in these liens. Potential public sector actions include: (a) public purchase of rail lines in order to maintain rail operations, (b) public subsidy of rail lines in order to maintain rail operations, and (c) investment in light density lines in order to improve ability to serve customers.

(2) *Public ownership of the railway*: When regional or short-line operators are cutting back service, there can potentially be a public interest in considering purchase and lease back of railroad line(s), as a way to promote the economic health of railroads serving a region.

(3) *Redevelopment of rail facilities*: Public agencies have powers that can be relevant to help development of railroad land that is no longer efficient to operate, and then turn around and apply the revenues to fund relocation of rail facilities to equivalent or superior sites.

(4) *Increasing mainline capacity*. Public agencies can potentially provide land grants, funding grants or regulatory support to help with rail line capacity increases such as adding tracks to the mainline corridor, upgrading existing track to allow higher speeds and heavier loads, improving signaling, improving clearances, and creating a multi-track, grade-separated corridor through the metropolitan area. It can also extend to actions to construct new routes or changes to existing rail routes (e.g., rail flyovers) through a city in order to reduce rail/highway conflicts or to provide better service to rail customers.

(5) *Increasing attractiveness of rail to customers*. Public support for land acquisition, or other agency support can help facilitate the construction of rail sidings, creation of industrial parks at locations with good rail service, and the location and construction of warehouses, freight terminals, and distribution centers, and improvement of highway (or rail) access to intermodal terminals.

Some of these strategies have been very effective, others less so. The success of any of them, naturally enough, depends upon the circumstances where they are introduced.

4.2.4 Decision-Makers - The political and economic viability of public sector initiatives depends in part on the applicable geographic area and corresponding levels of government involved in decision-making for funding and implementation. Decision-makers can include officials representing: (a) railroads, (b) metropolitan planning organizations, (c) cities and towns, (d) freight users and organizations, and (e) the financial community. Each group has its own interests, perspectives, and procedures.

Altogether, these various types of decision-makers provide a multi-modal perspective that can, in principle, determine whether or not specific investments in rail are the best way to deal with congestion or other transportation problems. Creating the conditions for these actors to get together is essential for achieving the multi-modal perspective. This may not be an easy, but it will certainly be an essential task.

In Task 1, we concluded that it is important to acknowledge the basic funding and implementation barriers affecting decision-makers. Specifically, these are that:

- Railroads do not want the acceptance of public money for a particular project, to be used as a reason for future restrictions or taxes on rail activities in the future. They want to discuss projects on a stand-alone basis.

- Since railroads mainly are privately owned, some local and state governments are restricted from direct investment.

- Railroads have a regional or national perspective that is much different from the focus of local agencies; a railroad may be dealing with dozens of states and MPOs, whereas the public agencies are only dealing with a couple of railroads.

- Rail costs are complex and rail costing is relevant to certain public policy issues, notable examples being track charges related to passenger use of freight lines, or for freight use of the Northeast Corridor.

- The scale of and justifications for public investment are much more complex than what is used by railroads; railroads have been obliged to think small, they are extremely concerned with ROI, and they focus on direct operating impacts. Government agencies have very large projects (especially for highways) that are justified in terms of broader concepts of economics, environment and equity.

Any one of these barriers may be sufficient to stall plans or even to prevent discussion of possibilities. In general, lack of knowledge may prevent the parties from coming together to try to find some better solutions. A basic motivation for the guidebook is therefore to provide public officials with the understanding that they need to determine when rail solutions might be feasible, and what kinds of actions might make sense in particular situations.

4.2.5 New Institutional Arrangements and Procedures - From the case studies in Task 2 and Task 7, we have seen that new institutional arrangements can be devised to overcome these barriers. In effect, it is possible to create a new decision-maker who in fact has a multi-modal perspective.

Institutional Arrangements: In Kansas City, a special type of corporation was created that was able to receive state transportation funds, qualify for low interest rates and be exempt from local property tax. These benefits were sufficient to allow the railroads to transfer portions of their property to the corporation until project loans were paid off, so that it became possible to construct flyovers. The rail portion of the investment was justified by lower taxes, lower interest rates, and higher average train speeds. The public portion of the investment was justified by the reduction in local congestion and other economic benefits. The nature and amount of the financing available was dependent upon the nature and amount of the expected benefits. With fewer trains per day, or with less importance attached to train delay, the railroads would not have been willing to invest so much. With less highway congestion, or a lower perceived cost of congestion, the public agencies would have been less willing to participate. If construction costs for the flyover had been much lower, the railroad might have been able to justify the investment on its own; if construction costs had been much higher, then even the public/private partnership would have balked.

In Task 7, we have taken a closer look at current policies and practices regarding public assistance to freight projects, and we further examined the barriers to expanding the extent of such activities. Perhaps the greatest barrier is the lack of generally accepted procedures for identifying, evaluating, selecting, and funding freight initiatives. Without clear procedures and guidelines, the public is uncomfortable with allocating funds to new types of programs. To alleviate these concerns, a multi-faceted framework is needed to deal with three inter-related sets of issues: (1) Funding Sources, (2) Dispersion Process and (3) Evaluation Process.

As detailed in the Task 7 report, a political process can create funding sources and the mechanisms necessary to channel funds to specific projects. There are many examples here and abroad that suggest the kinds of approaches that can be used, as well as the nature of evaluation criteria that can be used to select the best projects. The Task 7 report discusses the issues that need to be addressed at the MPO, state and federal levels in setting up new freight programs.

Procedures: At this point, we are more concerned with evaluation process than with financing. Specifically, this task identifies the tools that are needed to estimate the costs and benefits associated with potential projects. While general discussions of policy may be based upon broad concepts, such as intermodal efficiency or a balanced approach to transportation, the design of and funding for particular projects must consider their costs and benefits in some detail.

The earlier literature review (Task 1 report) showed that public agencies are sometimes asked to carry out studies to identify the *effects of proposed investments* in rail facilities or changes in rail operations on: (a) rail cost and performance, (b) highway traffic flows and associated congestion and air quality, and (c) land use and economic growth. The earlier case studies (Task 2 report) showed examples where diversion of freight from highways to rail was sufficient to allow states to defer highway capacity investments. Local and state governments also consider the effects of changes in mode share on air quality and accidents.

Thus, local and state officials will, at varying levels of detail, need to consider the following types of changes and impacts on:

- Freight users – for logistics and transport cost and service provided by the freight system,
- Railroads – for infrastructure costs and capacity,
- Trucking – for system costs and capacity,
- Non-freight highway travelers – for travel times, delay and accidents,
- Non-users – for socio-economic impacts, air quality, etc.

While any of these impacts could be important for some projects, it is unlikely that all will be important to any project. A comprehensive study of all benefits and costs is seldom necessary to justify a project either within the public or the private context. Rather, each project is likely to have a specific focus, with consideration of a few dominant types of impacts. However, enough analysis must be done to show that benefits will be sufficient to cover costs for the different parties involved.

The prior case studies, however, underscore another problem – which is that most available public data on costs and benefits of other projects are quite general, and do not provide detailed guidance for agencies to easily adopt or adapt strategies successfully implemented elsewhere. Thus, our objective in this task is to lay out a framework for decision tools that will be needed to evaluate potential projects, at various of detail, for many kinds of projects. This framework will guide planners to the key impacts and it will provide a structured approach for focusing the analysis at an appropriate level of detail for each of these impacts.

We will use some of the examples from the other tasks to illustrate how to evaluate the various opportunities that are likely to be available in many locations. For example, constructing intermodal terminals and providing better access to terminals are two common types of investments. The construction of terminals includes facilities designed to handle 10-20,000 containers and trailers per year, as well as facilities designed to handle that much traffic per week. Despite the vast difference in the size of the projects, the fundamental questions will be the same: will there be an adequate return on investment for the private partners? Will public benefits justify the public contribution to the project? Is a public/private partnership the best way to implement this project? For both the small and the large project, planners will need to estimate such things as the cost of the facility, the traffic volume that will actually use the facility, the changes in truck travel as a result of the facility, and the CMAQ benefits from the changes in truck travel. The effects on development and land values might or might not be important, and it may or may not be necessary to include such benefits in the analysis depending upon the potential for congestion relief.

Negotiation Strategies: In general, any project will involve an initial investment and continuing costs and benefits. The first question is whether the continuing net benefits are sufficient to justify the investment. For projects where all of the costs and benefits are financial, evaluation requires the choice of a discount rate, a project life, and calculation of return-on-investment or net present value. If the ROI or NPV is acceptable, and if such analysis is the best approach for this particular project, then the project probably is good. If only one company or agency is involved, this level of analysis may suffice.

