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**INTERMODAL FREIGHT MOVEMENT IN SOUTH TEXAS:
TRANSPORTATION CHALLENGES
AND EMERGING RESEARCH NEEDS**

A Research Study

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ABSTRACT

The objectives of this research were to document the changes that need to occur in the transportation landscape to facilitate intermodal transport and to identify research challenges to be faced for the future of increased intermodal traffic. In pursuing these objectives an examination was made of institutional impediments to intermodal transportation at the federal, state, and local level. Additionally, research challenges were discussed as they related to the areas of rail network optimization, service reliability, U.S.-Mexico cross-border logistics, and the intermodal transport of non-containerized freight.

EXECUTIVE SUMMARY

For there to be an increase in intermodal transportation in south Texas and for the benefits of a significant shift to rail to be realized by the citizens of Texas, a host of still-emerging issues must be identified and examined. Information technology needs, customer service, governmental policies, and intermodal terminal logistics and management are only a few of the potential research areas demanding attention.

Facilitating intermodal transportation is of increasing importance. In recognition of this, research was sponsored to examine the emerging issues in intermodal freight transport and identify those areas where investigation can add significantly to the speed and effectiveness of solutions. The private sector has spearheaded the move toward intermodal freight transportation, making the U.S. the world's leader in intermodal technology and innovation. For this status to be maintained, the public sector must become more involved. The lack of public and private decision-making systems and planning tools must be address in order to shrink the policy gaps that relate to intermodalism.

The rail network is a highly dynamic environment of day-to-day operations with constantly fluctuating demand patterns. These fluctuations are difficult, if not impossible, to forecast and thus pose a serious problem in resource management. Further research investigation is definitely needed to explore operations research approaches to rail network problems, especially efficient heuristic or ad hoc methods to obtain suboptimal solutions that considerably reduce the computational efforts in solving these problems. Ideally, these heuristic methods must be robust and able to accommodate fluctuations in demand patterns and changes in operating policies and network structure.

Many of the advantages of rail transport are offset by long transit times and lack of flexibility. A common experience of rail customers is the need to deal with multiple rail carriers in moving their product from origin to destination. Shipment tracking inefficiencies as well as poor empty car management have interfered with the rail industry's ability to provide seamless transportation and

reliable estimated times of arrival to its customers. In order to boost rail's market share of freight transportation, the industry must address these shipment issues as well as those of improving customer service and increasing sales efficiency.

Getting rail traffic from one country to another has improved greatly since the passage of NAFTA. Despacho Previo, essentially a means of process improvement, was implemented first at Laredo and has since been put in place at a number of other crossings. Unfortunately, traffic delays are still a common experience owing to the multiplicity of government agencies operating on both sides of the border. Delay is exacerbated by shipments being physically unloaded and inspected as many as four times, paperwork duplication, inconsistent procedures among various ports of entry, and abrupt implementation of new rules.

Any discussion of increasing rail's share of the south Texas freight transportation market must include the current state of FNM's (the Mexican national railroad) operations and infrastructure. Despite a modernization program that began in 1992, FNM remains a railroad in need of vast amounts of capital, requiring upgrades in power, track, and facilities. FNM estimates that an investment of as much as \$2.3 billion over five years will be needed to modernize its rail network. Operationally, FNM needs to improve its efficiency by responding to market needs, set rates that would allow it to compete with the trucking industry, and, in general, become more customer-oriented.

Intermodal activities such as rail/truck bulk transfers, rail/water vessel bulk transfers, and transloading offer opportunities to study multi-modal transportation of non-containerized freight. The transload strategy is an emerging intermodal practice involving unique partnerships between shippers, carriers, and in many cases, the public sector. Given the significant (and largely hidden) role non-containerized freight plays in the transport sector, research is required to provide transportation practitioners with a thorough assessment of the state-of-the-practice in intermodal transportation of bulk freight.

In 1994, intermodal growth was over 14 percent, with many industry analysts projecting similar growth for 1995. In fact, rail intermodal transportation for 1995 actually *decreased* by 1.5 percent. There is much to recommend about intermodal transportation, including providing users with more choice, more efficient use of infrastructure, and energy savings. The fact that there was a decrease in intermodal rail transportation in 1995 emphasizes the need for research investigating ways to facilitate intermodalism and underscores the importance of examining and identifying impediments to this form of transportation.

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CHAPTER 1. INTRODUCTION

Few would deny the speed and flexibility of truck transport. Unfortunately, trucks have been shown to be only one-fifth to one-sixth as fuel-efficient as rail in the movement of goods and material. Furthermore, because of increased trade with Mexico, highways in south Texas will become increasingly congested by growing numbers of relatively fuel-inefficient trucks. Transportation planners, faced with increasing traffic densities in the context of deteriorating highway infrastructure, are hearing calls for yet heavier and longer trucks. Congestion and the limitations on new highway construction, viewed in conjunction with surplus rail capacity, suggest that intermodal transport may offer solutions to highway congestion in the border regions of Texas as well as offering related benefits in the form of greatly increased fuel efficiency, improved air quality, and enhanced safety.

For there to be an increase in intermodal transportation in south Texas and for the benefits of a significant shift to rail to be realized by the citizens of Texas, a host of still-emerging issues must be identified and examined. Information technology needs, customer service, governmental policies, and intermodal terminal logistics and management are only a few of the potential research areas demanding attention.

Facilitating intermodal transportation is of increasing importance. In recognition of this, research was sponsored to examine the emerging issues in intermodal freight transport and identify those areas where investigation can add significantly to the speed and effectiveness of solutions. In fulfilling this goal, the current research endeavored to achieve the following two objectives:

- Document changes that need to occur in the transportation landscape to facilitate intermodal transport, and
- Identify research challenges to be faced for the future of increased intermodal traffic.

The following chapters of this report address important issues concerning intermodal freight transportation. In accomplishing the goals of the study, this report will examine institutional and

governmental barriers to intermodal transport, the immense challenges to be faced in the optimization of rail networks, customer service factors that impact the rail industry's ability to provide seamless transportation to its customers, and U.S. - Mexico trade issues that hinder intermodal freight transport across the border.

Chapter 2 describes the concept of intermodalism and the enormous potential it has for improving efficiency. The major focus of the chapter is the need to reorganize Federal and State transportation agencies to reflect the intermodal vision expressed by the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA).

Chapter 3 discusses the logistical factors affecting service reliability in the rail industry. Particular attention is paid to terminal operations and management, the problems unique to yard and line activities, and the industry-wide dilemma of engine and empty car distribution and control. Past attempts at deriving solutions to these problems are examined, and methodologies for potential future application are discussed.

Chapter 4 analyzes particular areas of customer service within the rail industry with a view toward increasing rail's share of the freight transportation market. Special emphasis is placed on increasing shipment tracking efficiency and the need for the industry to develop a more "outward" focus geared to improving service reliability.

U.S. - Mexico trade issues are examined in chapter 5, particularly as they relate to cross-border logistics and customs. Although much improvement has been made in speeding cross-border shipment by rail, the process is still enormously involved. Chapter 5 discusses this process, and the institutional practices that serve to hinder the efficient movement of intermodal freight across the border.

Chapter 6 discusses the multi-modal transport of non-containerized bulk freight. This sector of transportation, while representing a significant percentage of freight transported in this country, has

historically been given little attention in terms of research priority.

In 1994, intermodal growth was over 14 percent, with many industry analysts projecting similar growth for 1995. In fact, rail intermodal transportation for 1995 actually *decreased* by 1.5 percent. There is much to recommend about intermodal transportation, including providing users with more choice, more efficient use of infrastructure, and energy savings. The fact that there was a decrease in intermodal rail transportation in 1995 emphasizes the need for research investigating ways to facilitate intermodalism and underscores the importance of examining and identifying impediments to this form of transportation.

CHAPTER 2. INSTITUTIONAL IMPEDIMENTS TO INTERMODAL TRANSPORTATION

INTRODUCTION

Intermodalism describes an approach to planning, building, and operating a transportation system that emphasizes the optimal utilization of transportation resources and connections between modes.

Some of the many benefits of intermodalism are:

- Lowering transportation costs by allowing each mode to be used for the portion of the trip for which it is best suited,
- Reducing the burden on overstressed infrastructure,
- Generating higher returns from public and private infrastructure investments, and
- Reducing energy consumption and contributing to improved air quality and environmental conditions.

Significant intermodal freight transportation began in the mid-1980s, when ocean carriers and railroads cooperatively developed doublestack rail container service. Doublestack rail container service consists of stacking two shipping containers on specialized railcars for greater efficiency. Since this system was introduced, growth in intermodal transportation of freight has been explosive.

The environmental benefits to be realized from increased utilization of intermodal transportation would be significant. Rail transportation is five to six times more fuel efficient than truck transportation. Facilitating intermodal transportation would directly impact pollution emissions in a way that could be easily quantified and reported. As transportation trends associated with the passage of NAFTA become more accurately measured, research into social and environmental impacts will be demanded.

Confidence in the future potential of intermodal growth was demonstrated by the results obtained

by Mercer Management Consulting in their 1993 survey of almost 600 U.S.-based transportation and distribution center managers. The survey focused on information related to full trailerload shipments traveling 500 miles or more by truck or intermodal services. As shown in Figure 1, the managers surveyed estimated that by 1996 over 20 percent of the over-500-mile market would be intermodal. A key finding of the survey was that almost 70 percent of the shippers expected their truckload carriers to provide an intermodal option within the next five years.

