Implications of Electronic Clearance for Regulatory Enforcement of the Trucking Industry

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by

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This project was conducted in an effort to add knowledge to the issue of using advanced information technology in commercial vehicle weight and safety regulatory enforcement. Specifically, this project attempted to assess the impacts of the Commercial Vehicle Operations component of the Intelligent Vehicle/Highway Systems program on the enforcement of these regulations. This project could not have taken place without the cooperation of many individuals, organizations, and government agencies. The author wishes to extend thanks to all of those who assisted in this project.

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EXECUTIVE SUMMARY

Government, both federal and state, regulates the trucking industry for several reasons. The primary objectives of trucking regulation are to enhance highway safety and fund construction and maintenance of the highway infrastructure. Additionally, the trucking industry has been regulated for various socioeconomic purposes both by individual states and the federal government. These regulations are primarily designed to ensure shippers that firms in the trucking industry are financially sound and reputable. Government has also regulated the trucking industry to prevent market failure and the corresponding loss of services for shippers in some areas.

Although regulations are designed to accomplish given objectives, inherent to the process is the creation of administrative burdens. These are created in complying with as well as in the enforcement of the regulation. These burdens, although different for each, impact both the private sector and government agencies. Aside from the debate over the effectiveness of a given regulation, it is in society's best interest to minimize the compliance and enforcement burden of regulations. A more efficient private sector as well as more effective use of tax dollars are two of these benefits. The compliance and enforcement burden for existing regulations in the trucking industry are substantial.

Reducing the regulatory burdens for both the trucking industry and government agencies while improving the effectiveness of various regulations is a major objective of the Federal Highway Administration. One program currently receiving substantial attention and funding is the Commercial Vehicle Operations component of the Intelligent Vehicle/Highway System (IVHS/CVO). Basically, this initiative would introduce advanced technology into trucking regulation. Currently, most trucking regulations are enforced at weigh stations located on major truck routes. Trucks passing these weigh stations are required to stop so that an enforcement official can determine whether the vehicle and driver are legally qualified to operate in that particular state. However, verifying compliance with all of the different regulations is difficult at best.

There are two main thrusts to the IVHS/CVO initiative. One, known as transparent borders, would automate the enforcement process, ideally checking trucks at highway speeds, thereby allowing legal and compliant trucks to not stop at weigh and/or inspection stations. Another would allow trucking firms to achieve compliance with all of the various regulations and receive the necessary credentials or authorizations from one location, ideally through electronic data interchange (EDI) with the trucking firm's place of business.

Achieving regulatory efficiency through technology, however, requires a substantial commitment, both financially and organizationally, from regulating agencies. Additionally, industry perspectives and levels of participation will greatly impact the success of any initiative. Therefore, this study set out to identify and evaluate some of the various issues affecting the deployment of IVHS/CVO initiatives. This study was particularly concerned with electronic clearance initiatives which would allow legal trucks to bypass weight and safety inspection locations (i.e., through vehicle-to-roadside communication devices and information database referencing capabilities the legality of these vehicles would be determined without requiring the vehicle to stop).

This project has three primary objectives. First is to provide an analysis of the current trucking industry. This was performed to highlight how various aspects of the trucking industry have evolved over time, while, in many respects, regulations have remained quite static. Second is to determine the cost of current weight and safety enforcement activities (almost all enforcement of trucking regulations takes place congruently with the weight and safety enforcement process). This establishes a basis for discussing the benefits to the trucking industry, and society, from initiatives that reduce compliance and enforcement burdens. Of particular concern is the cost to legal trucking firms that are subjected to weight and safety enforcement activities. Third is to evaluate the benefits to state regulatory agencies of enhanced regulatory efficiency.

To accomplish the project's objectives, the following methods were utilized. Michael Porter's industry analysis techniques were employed in the analysis of the trucking industry. The structure of the industry, the competitiveness of the industry and of the segments, as well as the industry's evolution were analyzed. In determining the cost of current enforcement activities, the major cost drivers for the industry and the pervasiveness of the enforcement activity were determined. The cost to legal vehicles was determined by comparing the number of weighings and inspections to the number of weighings and inspections where a citation was issued (i.e., a vehicle that was not issued a citation was considered legal). A case study was employed to evaluate the benefits of the electronic clearance initiative for state regulatory agencies. Familiarity with the regulatory agency and access to data were the primary determinants in the selection of the particular case.