With multiple companies or agencies, it will not be sufficient to show that the overall project can be justified, or even that each participant receives equivalent benefits, or what are believed to be acceptable returns. With multiple participants, there are opportunities for negotiation: how much does each party contribute to the investment, and how much do they share in the costs and the benefits? Each party will have a minimum expectation, which would be in effect be the “zero cost” or “make us whole” solution: for a purely financial project, this would be a situation in which the ROI exactly equals the hurdle rate, or the NPV is zero. Equal partners will likely expect to receive equal returns, i.e. more than the hurdle rate for ROI, and a fair share of the projects NPV. A reluctant or shrewd participant might hold out for a greater share of the benefits and a lower share of the costs, knowing that others might be willing to accept lower returns. Legislation intended to provide public assistance to the freight industry is likely to have guidelines for how much support can be provided, under what conditions, given various kinds of justification and supporting analysis.

For complex projects, estimating the investment requirements, costs and benefits can be difficult and controversial. Issues that may arise include such things as:

- If a new facility is constructed to the same design as an existing facility, there will be little or no change in operating costs, capacity or performance. However, it will be a new, undepreciated facility that is actually better than the existing facility, so that expected maintenance costs will be lower. To what extent, if any, should the reduction in expected maintenance be considered a benefit for the railroad?

- The new facility could also be constructed to a better design, with higher capacity or better service capabilities. To what extent should the higher capacity or higher service capabilities be considered a benefit?

- The new facility may be constructed to higher standards to meet public needs (e.g. better track to allow faster passenger trains). To what extent should benefits to other traffic (e.g. to freight) be considered as a benefit for railroads?

Issues such as these can arise in adversarial proceedings, as when a public agency wants to upgrade commuter service on a line. It is possible to argue that the marginal costs of upgrading the infrastructure should be allocated entirely to the traffic that requires or asks for the better service, even though other traffic will benefit. However, in a cooperative proceeding, the railroad may be quite willing to use the ancillary benefits of a change to justify part of its share of the costs. The point is, that the negotiations could conceivably delve deeply into the marginal costs, marginal benefits, and the willingness of the various parties to pay for their portion of the benefits. Thus, the planners may need a means of understanding the costing issues at quite a detailed and sophisticated level.

4.3 APPLICABLE ANALYSIS MODELS

Overview: Ultimately, the unified decision tool to be developed for this project will be designed to help organize inputs and present analysis findings in a manner that facilitates public-private decision-making. As previously discussed, this approach recognizes that different situations will call for different levels of analysis detail, and analytic models that may be applicable for different types of projects and the viewpoints of differing parties. This section is not intended to be a comprehensive catalog of all analytic models, but it is intended to illustrate the wide range of potentially applicable modeling tools that might be used to provide inputs to the decision process. They are classified in terms of six types of models:

1) Rail service models;
2) Freight demand models;
3) Highway performance models;
4) Investment models;
5) Project evaluation models; and
6) Regional economic growth models.

4.3.1 Rail Supply and Service Models - Rail models are primarily designed for railroad use, to optimize operations and planning. They can be divided into the following categories:

- *Train performance calculators*: a TPC calculates train performance (speed and energy consumption) as a function of train and route characteristics.

- *Dispatching models*: these models predict the movement of trains along a route, taking into account the need for trains to use passing sidings on single track routes, and the need to allow high priority, fast trains (passenger or intermodal) to overtake slower trains. These models can include disruptions related to weather or maintenance; similar models are used by some railroads to assist in real-time dispatching of trains over their networks.

- *Train scheduling models*: these models are similar to dispatching models, in that they create a schedule for trains operating over a route, given the scheduled departure times, route characteristics, and train priorities.

- *Terminal performance models*: simple models estimate terminal processing time and cost requirements as functions of traffic volumes, schedules, and processing capabilities; more complex simulation models can analyze the effects of changes in layout or processing capabilities on performance.

- *Track maintenance models*: these models predict maintenance requirements as a function of the traffic mix and volume, equipment characteristics, track components, and maintenance strategies.

- *Network simulation models*: these models can simulate the operation of a terminal area, a region, or an entire system.

- *Rail cost models*: service unit costing is commonly used to estimate rail costs; this technique is an example of what is currently called "activity-based costing", as it relates costs to activities or service units such as train-miles, car-miles, cars handled at yards, and ton-miles.

- *Rail service models*: these models relate trip times and reliability to schedules, terminal capabilities, and traffic volumes.

- *Equipment utilization models*: these models predict cycle times for freight cars (which is the number of freight car-days that are required to move a load and to reposition the car for its next load). Fleet sizing, empty car distribution, and fleet management are very important matters for achieving efficient rail service; equipment costs can be very critical for some market segments.

4.3.2 Rail Freight Demand and Diversion Models - Freight demand can be studied at various levels of detail, using models of multiple types. Data sources are available that can show freight flows, by commodity, mode, and areas of origin and destination. Future flows can be extrapolated from past flows, with adjustments based upon expert opinion, customer surveys or economic forecasts. For some kinds of projects, flow data will be sufficient for evaluation. The carriers themselves have access to their customers through their sales and marketing staff, so they have, in principle, the ability to work with their customers to estimate future traffic flows. To some extent, customers are aware of changes pending in their traffic patterns based upon their internal production and facility investment plans. Both carriers and customers will be dependent upon some kind of trend analysis, commodity forecasts, and general economic forecasts for longer-term predictions.

Chapter 3 provided a framework for understanding the conditions, barriers, and potential for modal shift, and it summarized three kinds of models that have been used in large scale evaluations of diversion. Additional analytic approaches that can be used in conjunction with this framework, for preliminary estimation of diversion potential or for projecting modal traffic demand, are described next:

Carrier Cost Models can be employed to compare rail and truck capabilities to determine whether or not there might be a market for new services. Erickson (2001) provides a recent example of using cost models to investigate freight demand. He argues that there is enough freight on many branch lines to justify continued rail service, pointing out that the competitiveness of rail vs. truck is based upon shipment size and accessibility to non-circuitous rail service. His methods and ideas are based upon his experience running Conrail's Flexi-Flo operations from 1990 to 1999. He constructs cost models for rail and for truck based upon typical measures of cost and productivity, to estimate the cost per truckload or carload for various short distance moves. He envisions a hub-and-spoke rail distribution system that would be able to serve regional markets and attract industrial growth because of the low cost and convenience of rail service. He suggests that track costs are not large, only on the order of $5,000 per mile, and he believes that there is in fact a lot of regional truckload freight that could be diverted. He produces matrices that show rail and truck costs based upon cars per day and distance shipped and concludes that rail is viable for many low volume short distance shipments. This conclusion is dependent upon rather high truck costs (more than $5 per mile for 10-mile trips) and location of both shipper and receiver on the rail lines. However, it is clear that short-distance rail service is viable if there is sufficient freight for short unit trains (e.g. road salt, sand & gravel, or oil). Moreover, with this type of model, it is easy to conduct sensitivity analysis.

Merger studies involve a variation on the comparative cost approach where the focus is on how rail freight would flow over the new network resulting from the merger. Major rail mergers have required detailed assessment of traffic, and there are well-developed methodologies for predicting how changes in network structure and operation will cause changes in the flows of freight over a rail system. These models take into account the desire for the originating road to capture the longest or most profitable haul possible before a shipment is interchanged to another railroads. They can also take into account the choices available to shippers, who may choose the routing of a rail shipment that moves over multiple railroads; mergers typically result in closing some of the gateways previously available to customers, which will therefore shift traffic flows. Traffic studies for mergers typically take traffic flows for a base period and reroute them over the new network that is proposed for the merger. This exercise provides a clear prediction of the changes in traffic that will result simply from changes in routing decisions. Traffic studies may also consider the effects of traffic growth or diversion from other modes. The approach taken in these studies has in large part been determined by the requirements of the federal regulatory authorities, who are responsible for approving rail mergers.

Forecasting Models: For more complex projects with long time horizons, extrapolating from flow data or determining the best rail route will be insufficient, and it will be necessary to understand the forces that determine freight flows. Freight demand is driven by the demand for materials and products, which depends upon economic geography and the costs of transportation. Commodity forecasts and regional economic forecasts can be used to predict effects on freight flows. Some studies have predicted freight flows for specific commodities, e.g. coal or oil, by solving optimization problems that minimize the cost of transportation given the possible sources of supply and the location of demands.

It is seldom possible to contemplate highly detailed models that consider the supply and demand of many different commodities. The more common approach is to use economic forecasts to determine freight volumes, and to use logistics costs to predict supply chain configuration and traffic flows by mode. The logistics modeling approach has been used in many studies to look at freight demand.