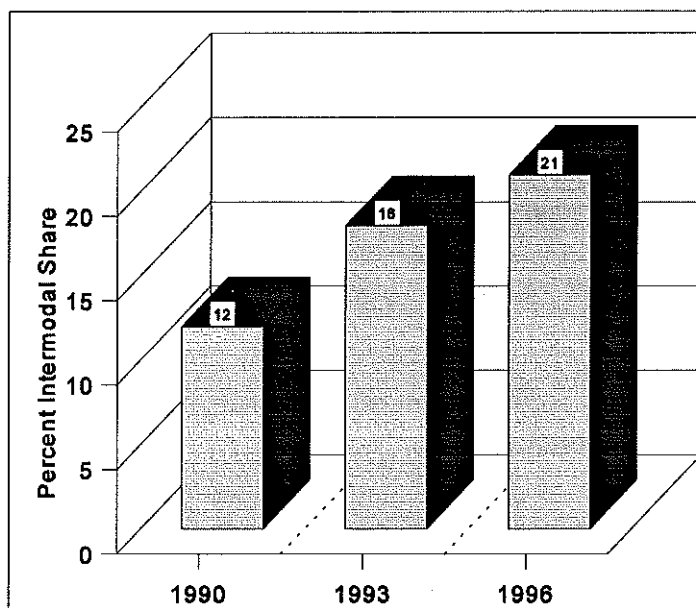


Figure 1. Estimated Intermodal Market Share

Such confidence was warranted in 1994, as intermodal container/trailer loadings jumped 14 percent. Completely unexpected though, were the 1995 figures showing a 1.5 percent *decrease* in intermodal traffic. The reasons for this drop in traffic are generally assumed to be the softening of the U.S. economy, the virtual shutdown of the Mexican economy, and aggressive spot pricing by trucking companies with excess capacity.

Even as the estimates of intermodal growth remain positive, there exists a growing awareness that fundamental change is required to ensure continued progress toward seamless transportation between modes. The discussion that follows will illustrate some of the barriers to increasing intermodal share of transport, and will address some of the proposed solutions for removing them.

DOT's MODAL ORGANIZATION

In its 1994 final report, *Toward a National Intermodal Transportation System*, the National Commission on Intermodal Transport stated:

“The modal structure of the Federal Government is a fundamental barrier to intermodal transportation. DOT is organized along modal lines, maintaining the structures of the agencies that were brought together when DOT was formed in 1967.”

While commending DOT for its initiatives aimed at satisfying the goals of ISTEA, the commission went on to state that a more complete reorganization of DOT would be required before the full potential of ISTEA could be realized. The current organization of the Department of Transportation can be seen in Figure 2.

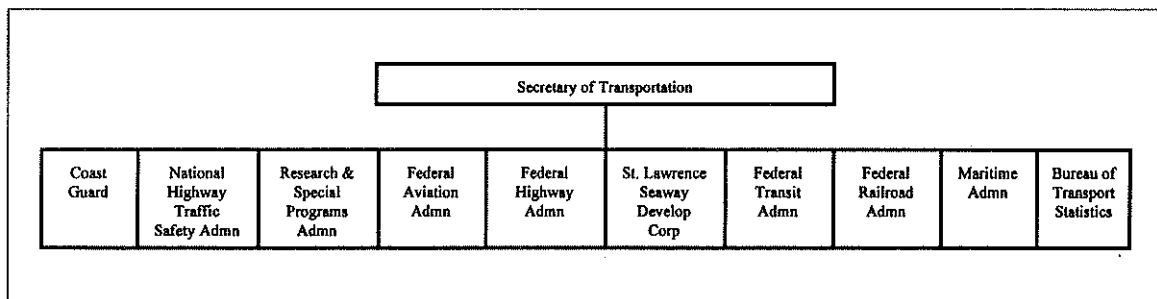


Figure 2. Department of Transportation Organizational Structure

DOT's modal organization fosters duplication of effort and sows confusion by disbursing policy making and funding decisions among agencies often having conflicting national goals. Unfortunately, this modal orientation finds itself replicated at many State DOTs. Compounding the problem is the fact that intermodal projects are often, by their very nature, more complicated than single-mode projects. Intermodal projects, because they involve different modes of transportation, tend to be governed by the regulations of more than one agency. All too often, the regulations are incompatible. Figure 3 displays the many federal agencies having a say in transportation policy.

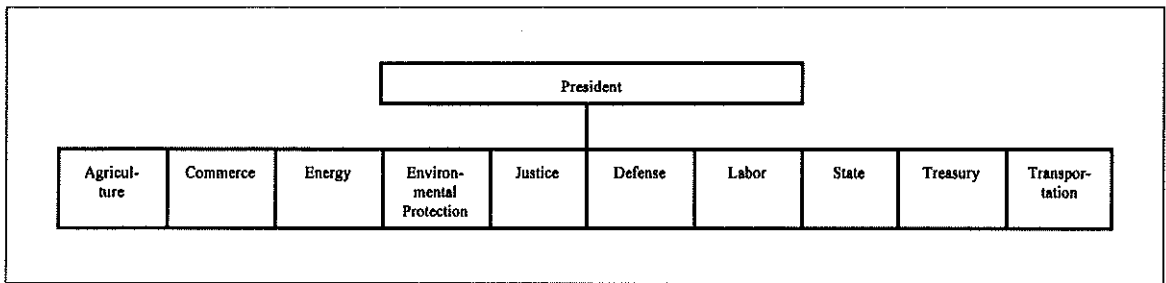


Figure 3. Federal Agencies Affecting Transportation Policy

RECOMMENDATIONS OF THE NATIONAL COMMISSION

Recognizing that seamless intermodal transportation is essential to the United States maintaining its competitive position in a dynamic global economy, the National Commission on Intermodal Transportation proposed a series of recommendations to help fulfill the basic vision and goals of ISTEA:

- Incorporate all modes of transport into a National Intermodal Transportation System,
- Foster development of the private sector freight intermodal system through a Federal policy of eliminating barriers to freight movement at ports and borders,
- Fully fund transportation infrastructure programs at authorized levels,
- Encourage innovative public and private financing methods for transportation projects, and allow greater flexibility and eligibility in use of funds for intermodal projects,
- Expand research, education, and technology development in intermodal issues,
- Restructure the U.S. DOT to better support intermodal transportation,
- Streamline the transportation planning and project delivery process, and require DOT concurrence on other Federal agency actions that affect intermodal transportation, and
- Strengthen the MPO process to accomplish the goals of ISTEA.

In hearings before the National Commission, testimony was consistently heard about the need to fully fund ISTEA. In particular, statements were given about unfunded infrastructure needs and the importance of funding transportation projects at authorized levels, citing the \$1.3 billion appropriations shortfall in 1994 surface transportation programs. A specific problem that was cited to the Commission was the constant drain on the transportation system of diversion of transportation trust funds to other uses, such as to offset the Federal deficit.

Given the current atmosphere of fiscal restraint, a major recommendation of the Commission was the need to encourage innovative public and private financing methods for transportation projects, and allow State and local officials greater flexibility in the way they spend transportation funds. Intermodal projects are placed at a disadvantage considering that funding too often comes from a modally oriented agency. Watson (1994) offers a solution to the lack of government funding of intermodal projects by suggesting that constraints on investment be removed to counteract the tendency of individual modal administrators to fund their own projects. One way to do this, he advises, is to create a transportation trust fund for all modes, reorganize congressional committees, and create an infrastructure to grant loans and favorable credit terms. The importance of innovative financing was underscored in President Clinton's Executive Order of January 28, 1994, *Principles for Federal Infrastructure Investment*, which directed all agencies to:

“Seek private sector participation in infrastructure investment and management. Innovative public-private initiatives can bring about greater private sector participation in the ownership, financing, construction, and operation of [Federal] infrastructure programs... agencies should work with State and local entities to minimize legal and regulatory barriers to private sector participation.”

CONCLUSION

Few could argue with the recommendations put forth by the National Commission on Intermodal Transportation. The private sector has spearheaded the move toward intermodal freight transportation, making the U.S. the world's leader in intermodal technology and innovation. For this status to be maintained, the public sector must become more involved. The lack of public and

private decision-making systems and planning tools must be address in order to shrink the policy gaps that relate to intermodalism.

Freight transportation, because of its regional and national significance, has often been ignored by local jurisdictions and MPOs due to the narrow focus of their political mandates. ISTEA, in fact, specifically prohibits funding for most types of freight or intercity rail projects. These funding restrictions should be lessened to allow local agencies the opportunity to evaluate transportation decisions across modes, especially when they have to do with projects involving connective linkages between different modes of transport, and other joint use projects such as bridge clearances and grade crossings.

Transportation planning, in both the public and private sectors, is becoming increasingly intermodal. The recognition of the many benefits intermodalism has to offer, and the realization that the future competitiveness of the U.S. in the global economy is strongly linked to seamless transportation, has sounded the call for policy makers to coordinate resources in the local, State, Federal, and private sectors. Such coordination, as well as creativity and flexibility in approaching transportation challenges, will allow the vision of ISTEA to be fulfilled.

CHAPTER 3. THE CHALLENGE OF RAIL NETWORK OPTIMIZATION

INTRODUCTION

Just like any other modes of transportation system through which commodities flow from their points of origin to their points of destination, the rail transportation system can be viewed as a network. In the graph theory terminology, a network consists of a set of nodes and a set of arcs that connects these nodes to one another. A node is a point from where a commodity originates, is relayed, or destined to go. An arc is a channel through which this commodity flows. In general, in a rail network, the nodes represent the terminals or classification yards, the arcs refer to the rail lines, while the commodities are the trains.

Network models and analyses have been extensively and successfully used in operations research to design, improve, or solve many optimization problems in various transportation systems. In the airline industry, network models have been successfully used to solve the problems of scheduling airline flights, crews, and maintenance services as well as fleet assignments. Other examples of successful applications are in the urban street networks for setting one-way street assignments, placement of traffic light signals, and scheduling street repairs.

In the past few decades, this trend has increasingly assumed similar important roles in rail networks. However, the relatively limited amount of literature in operations research devoted specifically to solving rail network problems, when compared to other areas, indicates that there are still a lot of challenging research opportunities to be explored in the rail industry. Furthermore, since the operations in rail networks are much more intricate in nature compared to other transportation networks, known modeling approaches to solve these networks may not be directly applicable to the rail environment.