Major results of the analysis performed in this project now follow. The trucking industry is comprised of two dominant segments, truckload (TL) and less-than-truckload (LTL). These two segments differ substantially in type of operation, commodities transported, and cost structure. For definitive purposes, TL firms are those who transport single shipments in excess of 10,000 pounds. These shipments typically originate at one point and have a single destination. All shipments less than 10,000 pounds are considered to be less-than-truckload (LTL). LTL firms pick up several smaller shipments that may have multiple origins, consolidate them, and deliver to a multitude of destinations. Inherent to the LTL process is an expensive network of terminal facilities. Additionally, LTL firms require an extensive fleet to ensure broad geographic service. As a result, TL firms have a substantially lower cost structure then LTL firms. Further compounding the difference in cost structures between the TL and LTL segments are different labor requirements. Easy substitution of owner-operators (similar to independent contractors) for TL drivers creates considerable downward pressure on wages. Owner-operators are not easily substituted into LTL operations where seamless service quality, cooperation, and coordination from the initial pickup throughout the terminal process and eventually to the final

destination are integral parts of the service product. Additionally, LTL employees are typically highly organized.

Differences in cost structure between the TL and LTL segments result in substantially different market structures and competitiveness. However, in recent times both segments have experienced pervasive low profitability. The causes of this are different in each segment. The TL segment, which is characterized by numerous small and homogenous firms, has become entrenched with commodity-like service strategies. Low entry barriers to the TL segment allow small unsophisticated entrepreneurs to continuously enter the market. This enhances price competition, further fosters commodity strategies, and ultimately has lead to the segment's pervasive low profitability. Commodity pricing strategies in the TL segment have resulted in an emphasis on being the low-cost producer, with little attention being paid to service quality or product differentiation.

The LTL segment can be further segmented into three distinct sectors, each with its own characteristics. These are regional, interregional, and national. The national and interregional sectors are dominated by a few very large carriers who have watched their market share be cannibalized by regional LTL carriers and the TL segment. A regionalization of freight movements and higher service values provided by competitors (primarily TL but also regional LTL carriers) has negatively impacted market share, leading to low profitability in the national LTL segment. The regional LTL sector is made up of numerous firms. However, within a given market there are usually only a few regional LTL firms. The regional sector, in contrast to the mature national LTL market, is actually in the growth stage of its life cycle. However, poor management, as demonstrated through strategic positioning, marketing, and financing, has plagued many small regional LTL firms and hampered profitability. Many regional LTL firms have been liquidated and their assets acquired by more successful regional carriers who possess stronger managerial talents and/or are more strategically positioned. As these opportunities have been

discovered, financing has become more available, further facilitating a rejuvenation of profitability in the regional LTL sector.

The federal government currently collects and distributes funds collected from a levy on fuel for the construction and maintenance of highway infrastructure. The federal government has stipulated that for states to receive these funds they must, among other things, enforce certain limits on the use of the highway infrastructure. In regard to the trucking industry, these limits are primarily concerned with vehicle weight. To comply with federal requirement, states have institutionalized weight enforcement programs. In fiscal year 1991, less than 0.6 percent of the vehicles weighed by state weight enforcement officials were cited for being overweight. However, this does not imply the effectiveness of current weight enforcement strategies. Instead, it offers justification for IVHS/CVO initiatives that reduce the burden for the approximately 99.4 percent of the trucks that are legal and in compliance. Current weight enforcement strategies cost legal trucks between $166 and $282 million annually. IVHS/CVO initiatives in this area provide a means to identify legal vehicles at highway speeds and allow them to bypass the enforcement site without altering current enforcement strategies.