Logistics Models: Minimizing total logistics costs is a key driver of freight demand, so that models of logistics cost can be very helpful in understanding how much freight will move by what mode. Spreadsheet models can be developed to estimate logistics cost as a function of customer, commodity and modal characteristics. These models show the importance of shipment size, inventory costs and access to freight systems. Complexities related to multiple sources of supply and distribution can be incorporated into more sophisticated supply chain models.

Logistics cost models can be used in conjunction with carrier cost models in order to study how changes in networks or performance will affect intermodal competition. A&L Associates, in a study done for the Volpe National Transportation Systems Center, developed and applied such models in a study of intermodal competition along the I-95 corridor from New York City to Atlanta.

A recent study (MIT Performance-Based Technology Scanning - JTRF Paper, 2002) is of interest because it illustrates a technique that could be useful for public agencies in screening opportunities for using rail freight. As part of a study on technology scanning, a logistics model was incorporated within a spreadsheet that could estimate the mode choice for 48 customers. The set of 48 customers was designed to represent a range of typical customer, commodities, distances or other factors relevant to the user. The inputs were broken into three categories: customer characteristics (e.g. annual use rate and trip length), commodity characteristics (e.g. value/pound and density), and mode characteristics (e.g. price, trip time, and reliability) for rail, truck and intermodal options. The MIT study was concerned with the effects of changes in technology on mode share, so the customers were defined to represent typical mixed freight shipments of low to medium value that were moving 250 to more than 1000 miles. A base case of transport options was set up with typical values for rail, truck and intermodal performance. Then, a number of options were set up to represent the types of changes in performance that could come from investments in new technology. These included fast or more reliable trip time, lower rates, more efficient loading and unloading, higher loading capacity (including double stack trains for intermodal) and various combinations. No attempt was made to relate these changes in performance to any particular changes in the rail system: the objective was to identify the kinds of performance improvements that were most likely to have a beneficial effect on mode share. This design concept makes it possible to understand much about the market without first having to show how – or whether – the railroads could actually provide the level of service.

In summary, there are various approaches to modeling freight demand. Data are available for documenting traffic flows at quite a detailed level, and this type of data may be sufficient for establishing whether or not traffic volumes are likely to be sufficient to justify certain types of investments. Traffic flow data can be supplemented with commodity and general economic forecasts in order to predict future traffic flows. Logistics cost models can be used to estimate how changes in mode performance might affect mode share, now or in the future. Full scale diversion models have been developed for competitive analysis, and estimation of the traffic capture from specific operating plans. Network optimization models can be used to consider national or international freight flows, taking into account patterns of supply and demand as well as mode costs.

4.3.3 Highway Performance Models - For the purposes of this study, it is necessary to understand several key issues:

- How addition or subtraction of trucks will affect traffic flow over a highway;
- How changes in traffic flow affect emissions and congestion (i.e. how to translate changes in flow into changes in emissions and hours spent in traffic, or other measures); and
- How changes in traffic flows affect highway maintenance costs.

The highway capacity manual provides the tools and methods for estimating the effects of adding or removing truck traffic from a major highway. It will be necessary to consider base case traffic flows and mix by time of day, then to estimate the effects on flow conditions of having fewer trucks on the road.

Highway traffic flows are generally growing and they can quickly adjust to the addition or elimination of truck moves or any other traffic category. Hence, a network analysis may be necessary to estimate equilibrium flows following a significant reduction in truck traffic.

Techniques developed in a prior NCHRP study (Economic Costs of Congestion - NCHRP 2-21) can be used to estimate the benefits of reducing congestion. That study was used to study the costs of congestion in the Philadelphia and Chicago regions.

Changes in emissions will come about for two reasons. Trucks have a different mix of emissions than automobiles, and it is possible to translate changes in truck-miles, by class of truck, into changes in emissions. Further reduction could come about if the reduction in truck traffic reduces congestion sufficiently to consider the reduced emissions from automobiles caught in congestion.

Predicting the benefits of diverting truck traffic can become very complicated if all of the factors mentioned above are considered. Much simpler approaches have been suggested for policy analysis. Most of the reports of savings from the various ISTEA projects simply state the number of truck trips or truck-miles diverted to rail, without any further attempt to quantify congestion or air quality benefits. In Europe, several countries have used per-mile estimates of the monetary benefits of reducing truck traffic, taking into account congestion and air quality factors. These factors obviously cannot be valid for every case, since diverting traffic during rush hour will have much greater benefit than diverting traffic in the middle of the night. Still, this type of factor simplifies the assessment and at least provides guidelines as to the magnitude of potential benefits.

4.3.4 Investment Models - Models for both rail and highway investment can take into account the optimal timing of investments as a function of the projected traffic levels and traffic mix. A good example of the required logic for a rail system is given by TRACS (Total Right-of-Way Analysis and Costing System). This is a set of models that was initially developed by MIT with the support and participation of the Association of American Railroads. This model was employed extensively in the industry's economic analysis of the impacts of heavy axle loads. It also has been used in other analyses by the AAR and by individual railroads, and can be applied for modeling the incremental effect of small changes in traffic on infrastructure costs.

TRACS is able to estimate the effects of changes in traffic mix, traffic volume, and axle loads on track deterioration, scheduling of track renewal (new rail or tie programs) and track costs. The major steps in using this model are:

- Specify the traffic volume, by type of freight.
- For each track segment, specify the type of components and their condition.
- For each type of component, specify the conditions that will require maintenance activities or replacement (e.g. replace the rail on a high density line if the wear on the rail head exceeds 0.5 inches).
- For each type of component, the model then a) computes the stresses imparted as a function of the type and weight of the equipment, b) estimates the deterioration rate, and c) determines maintenance and renewal activities required over the planning horizon (up to 100 years).
- The model then applies unit costs for each of the maintenance and renewal activities, and is thereby able to calculate measures such as net present value, equivalent uniform annual cost over the planning horizon, and cost per 1,000 net ton-miles.

TRACS can be used to estimate steady state performance as well as performance over a specified time horizon. Some railroads apply a similar analytic approach starting with current conditions, in order to identify whether there are benefits worth pursuing.

Models of similar type have been developed for highways, and the many truck size and weight studies are the highway equivalent of such rail analyses. Highway officials also use the ESAL (equivalent single axle load) approach to estimating the effects of truck traffic on the highway infrastructure. Based upon research and testing, it is possible to estimate the damage done to roads (e.g. pavement degradation) by different types of trucks or tractor-trailer combinations. The vehicle weight, the number and location of axles, the number of wheels per axle, and the size of the tires are among the many variables that affect the stresses that are imparted into the highway.

4.3.5 Project Evaluation Models - Project evaluation has several major elements. For a particular initiative, it is necessary to estimate costs and benefits over a suitable time frame, including qualitative and quantitative, financial and social, public and private benefits. If the benefits are, taken together, considered to be greater than the costs, then the project may be worthwhile. However, it is also necessary to compare alternative solutions, to determine whether other projects may provide more effective ways of achieving parallel or better benefits.

This means that we need to be able to:

- Estimate the costs and benefits of a particular project;
- Provide a framework for determining whether the benefits justify the costs; and
- Support alternatives analysis for comparisons to other projects, which might provide better ways to do the same thing.

The need for appraisal of alternatives is fundamental to the core of this study. The comparison of positive and negative aspects of alternatives allows us to establish whether benefits outweigh costs and also whether one project alternative is superior to others. However, moving beyond that basic concept, there are actually a variety of approaches for evaluating financial, non-monetary (but quantifiable) and qualitative impacts of congestion.

Economic Approach: Benefit Cost Analysis (BCA): At its most basic level, BCA is a comparison of all of the positive and negative aspects of a project. (In this context, project investment cost is an intentional negative element, since it means that other uses of the funds are foregone.) However, in practice, economic studies most frequently estimate the money value of benefits and costs for travelers and transportation agencies, and leave out other positive and negative impacts, which are dismissed as immeasurable "externalities".

Some economists have made attempts to convert other impacts into monetary (dollar) terms, through surveys that derive "willingness to pay" for impacts ("stated preference analysis") or observations of actual choices as reflected in property values ("revealed preference analysis"). However, there is generally a lack of consensus on the property value impact of other factors, such as truck and railroad noise, smell, and other impacts of freight transportation projects.

When both costs and benefits can be reduced to monetary values, there are well-developed methods for project evaluation. The net present value or the equivalent uniform annual cost or net benefit of a project can be calculated using an appropriate discount rate and time horizon. The discount rate should reflect the risks associated with the project and the opportunities available from other investments with a similar level of risk. The time horizon should be long enough to cover the costs and benefits that, when discounted, will have an important effect on the decision.