In the early 1970s, the Federal Rail Administration sponsored various studies to investigate factors affecting service reliability in rail freight transportation (see Martland, Little, and Sussman, 1993).

Yard operations and their mismanagement were identified as being the major problems. These studies discovered that 10 to 30 percent of cars experience delays at each classification yard. Some of these delays were attributed to inbound train delays, yard congestion, and insufficient empty cars or motive power on outbound trains. Line operations such as dispatching decisions and rules on meets and passes which affect the overall train movements in the network were also found to contribute significantly to train delays. Meanwhile, hardware and engineering failures like failures in tracks, signals, and equipment (bad car orders or locomotive failures) had relatively little impact on service reliability.

A more recent study by researchers at the Massachusetts Institute of Technology (see Martland, Little, and Sussman, 1993) also arrived at similar conclusions. An interesting and noteworthy observation from this study was that even with “perfect” technology and hardware, railroads can only reduce about 30 percent of the total delays. The majority of total delays (65 percent) can be attributed to poor management of resources (yard management, train management, and engine distribution). In order to improve service reliability and to be more competitive with other modes of freight transportation, railroads must concentrate their efforts to manage their resources more efficiently.

LOGISTICAL FACTORS AFFECTING SERVICE

The operating activities in the rail networks can be divided into yard activities and line activities. Yard activities refer to all operations performed on traffic entering a classification yard. These activities include receiving, inspection, classification, assembly, connection and so on. Line activities, on the other hand, refer to the decisions on train operations as it traverses the rail lines. These decisions determine the types of trains to provide service on a network; their routes, frequencies, and schedules; and the priority rules that govern meets and passes on the lines. Clearly, there is a strong interaction between yard and line activities which influences the overall network-wide train movements.

Yard Activities

One aspect of freight rail transportation which clearly differentiates it from other transportation industries, such as the airline and trucking industries, is that most freight shipments are not transported directly from their yards of origin to their yards of destination. They are generally shipped via a number of intermediate yards in order to take advantage of operating at or near trainload capacity. At these classification yards, all incoming trains go to the receiving yards, where the locomotives are removed, and the cars are thoroughly inspected for defects. Proper repair actions are taken to correct any problems. The cars are then moved to the classification tracks where they are grouped together into blocks, depending on their block destination. This may be their final destination or an intermediate yard where they will undergo another regrouping process. The decision on what blocks to form at each yard and which cars form each block is called the classification, grouping, or blocking policy. Next, these blocks are placed on a departure track awaiting their outbound trains' arrivals. The decision on which blocks of cars to be assigned to which train is called a train make-up policy. Clearly, the blocking policy strongly influences the train make-up policy, and vice versa. At each classification yard, a car can experience one or more different types of delay:

- Various reception and inspection delays at the reception tracks,
- Classification or sorting delay at the classification tracks,
- Connection delay at the departure tracks,
- Train assembly delay at the departure tracks, and
- Outward inspection and departure delays at the departure tracks.

Any blocking and make-up policy must carefully weigh the tradeoffs between the costs of these delays and the benefits of utilizing full trainload capacities.

An optimization problem is said to belong to a class of NP problems if no polynomial-time algorithms can be found to solve it. The computational effort required to solve problems belonging to this class to optimality increases exponentially with problem size. Within NP is a subset of

problems that are the hardest to solve, called the NP-complete problems. The blocking and train make-up problems, unfortunately, are such problems.

The blocking and make-up policies can be made further complicated if network-wide policies (decisions impacting the rail network as a whole that simultaneously consider the interactions between yard and line policies) are implemented. The network-wide blocking and make-up policies have to take into account any bottlenecked yards in the network. To avoid congestions at these yards, some cars may have to be grouped in a different block or regrouping must be done at a yard having extra handling capacity prior to the bottlenecked yard.

Holecsek (1971) formulated a network-wide blocking problem as a linear programming problem with the objective of minimizing total routing and classification delays. However, due to the computational complexity of the blocking problems, he reported computational results for very small networks having only two or three nodes. Bodin, Golden, and Shuster (1980) developed a nonlinear mixed-integer programming formulation for a network-wide blocking problem which can be viewed as a multicommodity flow problem with side constraints. The objective of the model was to minimize the costs of accumulation and connection delays, car processing times, and over-the-line travel times. They interactively and successively relax or fix some selected constraints and variables in the formulation in order to solve the resulting large problem via the branch-and-bound method.

Other researchers have approached the blocking problem from the train make-up point of view. Martens (1967) investigated a joint blocking and train scheduling problem by iteratively improving on existing train schedules to accommodate fluctuations in demand patterns. The objective of the model is to minimize classification costs as well as the costs of train operations. Achermann (1969) formulated a train make-up problem as an integer programming problem whose objective was to schedule trunk-haul freight trains to reduce intermediate classification activities and train transit times. Achermann allows only one intermediate classification yard in his model which he solves using branch-and-bound. Martinelli and Teng (1995) also examined a train make-up problem with the objective of minimizing total operating costs. They formulated the problem as a binary integer

programming problem and developed a genetic algorithm to solve it (genetic algorithms are search algorithms based on the mechanics of natural genetic selections, best known as the “survival of the fittest”). Their algorithm successfully finds the optimal solutions when tested on an example rail network with six yards and ten rail lines at three different complexity levels in the objective functions.

Line Activities

Line activities or policies significantly affect train movements as they traverse the rail lines. The key issues in line policies are scheduling, timetabling, and track priority rule.

Scheduling

Train scheduling is concerned with the determination of optimal allocation of train services given a forecast of traffic demand. It involves determining which routes on the rail network must be provided with service, which train services to provide (way-freight, fast freight, and so on), and the frequency of these services.

Timetabling

A timetable gives a train’s window of arrival and departure time at each yard. In establishing a timetable, careful considerations must be given to achieve efficient utilization of track capacity and prompt delivery of traffic. However, many yard operations such as accumulation and connection delays, inspection requirements, and empty car and engine availability, have a strong influence in forming a train’s timetable. Other factors like crew availability and minimum allowable headway must also be taken into account.

Track Priority Rule

The majority of track owned by railroads are single lines. Often times, trains going in the opposite directions may occupy the same track section at the same time or a fast moving train may find a slow train in front of it. To avoid the obvious catastrophe, a priority scheme for setting rules for meets, passes, and right-of-way must be established at track sections with sidings. These rules, however,

contribute to the over-the-road delays that these trains experience.

Optimization models of line operations are very useful in analyzing train movements and dispatching activities over the track sections. They can be used to examine track capacities by measuring the delays encountered by trains under various operating assumptions. These models are also helpful in identifying bottlenecked tracks and the impacts of different priority rules in meets and passes.

Train scheduling problems are another example of NP-complete problems. Due to their computational complexity, scheduling problems are usually solved in two stages. The first stage examines the tradeoffs in various zoning schemes, in various types of train services, and in the frequency of these services with respect to operating costs and service reliability. The second stage constructs a detailed timetable and examines the costs of the resulting train schedule more closely. Petersen and Merchant (1977) used this two-stage approach to find the optimal train schedule on a rail network. They used dynamic programming to solve the problem and define each dynamic programming stage as a yard in the network.

Track and timetable scheduling problems are also NP-complete. Szpigel (1972) solved a track scheduling problem by employing the branch-and-bound method, while Amit and Goldfard (1971) proposed a heuristic method to solve this problem. Beckmann et al. (1956) investigated a timetable scheduling problem with the objective of minimizing accumulation and connection delays.

Engine and Empty Car Distribution

Each railroad prefers to have just the sufficient amount of resources to satisfy customer demands on its line. Too few resources result in eventual loss of business due to the railroad's inability to satisfy customer needs. Too many resources, on the other hand, increase costs for the railroad. This cost (partly due to interest, depreciation, and maintenance) is the second largest single item expense on the railroad after transportation labor, consuming 20 percent of its total revenue (Armstrong, 1994).

Other issues further complicate the railroad resource management problem. The rail network is a

highly dynamic environment of day-to-day operations with constantly fluctuating demand patterns. These fluctuations are difficult, if not impossible, to forecast and thus pose a serious problem in resource management. Furthermore, once rail cars have been delivered to a consignee at their final destination, it is hard to predict when these cars will be returned to the railroad, hence leaving the railroad with fewer available resources. Some areas such as industrial and manufacturing centers primarily produce more goods than they consume. Outbound trains originating from these areas naturally require more train capacity than the inbound ones. Railroads may also choose to rent their cars from or to another railroad when necessary at some predetermined per-diem rental fees.

As traffic flows on a rail network, it invariably produces an imbalance distribution of empty cars and engines at various yards throughout the network. These empty cars and engines have to be redistributed from the yards where they are in surplus to those yards experiencing inadequate train capacity so that all scheduled trains will have the required number of cars and motive power. Needless to say, efficient management of empty cars and engines greatly increases equipment utilization, reduces fleet size by decreasing redundant equipment, and increases service reliability.

Due to the huge potential benefits to the railroads, many researchers have investigated the empty car and engine distribution problem. Leddon and Wrathall (1967) and White and Bomberault (1969) were among the first to formulate the empty car distribution problem as a linear programming problem. For the homogenous empty car fleet, the out-of-kilter method can be used to solve the empty car distribution problem (see Magnanti 1978). As for the inhomogeneous empty car fleet, Gorenstein and White (1971) proposed formulating a multicommodity flow problem which is considerably more difficult to solve.

One of the earliest works in rail modeling addressed the engine scheduling problem. Bartlett (1957) presented a method for allocating engines to outbound trains which minimized the required fleet size. His method pairs arrivals and departures at each yard and treats the engines as flows on the rail network. Gertsbach and Gurevich (1977) outlined a formal procedure for constructing an optimal periodic fleet schedule. Surmont (1965) used the out-of-kilter method to minimize the costs

associated with fleet size and deadheading in engine movements to satisfy train schedules. McGaughey (1973) also used the out-of-kilter method to solve an engine and caboose distribution problem. Florian (1976) used the multicommodity flow problem to obtain the optimal engine mix that met motive power requirements of all trains given an inhomogeneous engine fleet.