Safety is a major concern of both state and federal governments. To positively impact safety amidst the trucking industry, the federal government has established the Motor Carrier Safety Assistance Program (MCSAP). This program is intended to be a cooperative effort between the federal government, state governments, and the trucking industry. As part of the program, states that participate receive funds to conduct safety enforcement activities. States must also embrace standards for safety enforcement enhancing consistency between states. A major component of safety enforcement is the inspection process. Safety inspections are conducted either randomly or at fixed locations. Considerable debate exists over what constitutes a successful inspection as well as over what the true determinants of safety are and whether they are accounted for in the current inspection process. As with the weight enforcement process, current IVHS/CVO initiatives are a means to improve current safety enforcement.

They are not intended to eliminate or dramatically alter current activities. Current safety inspection strategies cost legal trucks between $7.8 and $13.3 million annually. Better selection of vehicles most at risk of being in violation of safety regulations would dramatically improve productivity for legal trucking firms as well as reduce costs and improve safety.

The impact of any IVHS/CVO initiative on state regulatory agencies must be considered as well. To determine this impact, the state of North Dakota was analyzed with respect to the implementation of electronic clearance technologies at its existing fixed weigh stations. Automating North Dakota's ten fixed weigh stations would cost approximately $2.5 million. The primary financial benefit of this investment would be an improvement in enforcement labor productivity, resulting in expanded enforcement efforts. Electronic clearance in North Dakota would allow current weight enforcement strategies to be conducted with 10 percent fewer full-time equivalent employees. These full-time equivalents are then available for deployment in an expanded weight enforcement strategy, yielding the state considerable benefits through reduced pavement damage.

This research is far from inclusive of all the IVHS/CVO issues that need to be addressed. Additional research should be initiated to determine the real cost to private industry from various enforcement strategies, the relationship between government resources expended on trucking regulation and the benefits received from that investment, the impact of IVHS/CVO on future government expenditures for truck regulation, the impact of IVHS/CVO on compliance, and the benefits of changes in compliance levels brought about by IVHS/CVO initiatives. Additionally, research should continue into the basis of government involvement in the trucking industry with respect to society's ever-changing goals.

INTRODUCTION

With each passing year, the American economy becomes more global. The percentage of manufactured goods imported and consumed by America continues to increase. At the same time, American companies are finding new markets overseas in which to sell their products. There is little doubt that the global village has truly arrived. Several other socioeconomic trends affect America's competitiveness, including a heightened focus on customer satisfaction, concentration in the domestic market, growing pervasiveness of information technology, flatter organizational structures and re-engineered processes, the increased formation of supplier-customer strategic alliances, emergence of the knowledge era and value of innovation, and the strategic value of implementing a competitive strategy.[1] All of these trends, including globalization, affect the competitive and comparative advantages of America's economy and its firms.

As the nation's economy grows more global, freight transportation's strategic role in America's competitiveness will be paramount. To be successful, American firms will have to be value competitive. There are two basic determinants to a good's value, which can be approximated by the good's price. These are cost of production, which includes the quality of materials and the production process, and logistical costs, which includes service quality attributes. Logistics adds space and time value to goods. However, for producers to realize this value, their goods must be available when and where the consumer who values them demands them. As a result, transportation from point of production to point of consumption is a major component of the logistical cost and therefore of the good's price.

The business profession has evolved considerably over time. The ability to successfully manage the production, marketing, or finance processes are no longer strategic advantages. The strategic advantage of managing these processes has been eroded by competitors who have been able to copy and initiate these strategies. This is the dynamic nature of business, where due to competition and emulation, what is a unique and effective strategic advantage one day is a commonality among competitors the next.

Heretofore, the logistics function, however, has been undermanaged. In addition to successfully managing the production, marketing, and finance functions, firms are beginning to create strategic advantages through the logistics function. Successful logistics management now is key to establishing a comparative advantage for American firms in a global market.

The logistics process was once characterized by large order cycles, long lead times, and generous delivery windows. However, to meet the demands of manufacturers and their customers for delivery of the right product, at the right time, all the time, as well as provide a service compatible with total quality management initiatives requires substantial managerial talents. Even though logistics encompasses much more than physical delivery or transportation, this one area provides an enormous opportunity for improvement in private sector efficiency.