There are two basic shortcomings in the use of BCA for evaluation of rail freight projects. The first is that BCA is designed to aggregate all benefits and all costs for society, without regard to their incidence. In the case of integrating highway and rail investment, the different roles of public agency investment for roads and private investment in railroad functions should be recognized and considered in evaluating opportunities for "win-win" propositions in public-private partnerships.

Cost-Effectiveness Analysis (CEA): CEA differs from BCA in that it does not seek to simultaneously evaluate all positive and negative impacts, and it does not require that all positive and negative effects be boiled down to a common measure of dollars. Rather, CEA compares the effectiveness of project alternatives in achieving various individual indicators of desired benefits.

If most of the costs can be expressed in monetary terms and if most of the benefits can be quantified at least in non-monetary terms, then it is possible to use measures of cost effectiveness that show the cost per unit benefit. This makes it possible to compare different designs and entirely different approaches to achieving quantitative, non-financial goals such as improving air quality and reducing congestion. However, CEA is limited as it examines single dimensions of impact that may affect different parties (travelers, shippers, or transportation providers), and it still does not differentiate coincidence of costs.

Data Envelopment Analysis (DEA): DEA is related to CEA in that it attempts to compare the effectiveness of alternative projects or programs in achieving results that can be measured, but not in monetary terms. Basically, DEA is a form of graphical analysis that simultaneously displays the effectiveness of alternatives in achieving multiple criteria. This makes it possible to identify alternatives that are clearly superior to other alternatives at all spending levels, those that can provide greater benefits among all dimensions per dollar of spending at certain levels of implementation, and those alternatives that provide tradeoffs in results.

In public projects, it is seldom possible to reduce the analysis to financial terms, and it will even be difficult to quantify some of the costs and benefits. Therefore, a more elaborate scheme will be needed to allow rating of multiple criteria with attention to incidence, as discussed in the next section.

Guidance on Methodology for Multi-Modal Studies (GOMMS): This is a form of multiple criteria rating, based on the UK Treasury's Green Book for appraisal of alternatives for public sector projects. GOMMS is the format of that analysis for transport planning. It is essentially a tool to lay out all the accessibility, economic, environmental, social integration and distributional impacts through use of Appraisal Summary Tables (ASTs). There is a worksheet for rating "Transport Economic Efficiency" from the perspective of consumers, business, private sector providers and developers. There are also separate worksheets for rating "Public Accounts" from the perspective of local and central governments.

Scottish Transport Appraisal Guide (STAG): This is a variant of the GOMMS approach, as employed in Scotland. It also builds on the concept of Appraisal Summary Tables, with a concise rating form for assessing project alternatives in terms of seven factors: (1) social and economic context, (2) planning objectives and measures of performance along them, (3) project rationale, (4) fit with land use and other policies, (5) implementability, (6) efficiency for conventional transport user benefits and costs, and (7) economic impact in terms of employment and GDP (gross domestic product - a measure of economic output).

Other Project Appraisal Schemes: There are many variants of the preceding two examples that all use some form of concise tables for rating by multiple criteria. They include:

- A social and economic appraisal form is applied by the World Bank for its projects;
- Several US states and Canadian provinces have appraisal rating sheets which can account for economic development and other desired goals;
- Criteria for screening federally funded projects in the US are specified in TEA-21 legislation. These include economic development, environmental and equity factors, as well as transportation efficiency.

Several of these systems for including economic impact considerations in project decision-making are discussed in the NCHRP Synthesis of Practice on Assessment of Economic Development Impacts of Transportation. US federal and UK approaches are also discussed in Weisbrod and Weiss, 2001.

TransDec: Transportation Decision Analysis Software: This package was developed as part of NCHRP 20-29 (2) in order to assist public officials in implementing a multi-modal approach to transportation investment decisions (NCHRP Research Results Digest 258). This package is concerned with both freight and passenger transportation. It helps to structure a process of evaluating transportation investments on the basis of multiple goals that are tied to specific objectives and values. The following types of goals might be considered: (a) improve mobility, (b) improve connectivity, (c) increase cost-effectiveness, (d) increase energy efficiency, (e) improve air quality, (f) reduce resource impact, (g) reduce noise impact, (h) improve accessibility, (i) reduce neighborhood impact, and (j) improve the economy.

For each general goal, the user specifies specific objectives and measures, so that it is possible to develop a weighting scheme to compare alternatives. The software allows quantitative or verbal (e.g. high, medium, or low) measures of impacts, and it allows the users to assign weights for each objective. The system is designed for comparing multiple alternatives, where the users are responsible for defining the objectives and the weights and conducting sensitivity tests. Users can also require a minimum threshold for any measure, so that the best alternative must satisfy some basic level of performance with respect to any or all of the goals. It is intended to provide a way for documenting an agency's values and its approach to decision-making.

4.3.6 Economic Development Impact Models - One of the motivating factors for interest in utilizing rail freight to address roadway congestion is the need to facilitate goods movement, as this can have particularly important repercussions for economic development. As noted in the Chapter 2 discussion of trends, logistics and scheduling factors are playing an increasingly important role in the global economy, and in facilitating local economic growth. The particular interest is in evaluating the broad economic growth implications of accessibility, separate from the assessment of travel time and travel expenses for existing users. Available tools for project assessment include:

ARC-OPPS: This is the Appalachian Regional Commission's Highway Economic Opportunities Model, distributed within the thirteen Appalachian states by ARC. Elsewhere, it is referred to as Hwy-Opps. This model analyzes how transportation projects change the accessibility of a place to labor markets, supplier markets and customer markets, as well as average speeds and accessibility to multi-modal (airport, seaport and rail) terminals. The key importance of this model is that it focuses on identifying how highway projects and policies can affect accessibility, and hence future potential for economic growth. It focuses on identifying opportunities to attract new business and hence new users to an area, which is entirely different from measuring how a project or policy affects time and cost for existing highway users.

State Models: State DOT models for transportation evaluation that recognize accessibility impacts, include Indiana's MCIBAS (Major Corridor Investment Benefit Analysis System) and Montana's HEAT (Highway Economic Analysis System). The core element of all of these models is the "Highway Business Attraction" module[75]; both of these systems focus only on highway impacts, but they could be expanded to address rail accessibility as well. In fact, the highway accessibility model has also been used to analyze impacts of high-speed passenger trains in Canada and in California.

REMI TranSight: This large scale multi-county regional economic simulation model is distributed by Regional Economic Models, Inc. It forecasts the economic growth impacts of changes in general county-wide transportation costs and inter-county travel costs. It is useful when a congestion mitigation project or policy is large enough to register impacts at the county level.

NCHRP Model: The NCHRP model of the economic implications of congestion is the product of a prior NCHRP project to calculate the direct economic costs of urban congestion for area businesses. It requires a detailed traffic zone analysis of travel times and distances, a zone-to-zone traffic simulation model, and a zone-to-zone representation of truck traffic by industry type and commuter movements by occupation. Due to its intensive data needs, it is mostly useful for demonstration purposes. However, it builds on some of the same concepts included in the Hwy-Opps model, and some of these concepts were subsequently used to develop REMI TranSight.

In closing, none of these economic modeling concepts are directly transferable for this study, but all offer elements of analysis that could be applied. The development and specification of appropriate analysis for this study will be further refined in its next phase.

[75] Developed by Economic Development Research Group, one of the authors of this report.

4.4 MATCHING ASSESSMENT TO RAIL INITIATIVES

4.4.1 Objective - The preceding section established that a wide variety of analysis models exists that can be applied to assess a wide variety of issues. A corollary is that different types of assessment and modeling issues will pertain to different types of projects. This presents a very real challenge for this project, which seeks to develop a guidebook to address the potential ways that greater use of rail freight can reduce highway congestion.

Our approach is not to duplicate what is already in place, nor to propose an extremely time-consuming and costly approach with an all-encompassing model for freight planning. Instead, we provide a general framework and show how it can be applied to key situations, where rail freight can be a part of an approach toward reducing local highway congestion.

4.4.2 Approach - There are various ways to structure assessment models. Our approach begins by identifying examples of prototypical situations where freight rail solutions should be considered as part of multi-modal planning to address road congestion. Then, for each situation, we describe the major types of rail solutions that could be considered and the most important elements to include in the evaluation. We recommend a multi-phase approach to studies that builds from preliminary assessment, to planning for implementation. Finally, we suggest models that can be used within each part of the analysis.