CONCLUSION

The above discussion not only illustrates the complexity of the optimization problems that arise from yard activities, line activities, and empty car and engine distribution, but it also shows the diversity in the optimization solution approaches to solve them. All of these optimization problems belong to the class of NP-complete problems which means that their computational times becomes exorbitant as the problem size increases. Unfortunately, these problems usually form large mixed-integer programming formulations and, in order to solve them, some assumptions and restrictions are generally imposed to reduce the complexity and size of the problems. The danger that may arise from such an approach is that while the solution method provides invaluable insights and is of theoretical interest, it has little or no practical application. Further research investigations are definitely needed to explore other solution approaches, especially efficient heuristic or ad hoc methods to obtain suboptimal solutions that considerably reduce the computational efforts in solving these problems. Ideally, these heuristic methods must be robust and able to accommodate fluctuations in demand patterns and changes in operating policies and network structure.

CHAPTER 4. IMPROVING CUSTOMER SERVICE

INTRODUCTION

Many of the advantages of rail transport are offset by long transit times and lack of flexibility. A common experience of rail customers is the need to deal with multiple rail carriers in moving their product from origin to destination. Shipment tracking inefficiencies as well as poor empty car management have interfered with the rail industry's ability to provide seamless transportation and reliable estimated times of arrival to its customers. In order to boost rail's market share of freight transportation, the industry must address these shipment issues as well as those of improving customer service and increasing sales efficiency.

SERVICE RELIABILITY

For the railroad industry to increase its share of freight transportation, service consistency and reliability must be improved. If the service provided is matched to a customer's desires and is consistent with expectations, the service may be considered reliable. Railroads provide unreliable service for a variety of reasons. In a study by Little and Martland, the causes of unreliability were grouped into the following categories:

- Lack of motive power,
- Terminal delays,
- Train delays due to decisions involving which trains to run (i.e., lack of traffic or train consolidation),
- Mechanical delays,
- Line delays due to track work or curfew, and
- "Other" delays such as derailments.

The percentages represented by the different categories of unreliability are displayed in Figure 4.

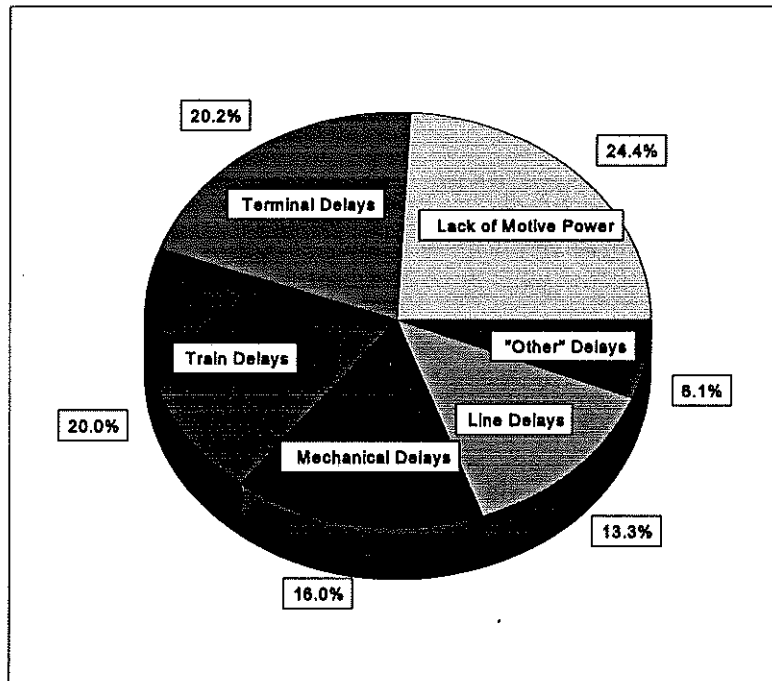


Figure 4. Causes of Unreliability

What was most striking about this research was the finding that 65 percent of the delays were due to poor allocation of resources involving terminal and train management, and the inappropriate distribution of motive power. Such a finding makes it abundantly clear that future research on improving service reliability must be focussed on railroad management, and not necessarily on technologies and hardware.

INTERLINE SERVICE MANAGEMENT

As defined by the Association of American Railroad's Interline Service Management Task Force, Interline Service Management (ISM) is a set of management procedures and supporting information systems that will allow the rail industry to monitor service commitments to customers, provide proactive problem resolution, facilitate post trip analysis, and allow customer information access. In scope, ISM is intended to encompass transit time commitment and delivery on all traffic, loaded or empty, moving via rail. The promise of ISM, in theory, is full control of each shipment from origin to destination, regardless of the number of carriers or mode involved.

A principal component of ISM is the lead carrier concept. The originating carrier assumes the lead role in bringing together the shipper, the consignee, and the carriers involved to develop mutually acceptable transit time and interchange commitments. Once customers and carriers have agreed to a service commitment, the lead carrier is responsible for recording and electronically transmitting to each party involved the commitment information for automatic updating of each party's computerized in-house commitment files.

Each participating carrier will utilize an on-line computer system that generates a trip plan for each loaded or empty car. These trip plans will serve as the basis for on-line computer support for day-to-day management of railroad train and yard operations. Each carrier involved would be responsible for monitoring actual reported car movement events on its lines. If an event differs from that called for in the original trip plan, the responsible carrier generates a revised trip plan which would then become part of the information mainstream.

Unfortunately, the Association of American Railroads (AAR) has placed a low priority on the development of functional requirements and specifications for systems supportive of ISM. These included the identification of appropriate models and software, contract support of systems development, and conduct of feasibility or needs studies for issues such as centralized shipment monitoring or interline logistics management. In addition, processes to achieve concurrence on customer commitments among interchange partners, performing impact analyses on hypothetical changes in railroad operating plans on service commitments, and booking freight reservations were deemed of marginal value. In general, the AAR's Customer Service Management Committee judged these conceptual aspects of ISM to be premature and recommended that any work in these areas be pursued, if at all, by the individual railroads.

Given that the ISM concepts deemed premature by the AAR are at the heart of ISM, it seems unlikely that significant progress will be in this area in the near future. This is particularly unfortunate considering the emphasis placed on customer service by transportation and distribution managers.

SALES

In the April, 1994 issue of *Progressive Railroading*, John H. Winner stated that sales people in the railroad industry typically spend only 10 to 20 percent of their time on face-to-face selling. This compares with 40 to 50 percent of the time spent by sales people in “best practices” industries. The time spent in face-to-face selling allows sales executives to develop insights into customer needs. The railroad industry could experience a significant increase in business simply by reengineering the sales process to more efficiently make use of time. This conclusion is reinforced by the finding of the 1993 Mercer Management Consulting survey that customers actually wanted *more* sales calls from intermodal providers.

CUSTOMER SERVICE

It is widely recognized within the industry that there is a need for railroads to adopt a more external outlook and better appreciate customer requirements. Since deregulation of the railroad industry, much improvement has been made in terms of enhanced customer focus. Nevertheless, it is widely believed that much still needs to be done in the way of continuously satisfying customer needs. Further advancements in this quest for quality will be manifested by:

- Providing totally seamless service to the customer through the formation of multi-modal, global, and integrated transportation systems,
- Greater emphasis on scheduled train services and improved service reliability,
- Faster transit times, and
- More “partnering” with shippers to ensure customer expectations are met.

One of the expected benefits of wide-spread adoption of ISM is improved customer service by allowing customers direct access to a central computer facility for real time tracing information. Customer feedback and post trip analysis would pinpoint causes of service unreliability, allowing carriers to address those causes through a continuous improvement process. Additionally, ISM would allow carriers to more effectively predict traffic demand fluctuations, yielding faster, more

regular and reliable service.

The impact of faster transit times on modal share cannot be over-estimated. In the 1993 Mercer survey, improved transit time was overwhelmingly cited by transportation managers as the way to increase market share. As shown in Figure 5, improved transit time was emphasized by 55 percent of the transportation managers surveyed. This was over twice the 24 percent that emphasized lower rates. This finding is in keeping with the view that rates tend to become a factor after performance is satisfactory.

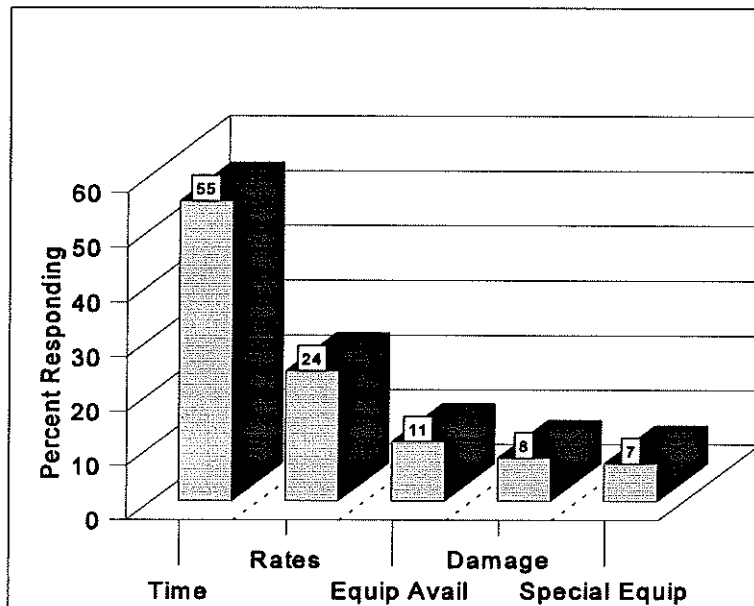


Figure 5. Factors Influencing Transport Mode Choice

CONCLUSION

For a number of years now, the rail industry has experienced what is essentially flat revenue growth per ton-mile transported. Such a finding indicates a need for the industry to identify areas where productivity may be enhanced and available resources used more efficiently. Additionally, in order to increase modal share, the rail industry must place greater emphasis on sales and the identification of new markets, as well as provide better service to their customers.