Aside from being an important component of the business process, freight transportation represents an extremely large industry in and of itself. This industry had an estimated value of $342 billion in 1990, or approximately 6 percent of the gross domestic product (GDP) for the United States.[2] Figure 1 shows the distribution of this market among alternative freight transportation modes. Truck services, receiving almost 80 percent of all expenditures on freight transportation, clearly dominate this market. Although rail and water as well as intermodal and multimodal freight transportation are important to the efficiency of the logistics process, this project will be restricted to the trucking industry.

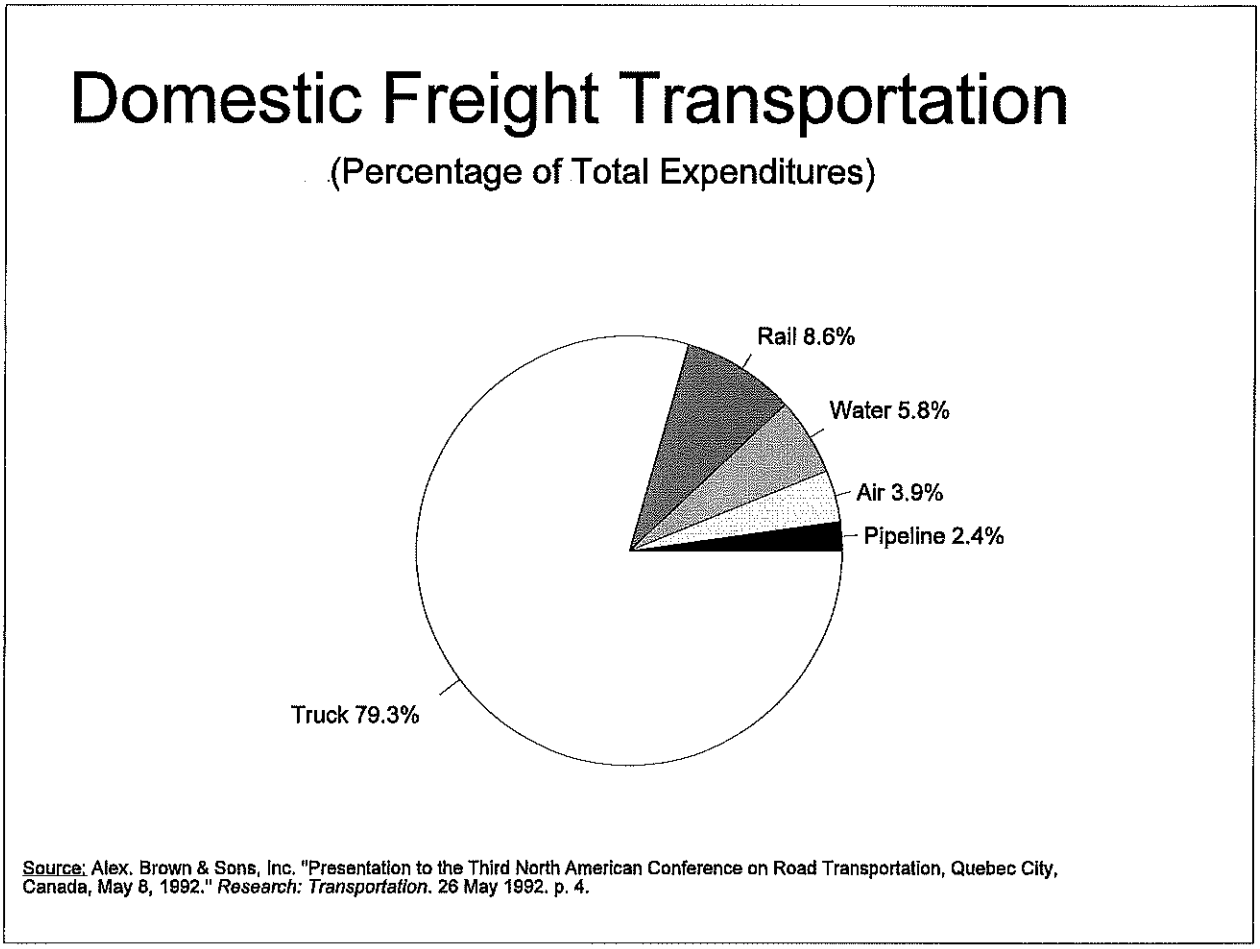

Figure 1. Share of domestic freight transported by individual mode.