Table 4-1 summarizes five typical situations where there is congestion and rail freight may be a potential solution. These situations require different levels of analysis, consideration of different types of rail initiatives, and analysis of various economic impacts. The structure of our six-step basic approach is summarized in Table 4-2. This is intended to illustrate how various methods and models can be utilized to obtain the information needed to evaluate multimodal freight transportation projects, ultimately producing outputs that can be used in multi-criteria comparison of alternatives (e.g. as defined by NCHRP 20-29).

Table 4-1 Examples of Situations Where Rail Should be Part of Multimodal Planning

1. Severe congestion seems to require extensive investment in highways
2. Severe local congestion due to over-reliance on trucks
3. Problems with the network structure restricts role of rail
4. Rail network structure restricts performance of highways
5. Freight users are too small or too scattered for efficient use of rail

Table 4-2 Steps to be Undertaken for Each Key Multimodal Planning Situation

Step 1	Identify the nature of the congestion problem in terms of area, time delay, severity, variability and type of transportation affected (truck, car, etc.).
Step 2	Describe the most important rail options available for this situation and provide a spreadsheet for estimating the effects on rail performance.
Step 3	Show how to estimate traffic diversions.
Step 4	Show how to translate traffic diversions into effects on congestion, highway investment needs, air quality and other benefits.
Step 5	Show how to address broader socio-economic issues and incorporate results within a multi-criteria evaluation of multimodal transportation alternatives.
Step 6	Assess organizational capacity for coordination and cooperation among public agencies and private transport providers.

The first four steps can be accomplished utilizing various transportation models and analysis tools tailored to the specific situation. Ultimately, we will have to outline a consistent "multi-perspective" approach for steps 5 and 6 that will facilitate comparing the public and private investments, as well as the public and private costs. This approach could allow sensitivity analysis for all of the major factors, so public officials could determine whether or not particular types of investments make any sense. The following subsections provide more detail on steps 1-4 of the modeling approach that is recommended for each of the five examples listed above in Table 4-1.

4.4.3 Example of a Congested Corridor

Step 1. Define the Situation. There is a congested intercity or urban corridor with a substantial percentage of truck traffic, and there are preliminary plans for large highway investments designed to add capacity and relieve present or future congestion.

Step 2. Rail Option. If a significant portion of the truck traffic could be diverted to rail, then it would be possible to reduce or defer some of the planned highway investments. Given the high cost of construction of highways, particularly in and around major metropolitan areas, it may be more cost effective to invest in rail than in highway solutions.

Step 3. Estimate Truck Diversion. The direct potential benefits to be achieved on the existing highway by diverting truck traffic comes as a result of :

- Reductions in highway maintenance expense (ESAL analysis);
- Reduction in traffic flow and resulting changes in congestion, taking into account the distribution of truck traffic throughout the day and its effect on traffic flows during those time periods (Highway Capacity Manual);
- Reduction in accidents related to trucks (truck accidents per mile based upon averages for this type of highway or upon a statistical analysis for this corridor);

- Reductions in fuel consumption and emissions (based upon emissions and fuel consumption per vehicle-mile).

Step 4. Analysis of Specific Benefits. The next step is to estimate the extent to which investments in highway capacity can be deferred or eliminated. The ideal approach would be to use the same capacity planning techniques for a base case scenario and for one or more scenarios with reduced truck volumes. The result would be a pattern of investments over an extended time period for each scenario. The benefits of reducing truck traffic could then be expressed in terms of net present value, or a change in equivalent uniform annual investment costs.

Estimating the potential benefits will provide some basis for deciding what kinds of rail solutions can be considered. At a minimum, the total benefits must be greater than the net costs associated with diverting traffic to rail.

Step 5-6. (Multiple Perspective Analysis). Given that freight users are free to use rail or truck, it is likely that their choice of truck is based upon rational decisions, taking into account their costs and benefits. To change their decisions, it will be necessary to accomplish one or more of the following:

- Change their perceptions of costs and benefits;
- Change the structure for taxes, fees, and tolls so that users pay more of the actual costs (including costs to the environment and to the public) of using highways;
- Change the regulations for using rail or truck services;
- Subsidize the rail service;
- Improve the rail service;
- Increase the capacity of the rail system;
- Make it more convenient for shippers to use rail service.

To affect congestion in a major intercity corridor, it will be necessary to divert a substantial volume of traffic to rail. To get some idea of the magnitude of the required shift, consider that essentially all such corridors are served by limited access highways that have at least two lanes of traffic in each direction. The capacity of the highway is therefore close to 4,000 auto-equivalents per hour in each direction, i.e. on the order of 20,000 auto-equivalents during the most congested morning and afternoon peak periods. Diverting a few trucks or a few dozen trucks per day will have no measurable effect on peak period congestion; it will be necessary to divert many hundreds or even thousands of trucks per day to achieve even a 1-2% reduction in peak period traffic volumes. Thus, we are talking about rail solutions that involve running several more trains daily in this corridor, rather than adding a few cars to existing trains.

There are several distinct market segments to consider:

- Regional bulk shippers who are using trucks to move large volumes of freight along this corridor. This might include general agricultural movements, sand & gravel, ores, rock salt (for highways), fuel oil, or other specialized bulk commodities. The use of truck rather than rail conceivably is based upon either minor variations in cost or the lack of suitable facilities for loading or unloading. Public assistance in provision of rail equipment, construction of rail sidings, or relocation of loading or unloading facilities may be sufficient to divert this traffic. Bulk traffic is especially worthwhile to pursue because a single rail car can handle 4-6 truckloads, so a relatively modest rail service can have a significant impact. A sand & gravel shuttle train that handles 100 rail carloads per day would eliminate 500 truck trips along the corridor.

- General merchandise currently moving by truck that could be handled in intermodal trailers or containers. The competitiveness of intermodal service, especially for shorter distances, is highly dependent upon the location and efficiency of the intermodal terminals. The time and costs associated with loading and unloading the train can be a major impediment to the use of intermodal services. Public investments in terminal facilities or equipment could, as with bulk, make intermodal service more attractive along this corridor. A trainload of piggyback trailers can carry on the order of 100 trailers; a double stack container train can carry 200 or more. Thus, a single intermodal train can eliminate 100-250 truck trips along the corridor.

- Freight that is already moving in intermodal service, but that uses portions of the corridor for access to and from the intermodal terminals. Which parts of the highway system are used by this class of freight depends upon the location of the intermodal terminals. Conceivably, it would be possible to relocate terminals or add terminals so as to reduce truck traffic on the highways. This is a market segment where traffic flows are concentrated to coincide with train schedules and customer preferences, so that it could be contributing more to congestion than the general freight moving by truck.

- General traffic that is moving by truck but that could move in carload service. This market segment includes such things as paper, lumber, food, chemicals, auto parts, automobiles, and the whole range of manufactured and intermediate products. There is insufficient traffic volume to justify unit trains, but there is enough to consider using low-cost rail carload or multi-carload service. Newspapers, food distribution centers, and major manufacturing facilities are obvious candidates for greater use of rail; most of these companies do make some use of rail and could make greater use. The dividing line between the use of rail and of truck may be small, so that incentives or assistance could have an effect. There are many more potential customers who may not have ever used rail and who are really unaware of the prospects. Public investment in such things as light density lines, in customer sidings, in consolidated warehouse or distribution centers could make this type of traffic more attractive.

For each of these segments, it will be necessary to consider either the total logistics costs of shipping by rail and by truck, and how these costs will be affected by potential solutions, or the door-to-door transportation costs, and the competitiveness of modal service. To be effective, the investments or other actions must make rail the most attractive option for at least some of the customers.

The investments in rail capacity will fall into various categories of terminal facilities, right of way, and line capacity or facility users. We will develop a set of screening steps that can be used to investigate investments in these categories of rail facilities. All of this information can then be summarized within a spreadsheet that can be used to compare public benefits to public costs, private benefits to private costs, and total benefits to total costs for the corridor. The results of the analysis can then be summarized for particular strategies:

- Planned investment or other actions to enhance use of rail;
- Impact of these actions on rail performance;
- Expected diversion of traffic from the corridor;
- Impact of diversions on corridor congestion, safety, and environmental considerations;
- Impact of diversions on future highway investments for the corridor;
- Evaluation of the proposal, including financial assessment, cost-effectiveness, and development of other quantitative and qualitative factors for comparing proposals.

4.4.4 Example of Localized Congestion -

Step 1. Define the Situation. Over-reliance on trucks leads to severe local problems. As noted above, there are two common problems: port access in urban areas and bulk traffic in rural areas.