Interline service management represents a technology that could significantly improve capacity utilization and customer service. Properly applied, the technology would reduce shipment tracking inefficiencies, simplify empty car management, and improve transit times through more effective prediction of traffic demand fluctuations.

CHAPTER 5. U.S. - MEXICO TRADE

INTRODUCTION

Historically, Mexico has been a closed economy with high tariff barriers and little dependence on foreign trade. This was due in part to an abundance of oil which was exported to create the necessary foreign exchange and protect the Mexican economy. When the world price of oil dropped dramatically in 1981 and 1982, Mexico's oil could not be sold for enough dollars to buy the same amount of U.S. products that had been previously purchased. As a result of the oil crisis, Mexico was forced to devalue the currency (peso). During this time U.S. exports fell from \$17.79 billion in 1981 to \$9.08 in 1983 (see Table 1). A similar result could obtain from the peso devaluation that occurred in December of 1994.

Table 1. 1977 - 1994 U.S.-Mexico Trade and Average Yearly Export and Import Trade Growth (Billions of U.S. Dollars).

Year	U.S. Exports to Mexico	Export Growth	U.S. Imports from Mexico	Import Growth
1977	4.82		4.77	
1978	6.68	1.86	6.20	1.43
1979	9.86	3.18	9.0	2.80
1980	15.15	5.29	12.84	3.84
1981	17.79	2.64	14.01	1.18
1982	11.82	-5.97	15.77	1.76
1983	9.08	-2.74	17.02	1.25
1984	11.99	2.91	18.27	1.25
1985	13.64	1.64	19.39	1.13
1986	12.39	-1.24	17.56	-1.83
1987	14.58	2.19	20.52	2.96
1988	20.47	5.89	23.53	3.01
1989	24.97	4.50	27.59	4.06
1990	28.38	3.41	30.80	3.21
1991	33.28	4.90	31.89	1.09
1992	40.60	7.32	35.19	3.30
1993	41.58	0.98	39.92	4.73
1994	50.84	9.26	49.94	9.58
TOTAL	367.92	46.02	388.97	44.72
AVERAGE YEARLY GROWTH		2.71		2.63

After the oil crises in 1981 and 1982, Mexico changed its national policy to that of becoming an

international competitive country. Actions were taken which stimulated the growth of U.S.-Mexico trade. In 1986 Mexico joined the General Agreement of Tariffs and Trade (GATT). Under the GATT, Mexico removed many of its required trade permits and reduced tariffs. This resulted in a substantial growth of U.S.-Mexico trade from \$12.39 billion of U.S. exports and \$17.56 billion of U.S. imports in 1986 to \$33.28 billion of exports and \$31.89 billion of imports in 1991. Trade growth has been further stimulated since 1991, first by the negotiations for the North American Free Trade Agreement (NAFTA), and then by its implementation, which further reduced tariffs and other trade restrictions when it was implemented on January 1, 1994.

CROSS BORDER ISSUES

Growth in trade necessarily leads to growth in traffic. Since most of the movement of goods across the border is accomplished by surface transportation (i.e., trucks and railroads), concern has been generated about transportation problems that could result from significant increases in trade between the U.S. and Mexico. This apprehension was expressed by government officials and private sector groups in a 1991 U.S. General Accounting Office study that identified the following major concerns:

- The existing U.S. border inspection facilities cannot adequately accommodate the current flow of commercial traffic. Additionally, current capital improvement programs did not anticipate increased traffic that could result from NAFTA, and no long-range planning process exists for designing, constructing, or renovating border inspection facilities.
- Traffic across the border remains congested, even after U.S. and Mexican Customs have introduced new automated and simplified procedures to speed the flow of commercial traffic.
- U.S. inspection agency staffing along the border has not kept pace with the increase in traffic. Staffing cannot adequately handle existing traffic.
- Adequate transportation infrastructure is required on both sides of the border in order to facilitate the flow of commerce between the countries.
- Most border cities were not designed to handle the existing and expected commercial traffic. The commercial traffic uses city streets that were never intended to handle such traffic, resulting in congestion, accidents, and

accelerated pavement deterioration.

Getting rail traffic from one country to another has improved greatly since the passage of NAFTA. Despacho Previo, essentially a means of process improvement, was implemented first at Laredo and has since been put in place at a number of other crossings. Under the program, the U.S. railroad notifies the customhouse brokers in advance that a shipment is en route. The broker then has 72 hours to pre-file for customs clearance. The pre-filing includes payment of import duties, receipt of Mexican customs authority, and notice to Ferrocarriles Nacionales de México (the national railroad of Mexico, or FNM) of authority to cross. Union Pacific has seen a reduction of a full day on traffic moving south from Laredo from the time a car is received until the time it is delivered to the FNM.

Unfortunately, traffic delays are still a common experience owing to the multiplicity of government agencies operating on both sides of the border. Delay is exacerbated by shipments being physically unloaded and inspected as many as four times, paperwork duplication, inconsistent procedures among various ports of entry, and abrupt implementation of new rules.

An example of an abrupt implementation of a new rule was related by a U.S. customs official in Laredo about the administrator on the Mexican side of the border (the second one in a month, demonstrating another problem--high turnover of personnel) arbitrarily instituting a tier system for truck crossings. Designated trucks had to cross into Mexico at a specific time of day, or face a delay in being reassigned to another time window. The effect of this new rule has been heightened congestion due to truckers, fearful of missing their time window, lining up to cross hours earlier than necessary. The interviewed customs official could see no rationale for the implementation of the tier system.

The Devaluation of the Peso

Many economists are in agreement that the Mexican peso was overvalued during the last half of 1994. When the peso is overvalued, international investors sell pesos and buy dollars. The Mexican

government must then enter the international money market and buy pesos, raise domestic interest rates, or devalue the peso and exchange more pesos for each dollar. Due to international money market pressure these actions all occurred in Mexico in December of 1994, quickly reducing the value of the peso, relative to the dollar, by 40 percent.

The effect this devaluation will have on U.S.-Mexico trade will be to decrease U.S. exports to Mexico while increasing U.S. imports from Mexico. Since the devaluation is much smaller than in 1981 and 1982, and since the Mexican economy is now in much better condition than in those years, it is reasonable to expect that the net effect of the current devaluation will be a net decrease in 1995 exports to Mexico, after which exports will again resume growing. Table 2 presents an estimate of trade volumes (in billions of dollars) for the year 2000.

Table 2. U.S.-Mexico Trade Estimates for the Year 2000

Trade Direction	1994	2000	Change
Southbound - U.S. Exports	50.84	71.74	41%
Northbound - U.S. Imports	49.94	73.37	48%

Mexico's economic crisis has had a severe impact on cross-border freight transportation. As reported by Perser (1995), southbound trucking is down by as much as 60 percent, while intermodal volumes moving by rail have dropped 35 to 45 percent. Particularly hard hit is rail freight involving autos and auto parts. Currently, autos are being deramped at the borders and being held for redistribution elsewhere in the United States.

The net effect of the devaluation of the peso could eventually be that of a diversion of traffic from rail to truck. Mexican railyards are experiencing gridlock due to consignees being unable to liquidate letters of credit upon the acceptance of goods. This fact, along with that of a reduction of shipment sizes, could result in a shift of freight from truckload to less-than-truckload carriers.

The National Railroad of Mexico (FNM)

FNM's 12,706 route-miles reach Texas at El Paso, Presidio, Eagle Pass, and Brownsville. The busiest rail interchange is Laredo, Texas, where FNM connects with Union Pacific and TMM's Tex Mex. FNM's line south from Laredo, running through the industrial city of Monterrey on its way to Mexico City, accounts for as much as 70 percent of all its traffic.

Any discussion of increasing rail's share of the south Texas freight transportation market must include the current state of FNM's operations and infrastructure. Despite a modernization program that began in 1992, FNM remains a railroad in need of vast amounts of capital, requiring upgrades in power, track, and facilities. FNM estimates that an investment of as much as \$2.3 billion over five years will be needed to modernize its rail network. Operationally, FNM needs to improve its efficiency by responding to market needs, set rates that would allow it to compete with the trucking industry, and, in general, become more customer-oriented. In a survey of Mexican transportation service users (Rivera, 1992) in which respondents were asked to rate different transportation modes in five categories (transit time, capacity, equipment quality, cargo damage, and cargo control), rail ranked the lowest in user confidence in all categories. In all cases, fewer than five percent of the transportation service users sampled rated rail as adequate.

U.S. railroad companies have long complained of difficulty tracking the location of their rail cars once they have been passed to FNM in Mexico. Currently, railroads must rely on visual confirmation for determining location. Given even conservative estimates of projected growth in rail traffic into Mexico, a desperate need exists for computerized tracking systems. The lack of such systems effectively acts as a non-tariff barrier to efficient intermodal operations.

U.S. carriers serving the Mexican market are continuing to incorporate intermodal linkages in their operations. Cargo is shipped in either containers or in trailers. Containers can easily be removed from a chassis pulled by a truck tractor and placed on a flat rail car. Truck railers can be lifted at intermodal yards and ramps onto special rolling stock designated trailers-on-flat-car (TOFC). Container operations are preferred in the U.S. while the Mexican rail system almost exclusively uses

TOFC. Mexico's preference for TOFC operations is a hindrance to more efficient intermodal movement of cargo from the U.S. Until the Mexican national railway (FNM) provides more infrastructure to handle container operations, this state of affairs will continue.

The Mexican rail system has been experiencing a steady decline in market share with respect to the volume of freight it hauls. The reasons for this are generally assumed to be due to poor service quality, noncompetitive pricing, and poorly maintained track and equipment. In response to this, the Mexican government is planning to privatize parts of FNM and allow investment by the private sector. The privatization of FNM will grant up to 50-year concessions to private investors, but will hold the percentage of foreign ownership below 50 percent.