Several aspects of the trucking industry and government regulation are covered in this project. The central theme connecting all of the analyses are the implications of IVHS/CVO for the trucking industry. To help interested individuals grasp the implications of IVHS/CVO, this project examined the trucking industry's current economic situation, reviewed the current regulatory environment in the trucking industry, analyzed the trucking industry's cost of current regulatory activities, and developed a case study involving implementing transparent border technologies in the state of North Dakota. What follows is an in-depth discussion of each of these areas.

INDUSTRY ANALYSIS[a]

The purpose of this chapter is to provide the reader with a better and more thorough understanding of the trucking industry today. There are four main parts to this chapter. First is a description of the industry. Second is an analysis of the industry's competitiveness. Third is an analysis of the industry's market structure. Finally, the fourth section is a broad discussion of various intelligent vehicle/highway systems for commercial vehicle operations (IVHS-CVO) program objectives, with respect to the analyses performed.

Industry Description

An analysis of the services provided, size of various segments, principle inputs, revenue trends, substitute services, evolutionary forces, and managerial aspects will all be used to describe the trucking industry. These attributes are described in the following sections.

Service Description

Truck services can be classified as either local or intercity. Figure 2 depicts the division of the truck freight market between local and intercity. The economic and service characteristics of these two segments are vastly different. Local carriers provide support services to an economic center, a city, and include services provided by dump trucks, delivery vans, garbage trucks, etc. Intercity carriers, on the other hand, facilitate the movement of commerce between cities, states, and even nations. Within the U.S., intercity services have allowed specialization and comparative advantages to develop. Government regulations also affect these two segments of the industry differently. This paper will focus on intercity carriers.

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[a] Analysis techniques and methodology drawn from Michael Porter, *Competitive Strategy: Techniques for Analyzing Industries and Competitors*. (New York: The Free Press, 1980).