- Since ports concentrate traffic, often within older, highly developed portions of a city, port access becomes a problem. The general problem is likely to grow, as international trade is expected to continue to expand more rapidly than the general economy. Overall growth in port traffic eventually will lead to congestion and bottlenecks, as more trucks are required to move on streets that were not designed for heavy trucks.

- In rural areas, grain elevators, mines, paper mills and similar facilities can concentrate freight traffic on roads that were not designed for heavy trucks. Since rural roads are less traveled, congestion is perhaps less likely to be a problem, while road deterioration will be a major concern (e.g. Prater, 1998; Prozzi et al, 2003). However, the main roads in most rural areas go right through the cities and towns, so that traffic volumes that would not be noticed in a large city will in fact be highly visible and a concern.

Step 2. Rail Option. For ports, the rail options include:

- Better highway access to the rail intermodal terminals that serve the port;
- On-dock rail service – to eliminate the delays and costs associated with using trucks for drayage to more distant terminals;

- Grade-separated rail access – to reduce crossing delays for both highway and rail traffic and to provide better (faster, more reliable, and higher capacity) rail service for port traffic;
- Improved lateral and vertical clearances to allow operation of larger, more efficient equipment (especially for high cube box cars, handling multilevel auto racks or double-stack container trains);
- Expansion of intermodal terminals, in order to support higher volumes moving to and from the port by rail;
- Shuttle services between the port and inland terminals, to enable greater utilization of expensive land at the port, to eliminate truck moves through congested urban areas, and to achieve economies of scale and scope at the inland terminal;
- Expansion of rail capacity along approach routes;
- Relocation of port facilities in order to allow more efficient intermodal operations (and to allow redevelopment of existing port facilities).

For rural transportation, the main idea is to deal with the specific companies that account for the high volume of trucks moving through the small cities and towns. It will be necessary to understand why they use truck rather than rail, and to determine whether feasible changes in rail performance would be sufficient to cause them to reduce their truck traffic. This will require use of a logistics model. In considering the public costs and benefits, it will also be necessary to consider the importance of the economic activity to the regions affected by the congestion. Congestion may be a problem, but jobs and economic growth may be more important local concerns.

<u>Steps 3-6. Analysis</u>. The steps of the analysis are similar to what was outlined in the previous section example of corridor congestion. It is first necessary to understand the size of the problem in terms of the effects of trucks on congestion and road/street/highway performance. Next, it is necessary to understand the market segments, which will be a much easier task since the flow problems are much more localized. Third, it is necessary to understand how improved rail service might divert traffic from trucks, and finally, it is necessary to determine if the costs of the rail improvements justify the expenditures from the perspectives of both the public and the private parties.

The rail models needed for this analysis will mostly be the same as those needed for corridor analysis. The highway analysis will be more complex, as it involves local streets rather than interstate highways. The main difference, already noted, is that the traffic is much more readily definable.

4.4.5 Example of Structural Problems with the Rail Freight Network -

<u>Step 1. Define the Situation</u>. The rail network was, in many locations, fully developed long before highway transportation provided a realistic alternative. Cities were smaller and denser, with land use often determined by or dominated by rail system requirements. While the rail system has to a large extent been rationalized, through a long process of mergers, consolidation, abandonment, this process has largely been driven by private

rather than public needs. As a result, we have a largely private rail system that at times is not providing important services that could be justified from a public perspective. Particular problems are likely to emerge concerning the location of intermodal terminals and the capacity for commuter rail, as alluded to above. In both of these situations, private perspectives tend to shrink the network and to focus on the most profitable business, whereas public perspectives might expand the network to maximize the environmental benefits of rail.

Step 2. Rail Options. Solutions to address highway congestion may include investments in upgrading rail facilities, including yards, terminals and loading access routes.

Steps 3-6. Analysis. Dealing with fundamental structural problems may help reduce highway congestion in several ways:

- By reducing cost or improving service, more traffic will be attracted to rail;
- More capacity can be made available to commuter rail, which can then play a larger role in alleviating peak hour congestion;
- By providing better locations for intermodal terminals, more traffic will be diverted to rail, and traffic already moving intermodally will travel shorter distances on urban streets;
- By eliminating rail-rail or rail-highway conflicts, rail and highway congestion can be improved, even if there is no diversion from truck to rail.

The general freight issues are the same as discussed above, but the commuter rail is a new consideration. The benefits of rationalization are also highly dependent upon land values and alternative uses for the land.

Assessing rail options in this type of situation normally will be quite complex, as difficult issues of land use and economic development must be considered along with both passenger and freight transportation issues. Furthermore, any significant restructuring of the rail system will be costly and potentially disruptive to implement. Thus, assessment of this type of situation will require sophisticated modeling related to rail systems, urban passenger transportation systems, and regional economic growth.

Before getting deep into the modeling, it will be necessary to document current rail performance levels, in order to support expert judgments concerning the potential for improvements in service and capacity. In other words, the first step is to build a case for change, showing that the existing infrastructure severely limits the quantity or quality of freight and passenger service provided.

Trend analysis and economic forecasts can then be used to assess future performance under the existing plans for infrastructure improvements. Congestion and capacity problems will be expected to worsen with economic growth, unless infrastructure or system management improves.

Deteriorating transportation performance can be incorporated within a regional economic model to show how transportation bottlenecks might limit growth in terms of jobs and income. Other scenarios can be run to show the effects of investing in transportation, taking into account the influence of investments on the economy, as well as the consequence of reducing transportation and congestion costs. This type of study can help determine the extent to which transportation constraints are likely to become strategic problems for a region, and provide some indication as to the ability of the region to afford substantial investments in transportation infrastructure.

4.4.6 Example of Obstructive Rail Freight Infrastructure -

Step 1. Define the Situation. This type of situation differs from the previous one in that the problems with the rail freight infrastructure are felt by abutters and highway users, not by rail customers. Even though the railroad may function perfectly well for its customers, it can be a massive impediment to highway traffic flow, economic growth and land use in the region. Grade crossings are an obvious problem for traffic flow; blocked corridors or restricted cross-town routes can be much greater, but much less visible problems.

Step 2. Rail Options. The rail solutions for this type of problem involve relocating or rationalizing some portion of the rail system so as to free up land for development, or to open up new transport corridors.

Steps 3-6. Analysis. It is possible to view the structure of the rail system as part of a regional planning process for transportation and land use. The Task 2 report described a case study of planning efforts initiated in Vancouver, British Columbia, that included freight within the context of a general review of transportation projects. The process was driven by two main observations. With continued growth, the region would slowly become more congested; as mobility declined, it would become more difficult for much of western Canada to remain competitive in exporting grain and other products. Vancouver, which would like to be the major gateway on the west coast, could not fulfill that role without substantially upgrading its transportation infrastructure. Vancouver therefore created a public/private council to investigate potential solutions and to identify the key projects that were needed for the system. Their experience is relevant to our task because they included freight and rail concerns, not just passengers and highways.

Assessing any significant change in transportation networks is a complex problem that will likely require the use of regional transportation models, land use analysis, and rail simulation models. Regional transportation models can be used to predict how traffic flows would change, if new roads were constructed across the areas previously blocked by rail facilities. Land use models or real estate analysis will estimate the development potential of the land that would be released by the re-location or downsizing of the rail facilities. Rail simulation models could be needed to estimate the effects of the changes on rail costs and service levels. The railroads will be concerned with the effects of the change on a) terminal capacity, costs, and accessibility; b) line quality, costs, and capacity; and c) costs, capacity and service levels for reaching local customers.

Terminals, of course, are a much larger impediment to highway flows than rail lines: it is not difficult to provide grade crossings or to build bridges over a line, but it can be extremely difficult to build bridges over a rail terminal that could be a quarter- or a half-mile across. Service to customers is not dependent upon having a nearby terminal, so long as local trains can move from the support yards to the customers and still have sufficient time for reliable pickup and delivery of freight cars. Local train service and the number and location of local support yards can be (and has been) adjusted and revised to take into account changes in traffic volume, customer locations, and the location, utilization levels, and economies of scale in operations at nearby yards.

There are several distinct scenarios for the relationship between the railroad and the public agencies. The railroad may already have reduced operations or even closed the facility, and it might welcome discussions concerning redevelopment. Major projects such as the Prudential Center in Boston and Crystal City in Washington DC have resulted from converting underutilized rail facilities. In such situations, the railroads and public agencies might well be allies in seeking better uses for the land. The other extreme would be a situation where the rail facility is vital to the railroad, so that relocation could potentially be very disruptive and the railroad naturally will resist changes. In between are many situations where the railroad might be willing to cooperate, but only if there is a chance to move to a more modern, more efficient, larger, or better situated facility.