CROSS-BORDER LOGISTICS

Border activities involving truck and rail crossings are very complicated because of the policies and practices of both nations. Clearance processes involving U.S. and Mexican customs, customs inspections, U.S. and Mexican customs brokers, the declarations associated with commodity descriptions, import duty assessment, government tax identification, and a hoard of other special documentation all impede the smooth movement of freight transportation between the U.S. and Mexico.

Nevertheless, the number of freight crossings every year is staggering, and continues to grow. Figure 6 displays the number of southbound and northbound railcars that crossed the border from 1991 to 1994. The numbers represent Southern Pacific and Union Pacific railcars only (which constitute the vast majority of railcar crossings in Texas) and average double digit growth over the four years.

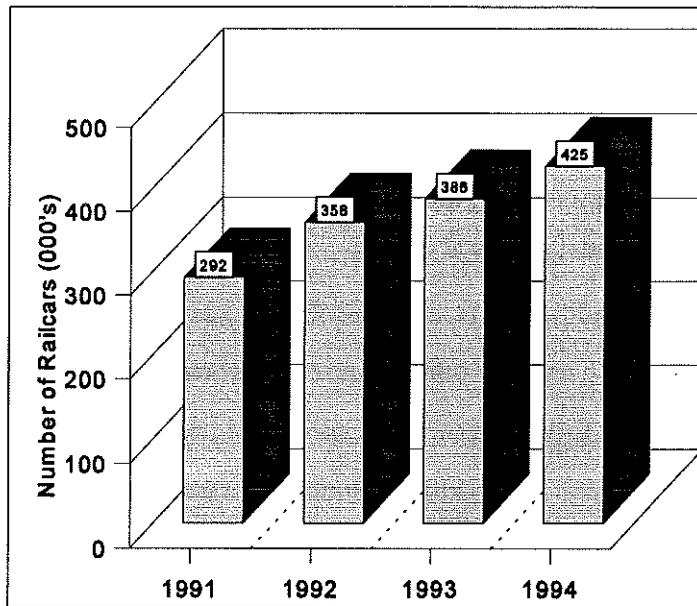


Figure 6. Railcars Conveyed To and From Mexico

The following discussion will detail the logistics process involved in northbound and southbound trade for both rail and truck transportation. The discussion of rail logistics in cross-border operations will be concentrated on the practices of the Southern Pacific railroad. The practices of the other rail players (primarily Union Pacific) involved in cross-border freight transportation are essentially the same.

Logistics Process for Southbound Mexico Shipments - Rail

The process of shipping a commodity to Mexico begins when the customer orders a rail car (or cars) from the originating railroad for loading. The customer then generates a Bill of Lading which consists of the following information:

- Origin and border destination, indicating “for export,”
- Mexico destination,
- Consignee name, address and phone number,
- Mexican broker,
- Quote or contract number,

- Weight of shipment, and
- Seal number(s).

At this point, the customer faxes a copy of the Bill of Lading to the originating railroad for waybill purposes (if the originating railroad is the Southern Pacific, the Bill of Lading is faxed to SP's Regional Business Center). Additionally, the customer faxes a copy of the Bill of Lading, the commercial invoice, packing list, and any other required certificates to a designated Mexican broker and to the affiliated U.S. freight forwarder or U.S. Customs to begin the clearance process. It is also customary for the customer to send all document originals via overnight express service to the U.S. freight forwarder or customs broker. Failure to supply all proper documents could result in border demurrage and late document charges.

All monies for FNM freight charges are rendered by the Mexican customs broker to FNM along with the Bill of Lading as well as shipping instructions. The Mexican customs broker then renders per diem charges to the U.S. railroad serving at the border point at the time the car is cleared. Per diem charges do not apply on private equipment or northbound shipments and are ordinarily paid by the Mexican consignee, depending on the agreement that was in effect at the time of sale. The origin railroad is responsible for giving a waybill to the Mexican broker to complete the documentation.

Southbound Documentation

The redtape associated with southbound freight transportation is, at best, complicated. The following discussion will enumerate the many transactions necessary to accomplish cross-border freight transport by rail.

U.S. Customs Broker (Freight Forwarder). The U.S. customs broker represents the exporter or importer, depending on the terms of sale. Exportation does not require a licensed U.S. customs broker. Typically, the U.S. customs broker:

- Prepares and files a "shipper's export declaration" (SED) which will

accompany the crossing list given to the U.S. railroad,

- Receives authority (clearance) from U.S. Customs,
- Gathers the U.S. certificates required by the importer into a contract to be given to the Mexican customs broker for documentation purposes, and
- Gives the U.S. railroad a crossing list which is accompanied by the SED, a copy of the FNM waybill, and a copy of the paid per diem form. In-bond shipments do not require a shipper's export declaration.

Mexican Customs Broker. The Mexican customs broker represents the Mexican importer and is the only legal facilitator authorized. The Mexican customs broker is required by law. Mexican law holds the broker responsible for all declarations, including the description of the commodity, its value, import duty assessment, the commodity's government tax ID number, and special documentation required for certain commodities. Typically, the Mexican customs broker:

- Presents documentation (Pedimento) and duties to the Mexican Customs office,
- Prepares FNM shipping instructions and the Bill of Lading,
- Pays applicable per diem charges to the U.S. railroad making the interchange with FNM,
- Pays any accrued border demurrage on behalf of the shipper or consignee, depending on the terms of sale, and
- Gives a copy of the FNM waybill and certified paid per diem form to the U.S. customs broker (or freight forwarder), who will then attach it to the crossing list to be given to the U.S. railroad.

The Southbound Crossing. The U.S. railroad gives the list of proposed cars to interchange to FNM. FNM checks the list against the documentation list and accepts the interchange of cars if they are properly documented. Each car goes through a green light-red light process, and if red, must be inspected. The entire southbound traffic process is shown schematically in Figure 7

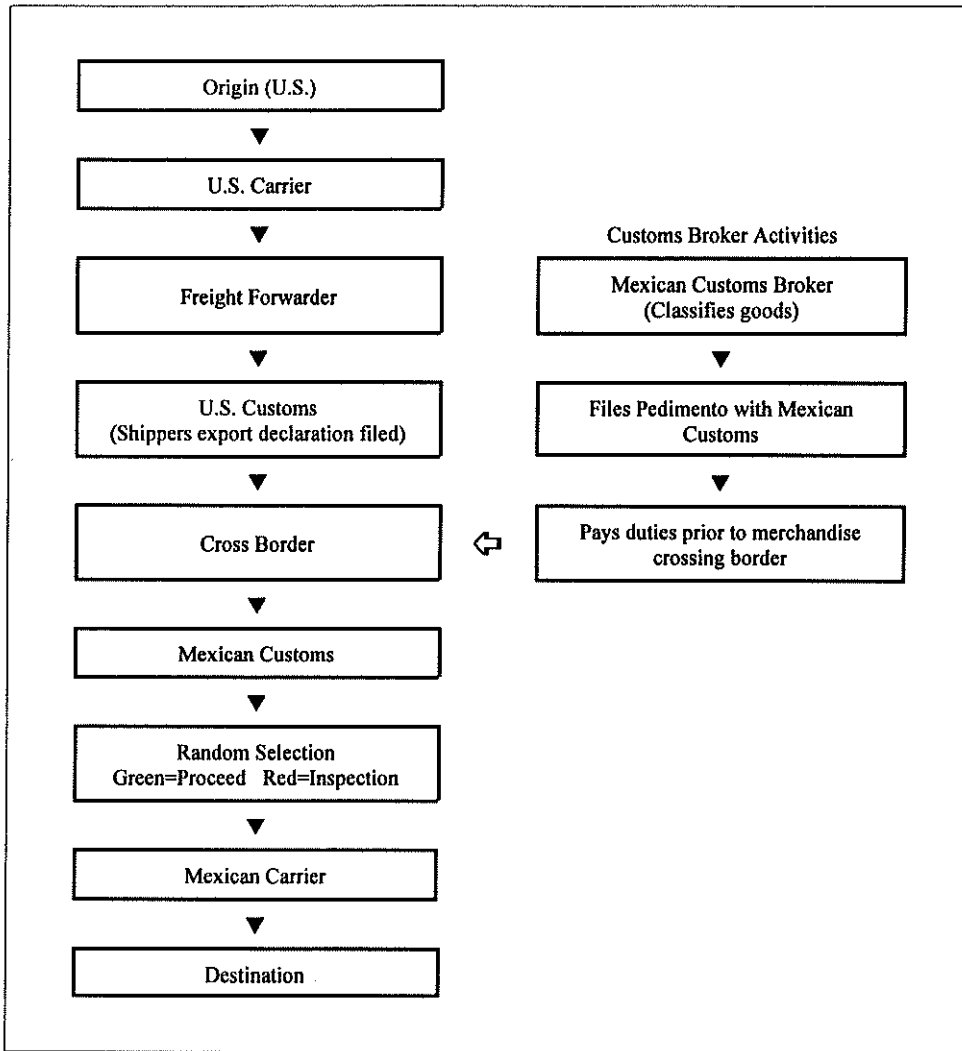


Figure 7. Southbound Traffic Process (Mexican Customs)

Logistics Process for Northbound Shipments - Rail

The process of shipping a commodity north of Mexico begins when the customer orders a rail car (or cars) from FMN for loading. The customer then generates a Bill of Lading which consists of the following information:

- Origin and border destination, indicating “for export,”
- U.S. destination,
- Consignee name, address and phone number,
- U.S. customs broker, name, phone, and fax number,

- Quote or contract number, and
- Seal number(s).

At this point, the customer faxes a copy of the Bill of Lading, commercial invoice, packing list, and any other required certificates to the Mexican broker and also to the U.S. customs broker to begin the clearance process. It is usually customary for the customer to send all originals via overnight service to the U.S. customs broker or freight forwarder. Failure to supply all proper documents could result in border demurrage and late document charges. The Mexican broker then forwards all documentation to the U.S. customs broker or freight forwarder for U.S. clearances.