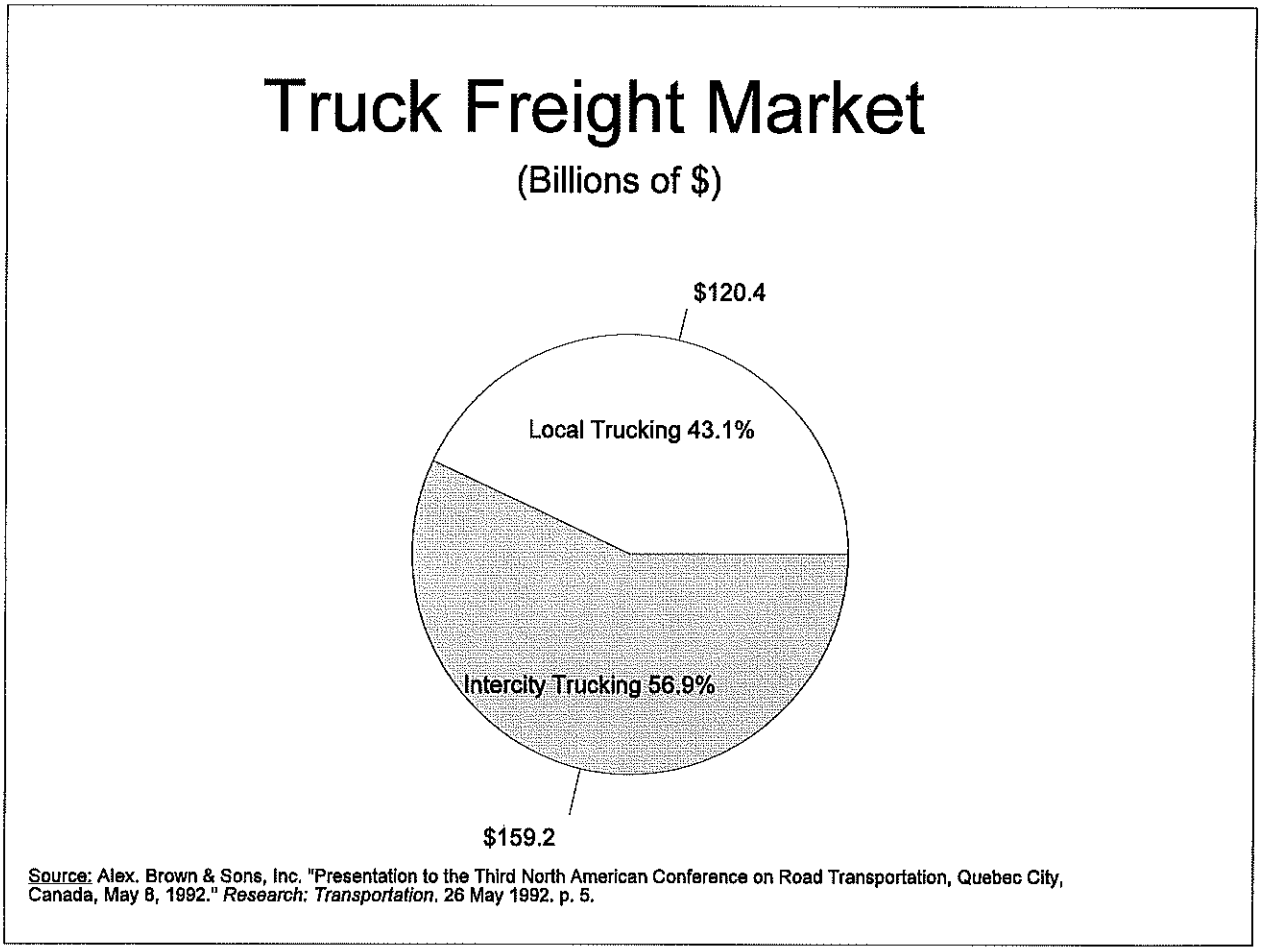

Figure 2. Segmentation of the U.S. truck freight market.

Intercity freight movements by truck can be broken into truckload (TL) shipments and less-than-truckload (LTL) shipments. TL carriers provide door-to-door service of full load shipments (greater than 10,000 pounds). LTL carriers compile small loads (less than 10,000 pounds) at a terminal, transport them to another terminal near their destination, disassemble, and deliver. Small package delivery services (shipments under 500 pounds) provided by carriers such as UPS are a component of the LTL segment. However, the domestic air freight market, dominated by Federal Express, UPS, DHL, and Airborne Express, is considered a separate and distinct market from the LTL market and will not be included in this project.

Industry Size

Freight movement is extremely important to the American economy. The annual intercity freight market is estimated at $159 billion.[3] Figure 3 shows the market size of various segments of the intercity truck market. According to this figure, the TL segment, comprised of for-hire and private fleets, controls over 80 percent of the non-local or intercity market.