Complexity will increase if there are multiple railroads involved. A facility that is clearly underutilized may still be viewed by one of the roads as a strategic asset. For example, they might be able to erect a new intermodal terminal in the location if existing terminals become congested – or if the competing railroad decides to relocate its intermodal terminal to a more distant location. Railroads will be anxious to preserve any competitive advantages that they currently enjoy with respect to route or terminal characteristics. This can be an impediment to consolidation schemes that might seem natural to a public agency, such as consolidating several small intermodal terminals into a single central facility, or in providing public support to railroads for improving clearances for double-stack trains.

Thus, there will be several steps to achieving major structural change. First, it will be necessary to get a sense of the potential costs and benefits associated with removing or relocating the rail facilities. This will require a comparison of the costs of relocation with the benefits that are achievable. Rough estimates of the costs of relocation can be based upon the size and type of the terminals, and the nature and length of the lines that need to be upgraded or constructed. Comparisons with recent projects can provide an order of magnitude estimate of the cost of building terminal or a line, and such costs are probably adequate for a first consideration. The effects on traffic may or may not require detailed traffic modeling; if an agency already has a network model coded for the region, it may be an easy matter to insert a couple of new links and estimate the effects on traffic flows and congestion. The initial comparison therefore will show whether or not the potential improvements in traffic flow could come close to justifying the relocation cost. If the answer is yes, then more detailed analyses could continue, taking into account more of the development and indirect economic benefits. If the answer is no, then other options may have to be pursued, unless it is clear (to the public agencies) that the redevelopment potential of the site can in fact cover the costs of relocation for the rail facilities.

4.4.7 Example of Insufficient Small User Infrastructure Constraint for Rail Service -

Task 1. Identify the Situation. Railroads are most efficient in serving customers with high volumes of freight. For customers shipping smaller amounts, the sheer size of the rail equipment and the cost of having a rail siding can prevent consideration of rail. The size of the user equipment needed for shipping relates to the size of the shipment, which determines the frequency of service and the cost of inventory. For many commodities, high inventory costs favor truck over rail, so this is a serious problem for small shippers.

Task 2. Rail Options. If the initial cost of the siding is the main problem, then the railroads and public agencies can provide grants or loans to defray the initial costs. As seen in the case study of state rail access plans in the Task 2 report, Maine, Ohio, and other states have helped support the construction of new sidings, which are normally less than a mile long and cost approximately $250,000- $400,000.

Providing rail access can be viewed as part of a state's economic development program. The goal is to provide better sites for new industry, in order to attract more jobs and economic activity to the state.

Another classic rail solution is to provide distribution or consolidation facilities where the large rail cars can be transloaded from or into trucks. If this can be done cheaply and efficiently, then an intermodal trip can be better than a truck trip. For low-volume customers, it will be easier and cheaper to obtain product from a distribution center than to order a truckload direct from the manufacturer. Once again, reducing total logistics cost is the key. The new situation must offer either cheaper or better service in order to attract more customers. Location is also critical in terms of the potential effects on highway traffic; locations with good access to highways and to rail switching facilities are essential.

Tasks 3-6. Analysis. As summarized in our Task 2 report on case studies, Maine DOT identified the four major benefits for this type of project: (1) lower cost transportation for shippers; (2) more revenue for railroads; (3) reduced highway maintenance cost for the state; and (4) reduced highway congestion for the public.

Projects that involve more freight generally will have the greatest effect on congestion and highway maintenance. These benefits are all roughly proportional to the amount of freight and the distance that it is shipped (and the state may only be concerned with the effects on highways within the state). Each of the actors has a unique perspective on the project.

Before investing in a rail siding, a railroad will want to be sure that it will get enough traffic to justify the investment. This may not be too much of a concern if a long-time customer seeks to expand their operations. However, railroads have had experience with customers anxious to get a siding or to avoid abandonment of a rail line, even though they do not use rail. By having access to rail service, they are able to obtain better truck rates and the railroad is left with another turnout to maintain. A railroad will therefore be leery of constructing sidings for new, untried customers. Even if the railroad is willing to make an investment, it will be looking for a rate of return acceptable for private industry. The railroad, especially a railroad short of capital, therefore will welcome this kind of program.

The customer will be interested in rail if rail provides a better transportation solution. Like the railroad, the customer may be short of capital, or require a high return to justify the initial expense of constructing a siding.

The state must relate its investment to net savings for public agencies, and the benefits to the public of reduced congestion, improved air quality, and jobs. The benefits of this program could be compared to the benefits from other approaches to reducing congestion. Some state agencies, e.g. turnpike authorities, might want to consider loss of tolls, fees or taxes if truck traffic is diminished.

Two projects in Maine provide examples of the magnitude of costs and benefits in this type of situation. One project required an investment of $550,000 to construct a rail siding to allow a paper company in Hinckley to bring pulpwood in by rail. This investment had the effect of eliminating 2,100 truck moves per year between northern Maine and the paper mill, a distance of more than 300 miles. The annual truck-miles saved was therefore more than 600,000, while the equivalent annual cost of the investment in the siding was about $36,000 (assuming 5% for 30 years). Thus, just using these numbers, this project reduced truck traffic at a cost to the state of approximately $18 per trip or $0.06 per truck mile. Since the route was across rural Maine, the major benefits would be reduced highway maintenance, rather than reduced congestion. Another project had an investment of $570,000 to provide a transload facility that eliminated 100-150,000 truck trips per year to the seaport, thereby reducing congestion in Portland. In this case, the cost to the state was approximately $2 per trip, and this could be compared to the congestion associated with an additional truck going through the metropolitan area.

When investments are made in user infrastructure, it may or may not be necessary or desirable to provide some sort of repayment mechanism to help ensure that the rail service is actually used. As noted above, customers may want the option of rail service in order to obtain better truck rates. This is a major concern for the railroad, but less of a concern for the public. To the extent that the siding does help attract development and jobs, the public would be less concerned about the actual utilization of the siding. In Ohio, for example, there is a strong emphasis on economic development, and the criteria for this type of rail investment includes state taxes from the related investment on the part of the rail customer. However, if the objective is to reduce congestion, then it would be prudent to have some provisions to ensure that the siding is actually used.

This type of program involves relatively small expenditures and does not require extensive analysis. The size of the program is limited by the appropriations (on the order of $5 million per year in both Maine and Ohio), not by the number of applications that make economic sense. The states first established the criteria that were to be used to select and rank qualified applications; once the programs were in place, the question of assessing costs and benefits of particular projects was replaced by the need to rank and select applications. The economic issues would arise again if attempts were made to curtail or expand the program. At that point, the public would also be involved, to the extent that they would support or oppose the rail programs in the midst of political efforts related to budgets and taxes. Thus, the public would have to be convinced that the savings in maintenance costs and congestion were actually being achieved, and that they justified the amounts of money being spent.

4.4.8 Next Steps - The examples provided here illustrate how a variety of different situations can present unique opportunities for utilizing rail freight to address traffic congestion. These examples also illustrate how various problems and solutions can be assessed through a common analytic structure. The process of developing this framework for analysis is discussed further in Chapter 5.

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Chapter 5: Towards a Decision Framework

This chapter is designed to summarize the importance and use of findings from Chapters 1-4 as interim stepping stones toward developing the project results. It is important to stress that the purpose of this Interim Report was to identify key factors and considerations, that will ultimately shape the decision framework and accompanying guidebook and tools for assessing rail freight solutions to road congestion. In particular, we note that:

- In the Introduction (Chapter 1), we laid out the basic concept that rail freight solutions to congestion must be viewed from a three-dimensional perspective.

- In the discussion of trends (Chapter 2), we showed how a variety of changes in underlying factors are affecting freight patterns, traffic conditions, and business needs for freight shipping.