Northbound Documentation

The following discussion will detail the many transactions required to accomplish northbound cross-border freight transport by rail.

Mexican Customs Broker. The Mexican customs broker represents the Mexican exporter and is the only legal facilitator authorized. The Mexican customs broker is required by Mexican law. Typically, the Mexican customs broker:

- Gathers Mexican certificates required by the U.S. importer and forwards them to the U.S. customs broker or freight forwarder,
- Prepares and submits an export declaration to Mexican Customs,
- Receives and acknowledges authorization to exit merchandise, and
- Notifies FNM of clearance.

U.S. Customs Broker. The U.S. customs broker represents the importer and, for northbound shipments, is the only legal facilitator authorized by law. The U.S. customs broker protects against U.S. Customs fines by arranging inspections of merchandise, preparing commercial invoices and packing lists, collecting duties from the importer and paying them to U.S. Customs, preparing all required forms, and gathering all required certifications. Typically, the U.S. customs broker:

- Presents documentation to U.S. Customs,
- Prepares the Bill of Lading and shipping instructions,
- Prepares the documentation for shipments entering “inbond” to the U.S., both for shipments that are destined to cross the U.S. for export or are moving to an interior port of entry,
- Prepares the crossing list of cleared rail cars, and
- Delivers U.S. Customs documentation signifying authority to cross to all interested participants.

The Northbound Crossing. FNM gives the list of proposed cars to interchange to the U.S. railroad. The U.S. railroad checks the list against the documentation list and accepts the interchange of cars if they are properly documented.

U.S. Customs selects approximately 15 percent of import shipments for inspection. Approximately one half of the 15 percent are inspected in order to insure the products comply with trademark, copyright, labeling, and commercial invoice description regulations. The other half of the 15 percent are inspected for enforcement of smuggling and other interdictive reasons. All shipments are subject to selection for U.S. Customs inspection. Some enforcement inspections require complete off-loading of lading. The cost of this is borne by the importer of record. The entire northbound traffic process is displayed schematically in Figure 8.

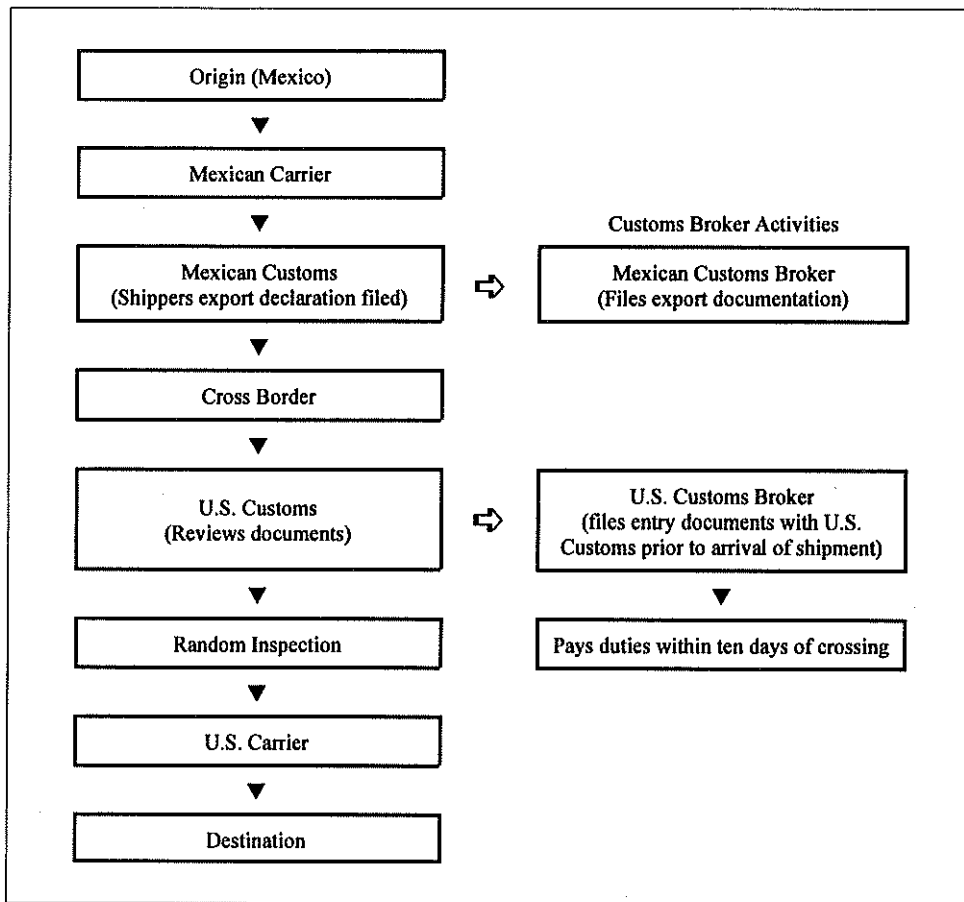


Figure 8. Northbound Traffic Process (U.S. Customs)

Cross-Border Truck Logistics

Years of increased trade with Mexico have brought a tremendous number of trucks to the border. In 1993, almost 1.7 million northbound and southbound trucks crossed the border between Texas and Mexico. In the first three quarters of 1994 commercial truck crossings in Laredo were up 40 percent. In 1993, the Laredo customs district, by itself, accounted for 54 percent (22.5 billion dollars) of all exports to Mexico from the United States.

The logistics associated with northbound and southbound truck traffic are, at least from the standpoint of customs and paperwork, essentially the same as that for rail. A major difference has to do simply with the number of entities involved. For rail, you are dealing primarily with Southern Pacific railroad, the Union Pacific railroad, and FNM. For trucks, you are dealing with hundreds of

companies. The other major difference between the cross-border logistics associated with rail and truck has to do with the institutional practice of drayage.

Drayage

As described by Molina and Giermanski (1994) the drayage system as practiced in Laredo is as follows. A truck carrying freight destined for Mexico City drops off the trailer on the U.S. side of the border. After the cargo is cleared by customs, a U.S. drayage company picks up the trailer and transfers it to a designated location on the Mexican side of the border where a Mexican carrier takes the trailer on to its final destination in Mexico City. The U.S. drayage truck driver then returns to the U.S. without any cargo. The same drayage activity is practiced for northbound shipments coming from Mexico.

CONCLUSION

Streamlining and rationalizing border operations is one of the largest challenges to improving cross-border transit times. In the past few years formal mechanisms to simplify customs procedures have been put in place and require only that they be enforced. Current practices involving Mexican brokers are also being examined. Other relatively simple solutions to the border bottleneck are being considered such as increasing operating times at the border, coordinating border patrol work schedules in both countries, and shifting commercial traffic to non-peak times. Correcting cross-border inefficiencies could have enormous positive consequences for the Texas economy. Addressing this challenge should be of the highest priority.

In order for FNM to continue to function as a strategic transport system within the Mexican economy and be able to fill the role required as a valued partner in the North American freight transportation scheme, it will be necessary to make significant modifications in the way it does business. In recognition of this, FNM has embarked on a series of strategic plans to increase productivity, ease implementation of improved techniques, foster private company participation, and provide investment in information systems for cargo tracking and infrastructure management.

One area in particular that would realize relatively quick productivity returns would be for FNM to accelerate reduction of redundant personnel. The FNM has 2.38 employees per kilometer. This is over twice the average for the U.S. railroad industry of one worker per track kilometer. A step in the direction of employee reduction was a voluntary retirement program initiated by FNM in 1992. As a result of this action, the total number of field personnel related to engineering services was reduced from 17,500 to 11,000.

With total staff reduced by a third and traffic rising, FNM has increased its labor productivity by close to 50 percent in the last two years. Additionally, FNM has begun to move toward its goal of financial self-sufficiency, achieving a 1993 operating deficit almost 64 percent below that of 1992. Even with these improvements, FNM has much to do in order to provide the service necessary to support the expected increases in freight movement demand between the U.S. and Mexico.

CHAPTER 6. TRANSPORT OF NON-CONTAINERIZED FREIGHT

INTRODUCTION

Intermodal transportation has been defined as the “concept of transporting passengers and freight in such a way that all the parts of the transportation process...are efficiently connected and coordinated, offering flexibility” (Muller, 1995). Applying this definition to the movement of freight, Muller defines intermodal freight transportation as:

“...the seamless and continuous door-to-door transportation of freight on two or more transportation modes. It is logistically linked and handled as one continuous through-shipment under the authority of a single freight bill.”

Effective intermodal freight transportation requires reliability, connectivity between modes, and flexibility to change in response to developing business opportunities.

Common references to intermodal freight transportation equate this freight movement strategy with freight movement by container (i.e., doublestack and “container-on-flatcar,” or COFC) and highway trailer (i.e., “trailer-on-flatcar,” or COFC). Non-containerized intermodal transportation is frequently overlooked or ignored. Holcomb and Jennings (1995) criticize narrow conventional definitions and interpretations of intermodal freight transportation. Equating intermodal freight movement with containerization eliminates from consideration a significant part of the freight transport sector which involves multiple transport modes, but does not employ a container or trailer for the physical movement of the commodity. Examples of such non-containerized freight include coal, grains, ores, and gases in chilled or compressed form.

Intermodal activities such as rail/truck bulk transfers, rail/water vessel bulk transfers, and transloading offer opportunities to study multi-modal transportation of non-containerized freight. The transload strategy is an emerging intermodal practice involving unique partnerships between shippers, carriers, and in many cases, the public sector. Given the significant (and largely hidden)

role non-containerized freight plays in the transport sector, research is required to provide transportation practitioners with a thorough assessment of the state-of-the-practice in intermodal transportation of bulk freight.

TRANSLOADING

Transloading is the practice of breaking or transferring bulk shipment from the vehicle or container of one mode to that of another mode at one or a series of terminal interchange points (Muller, 1995). Transload operations may be thought of as “the transfer of a product from one mode to another and the physical transfer from one type of containing device to another” (Holcomb and Jennings, 1995). An example of the transload process is the transfer of cotton from rail boxcars to ocean containers for foreign export. Transloading usually involves transporting a continuous volume of similar products. The advent of computer tracking of shipments in-transit in the logistics industry has advanced the concept of the “rolling inventory.” This practice is advantageous because inventories created in-transit eliminate the need for warehousing or materials storage facilities (Muller, 1995).

Holcomb and Jennings (1995) recently conducted an in-depth study of transloading as a strategic component of an intermodal freight transportation system. Their study addressed the current state of the transload practice and enumerated the potential impacts of transloading on freight movements.

State of the Practice

The ability of various modes to coordinate and the physical characteristics of the commodities being handled are essentially the only limitations on the number of possible modal partnerships in transloading. Table 3 identifies potential modal partnerships for transload operations.

Table 3. Potential Modal Partnerships in Transloading

Originating Mode	Delivering Mode			
	Motor Carrier	Pipeline	Railroad	Water Carrier
Motor Carrier		✓	✓	✓
Pipeline	✓		✓	✓
Railroad	✓	✓		✓
Water Carrier	✓	✓	✓	

Note: "✓" indicates a potential match for a freight movement.

Source: Holcomb and Jennings, 1995.

As can be seen in Table 3, no overt restriction exists between modes that would preclude the transfer of bulk commodities. The only limiting factor hampering transload operations has to do with the type of commodity being handled. As displayed in Table 4, non-flowable bulk commodities are not suitable for pipeline operation.

Table 4. Influence of Commodity Characteristics on Transloading

Commodity Characteristics	Handling Mode			
	Motor Carrier	Pipeline	Railroad	Water Carrier
Liquid Flowables	✓	✓	✓	✓
Solid Flowables	✓	✓	✓	✓
Non-Flowables	✓		✓	✓

Note: "✓" indicates a potential match for a freight movement.

Source: Holcomb and Jennings, 1995.

Tables 3 and 4 suggest a diversity of modal options, commodity types, and volume distributions. The implication is that transload can add revenue potential, provide savings and service improvements, and be a tool for gaining new business or controlling at least a portion of a product's movement.

Benefits and disadvantages of transload operations extend to both shippers and carriers. Third-party service providers and the general public also realize benefits from transload operations. Many third-

party service providers, primarily transload terminal operators, are able to stay in business providing this service alone. Table 5 summarizes the findings of Holcomb and Jennings with respect to pros and cons of the transload strategy.

Table 5. Advantages and Disadvantages of Transload Operations

Perspective	Advantages	Disadvantages
Shipper	<p>Avoidance of investment costs</p> <p>Continuance of transportation service despite direct service abandonment</p> <p>Reduction in transportation costs</p> <p>Transportation volume capacity</p> <p>Size and weight restrictions</p> <p>Access to new markets</p> <p>Purchaser contract obligations</p> <p>Elimination of duplicate facilities</p> <p>Reduced need for new infrastructure or facilities</p> <p>Greater competition and freight transportation options</p>	<p>Lack of one carrier ownership of the move</p> <p>Delays in payment when shipment times are extended by transload operations</p> <p>Fixing responsibility for product damage</p> <p>Must oversee an additional operation when an off-site transload facility is maintained and used</p> <p>Organizational incompatibility</p> <p>Complications in contract negotiations and assessing responsibility for product damage</p> <p>Increased transit time due to additional product handling during transload</p> <p>Increased damage due to additional product handling during transload</p>
Carrier	<p>Attract new customers</p> <p>Open new markets for existing customers</p> <p>Make services attractive over a larger geographical area</p> <p>Control freight movements off of carrier's normal system</p> <p>Maintain business volumes after partial abandonment of services</p>	<p>Organizational incompatibility</p> <p>Differences in modal capacity</p> <p>Increased transit time and product damage due to additional product handling</p> <p>Complications in contract negotiations and assessing responsibility for damage</p> <p>Added competition with an existing transportation service</p> <p>Market skepticism</p> <p>Complications in receiving payment</p>

Source: Holcomb and Jennings, 1995.

There are indications that third-party service providers are experiencing increased business at transload terminals, and in fact, new terminals are being added. Public benefits of intermodal freight transload operations include the elimination of duplicate transportation facilities, a reduced need for new transportation infrastructure, and greater competition and more transportation options.

Impacts on Freight Movements

Holcomb and Jennings (1995), identified the following transportation system-level impacts of multi-modal freight movements:

- New markets are established beyond a carrier's existing operating area,
- Opportunities are presented to reduce transportation costs,
- Productivity improves if the introduction of service results in incremental traffic or throughput over a system without corresponding increases in cost,
- Improvements are realized through faster, more frequent service, and/or better scheduled service, and
- Profits improve for participating entities.

For these benefits to be realized, it is essential that shippers and carriers enter partnering relationships to provide infrastructure and facilities to accommodate transload operations.

All modes are characterized by unique or inherent strengths and weaknesses. An underlying principle of intermodal freight transportation is the ability to capitalize on the inherent strengths of individual transport modes to deliver high-quality service at a competitive price. Integration of service capabilities across modal boundaries ultimately leads to more efficient and effective customer service, thus multi-modal capabilities are essential to the provision of seamless transportation services. Acceptance of multi-modal operations by shippers, carriers, and public sector entities is key to its success. The means to promote this acceptance are not well understood, however, suggesting the need for further study in this area.

CONCLUSION

The impacts of transportation deregulation and discontinuation of railroad service to small communities and rural areas are fairly well understood. How to keep and expand existing businesses, and moreover attract new business development, in the face of reduced transportation services and increasing transportation costs is less clear. Multi-modal non-containerized movement of freight may play a vital role in maintaining the economic health and stability of small communities and rural areas in the wake of rail service-level reductions or abandonment.

Transloading is an intermodal tool whose applicability is not limited to just the larger, Class I railroad companies. Previous research reports the successful use of transload strategies by shortline and regional railroad companies as well. These findings suggest transload may be a viable option for enabling shortline railroads serving south Texas and the border region to enhance vital transportation services in these areas. Identifying and quantifying the potential for transload to work successfully in Texas requires thorough knowledge of the types and amounts of commodities being produced and transported, their origins, and the types and coverage of freight transportation services currently available. Such analysis will lead to identification of potential multi-modal partnerships that can effectively improve service quality at a competitive price.

CHAPTER 7. CONCLUSION

The objectives of this research were to document changes that need to occur in the transportation landscape to facilitate intermodal transport and to identify research challenges to be found for the future of increased intermodal traffic. In accomplishing these objectives, this study examined the following important issues concerning intermodal freight transportation:

- Institutional impediments to intermodal transportation,
- The challenge of rail network optimization,
- Service reliability,
- U.S.-Mexico trade, and
- Intermodal transport of bulk non-containerized freight.

In order to overcome the barriers to seamless transportation between different modes of transport, fundamental change will be necessary in the institutional and governmental culture that is concerned with making transportation policy. This change will need to be spearheaded by a more complete reorganization of the U.S. DOT along lines that will better support intermodal transportation, and the incorporation of all modes of transport into a national intermodal transportation system.

Network models and analyses have been extensively and successfully used in operations research to design, improve, or solve many optimization problems in transportation systems. Examples of such systems include the airline industry and street networks in urban settings. It has only been in the last few decades that the importance of applying such solutions to the rail industry has been recognized. The paucity of literature in operations research devoted specifically to solving rail network problems, when compared to other areas, indicates that there are immense opportunities for beneficial application of this technology in the rail industry. Areas within the rail industry that could immediately profit from optimization include the realms of service reliability (involving both yard and line activities), and engine and empty car distribution.

For the railroad industry to increase its share of freight transportation, service consistency and reliability must be improved. Shipment tracking inefficiencies as well as poor empty car management have interfered with the rail industry's ability to provide seamless transportation and reliable estimated times of arrival to its customers. While having made great strides in the area of intermodal freight transportation, it is imperative that the railroads better address the customer service issues of emerging market identification, sales process improvement, and the problem of long transit times and lack of flexibility.

The passage of NAFTA promises to streamline the process of transporting freight across the border between the U.S. and Mexico. Currently, though, traffic delays are the norm owing to the multiplicity of government agencies operating on both sides of the border. Fortunately, both the U.S. and Mexico are working to address the problem of border delay. Of particular importance to the movement of trade across the border is the recognition that FNM, the national railroad of Mexico, needs to improve productivity in its workforce and increase investment in information systems for cargo tracking and infrastructure management. The Mexican rail system has been experiencing a steady decline in market share with respect to the volume of freight it hauls. The reasons for this are generally assumed to be due to poor service quality, noncompetitive pricing, and poorly maintained track and equipment. It remains to be seen what effect the planned partial privatization of FNM will have on boosting the fortunes of the railroad.

Non-containerized bulk freight is characterized by commodities such as coal, grain, ores, and gases in chilled or compressed form. Although shipments of this kind represent a significant percentage of the total freight transported in the U.S., non-containerized intermodal transportation is frequently overlooked or ignored. This lack of attention needs to be reversed. Given the significant (and largely hidden) role non-containerized freight plays in the transport sector, research is required to provide transportation practitioners with a thorough assessment of practices in intermodal transportation of bulk freight. A potential beneficiary of improved understanding of transload operations in general could very well be small communities and rural areas. Initial research has demonstrated the successful use of transload strategies by shortline and regional railroad companies.

Further research is needed to identify and quantify the potential for non-containerized bulk transload to help maintain the economic health and stability of areas such as these in south Texas.

Effective intermodal freight transportation requires reliability, connectivity between modes, and flexibility in response to developing business opportunities. Although the rail industry has improved greatly in these areas (as well as having speeded transit times for cross-border transport of freight to and from Mexico), much still needs to be done to characterize the industry as being state-of-the-art. Additional research, focussed on addressing the truly pressing need of increasing intermodal transport of freight, will go a long way toward achieving the goals of ISTEA.

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