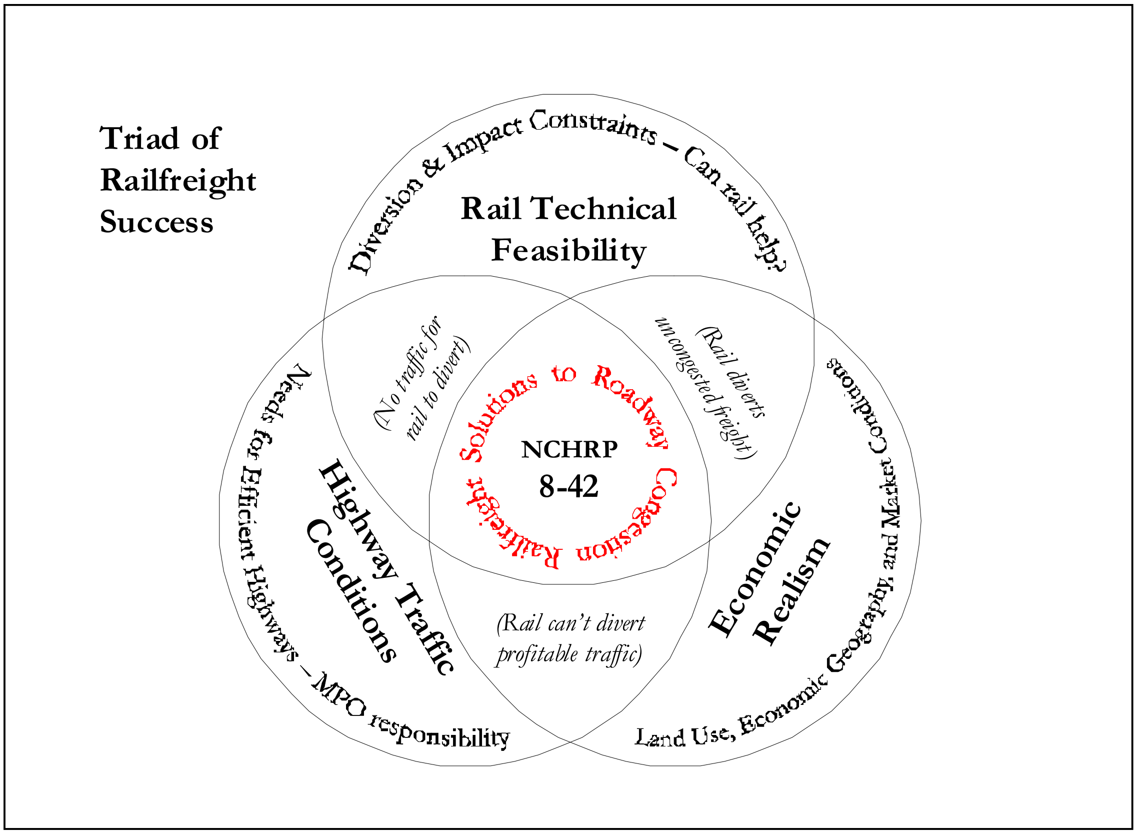
- In the discussion of diversion issues (Chapter 3), we showed how rail technical feasibility, as well as economic factors for transportation providers, are together defining potentially realistic rail solutions.

- In the discussion of analysis tools and approaches (Chapter 4), we showed that there is a sufficient plethora of analysis models available to overwhelm any well-intentioned analyst. Accordingly, there is a real need to focus on core issues and utilize straightforward approaches to screen for feasibility – at least if we are to have any hope of moving forward with practical applications of rail freight, to address public concerns about roadway congestion.

Finally, underlying all of the chapters of this report is a recognition that cooperation among public agencies, private carriers and customers is needed, and that means that each group's concerns must be addressed in any decision framework.

Figure 5-1 illustrates the ways in which a screening of alternative solutions can identify those that meet (and fail to meet) various considerations of highway, rail and economic feasibility.

Figure 5-1 Triad of Rail Freight Success



5.1 BASIC COMPONENTS OF A MODELING FRAMEWORK

The proposed modeling framework is summarized in **Figure 5-2**.

Phase I is the preliminary assessment of whether or not there are rail options that might be useful in dealing with a particular situation (or type of situation). As described in Chapter 4, there are five generic types of situations where rail freight could play a role in reducing congestion:

- Severe congestion seems to require extensive investment in highways;
- Over-reliance on trucks leads to severe local problems;
- Problems with the network structure restricts role of rail;
- Rail network structure restricts performance of highways;
- Freight users are too small or too scattered for efficient use of rail.

For any one of these, simple models and rules of thumb can be used to estimate the magnitude of the problem in terms of hours of congestion, emissions related to truck, highway damage, or any other measure of interest. The magnitude of the problem is important because that is what determines the types of rail options that might be appropriate – which is to say, affordable. Talking to carriers and customers may help identify problems and opportunities, and it will certainly provide insights into the relevance of possible investments. Phase I therefore leads to a meeting (or other type of interaction) where knowledgeable people can quickly separate the promising prospects from those that are far too expensive, and those that are addressing minor items.

Thus, Phase I will require basic information, including: (a) current highway traffic volume, mix, and performance; (b) current highway investment plans and proposals; (c) rules of thumb to estimate the benefits from reducing truck traffic; (d) estimates of the range of rail investments that might be considered; and (e) qualitative input from carriers, customers, and highway officials.

Figure 5-2 Steps in the Screening and Analysis Process

Phase I	**Preliminary Assessment**
I-1	Identify situation where rail could help relieve highway congestion
I-2	Estimate magnitude of the congestion problem
I-3	Identify relevant carriers and representative customers
I-4	Identify potential rail options
I-5	Qualitative assessment (with feedback from public officials, carrier representatives, and customers)
Phase II	**Detailed Assessment**
II-1	Analyze rail options in terms of investment cost and service results
II-2	Analyze potential for traffic diversion
II-3	Analyze effects on highway performance
II-4	Comparison of direct costs and benefits in terms of cost effectiveness
Phase III	**Multi-Criteria Evaluation**
III-1	Evaluation: effectiveness of rail freight vs. other alternatives
III-2	Evaluation: benefits and costs to public and private decision-makers
III-3	Evaluation: social and economic impacts
III-4	Multi-criteria evaluation
Phase IV	**Funding and implementation planning**

Phase II involves more detailed analysis of the proposed options. The logical place to begin is by looking at specific rail investment options and estimating how they could affect cost, or any of the service factors that influence total logistics performance. The next step is to use benchmarks or a logistics model for a representative set of freight movements, to determine whether the service improvements, if obtained, would be likely to affect mode choice and how many trucks might be diverted to rail. Given the potential diversion, it would be possible to estimate the effects on highway performance using various highway models. The changes in highway performance can then be compared to the costs associated with the rail initiatives, to see if further consideration is warranted.

Thus, Phase II will require: (a) highway performance analysis, (b) rail cost and performance analysis, (c) truck/rail diversion analysis, and (d) financial evaluation and cost effectiveness models.

Phase III provides a more thorough evaluation of the proposed project. Three distinct kinds of evaluation are needed.

(1) Identification of other available options. Every case presumably has an option of building more highways, or using tolls or regulation to restrict traffic flows. And, every case presumably has rail alternatives as well.

(2) Analysis of the effectiveness of each alternative in improving highway system performance, rail system performance, and reduction of the negative impacts of congestion.

(3) Analysis of distributional effects. This makes identification from the perspective of the various participants and affected parties, concerning how costs and benefits are borne. The various elements of transportation user impacts, public impacts, shipper impacts, and operator impacts can then be evaluated through multi-criteria evaluation models.

Phase IV is conducted only if the evaluation phase concludes that the project really does make sense, from all of the various perspectives. Only then is additional effort applied to systematically assess funding and implementation options.

5.2 NEXT STEPS

At this point in the research study, we have worked to draw key findings from the literature review, case studies, trends, diversion evaluation, and review of modeling approaches. From that effort, we have distilled key types of problems, solutions and methods that can be applied to address highway congestion and potential rail solutions.

- We have identified five generic strategies that could be used to improve rail system performance and thereby reduce highway congestion: (1) rationalization of the center-city rail network; (2) reduction in conflicts among traffic flows; (3) greater use of rail/truck intermodal transportation; (4) improved rail service to industry; and (5) upgrading facilities to handle heavier cars.

- Within each category, we have identified several specific rail investment options and discussed the kinds of analysis that will be needed to select the best alternatives. To be effective, analysis will have to take into account issues related to railroads, highways, freight customers, and public agencies. It will be necessary to summarize the most promising options with respect to multiple criteria, so that both public and private agencies can evaluate different approaches and negotiate effective strategies.

- We have mapped out a 4-phase decision-making approach and the types of models that will be needed in each phase: (a) Phase I - Preliminary assessment; (b) Phase II - Detailed assessment; (c) Phase III -Multi-criteria assessment; and (d) Phase IV - Funding and implementation planning.

After review of this interim report, we will move on to the next phase of the study, which is to flesh out the components of this approach and each of its steps.

A great many modeling and analysis tools already exist. Our focus therefore will be on developing or assembling a set of spreadsheet models that can be used by public or private planners, for preliminary assessment of the costs and benefits of proposed rail freight investments designed to reduce highway congestion. We will then use these models to illustrate the sensitivity of common projects to key parameters, including rail traffic volume, highway traffic volume, investment cost, and the extent of regional impact. The sensitivity analyses will be loosely based upon actual projects, illustrating each category of problem.