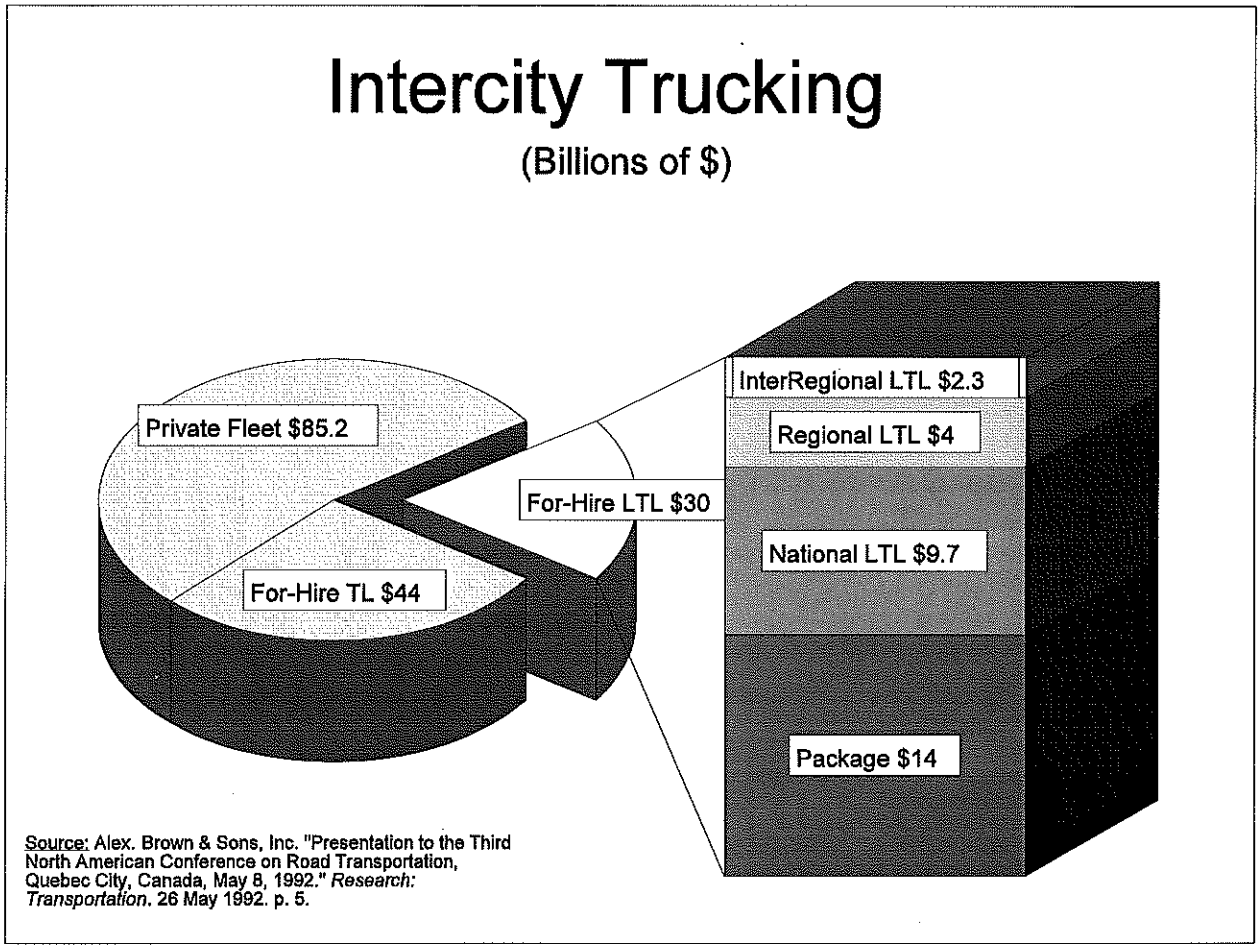

Figure 3. Segmentation of the intercity truck market.

The degree of consolidation among firms in the intercity freight market is different in each segment. There is very little concentration among the over 40,000 for-hire TL carriers; the ten largest carriers only control 10 percent of the market.[4] Additionally, another 50,000 private fleets provide TL

services.[5] Information on these private fleets is difficult, if not impossible, to obtain since they are not required to file reports with the Interstate Commerce Commission (ICC).

The LTL market is more concentrated than the TL market. This is primarily due to differences in market economies in services provided, and in economies of scale. The three largest LTL carriers have 36 percent of the total LTL general freight market (over 500 pounds).[6] Additionally, the LTL small package market (less than 500 pounds) is dominated almost exclusively by UPS. Further analysis of the LTL market reveals that there are only five carriers who provide national LTL services and only four who provide interregional LTL services.[7]

Industry forces indicate that both segments of the intercity freight market will be become further concentrated. Specific causes of this will be discussed in more detail later. Carriers who cannot fully utilize their productive capacity will be subjected to the forces of creative destruction. Within the next decade, economists estimate that the TL market will be reduced from the current 40,000 carriers to 20,000 carriers.[8] Although this degree of consolidation may seem drastic, none of the remaining firms are expected to gain a position of market dominance.

Intercity LTL markets have been experiencing consolidation pressures for quite some time. Rate competition, service competition, and changing shipping patterns are all fueling this trend in the LTL segment. Regional intercity LTL carriers currently have 66 percent of the intercity LTL market and should continue to take share from the shrinking long-haul, national LTL sector.[9] This shrinking national LTL market has forced most national carriers into the regional marketplace. National carriers bring progressive management techniques, a strong financial position, efficient computer and information systems, and favorable market economies in marketing, insurance, and equipment costs.[10] Non-union regional carriers, however, have a competitive advantage over their mostly unionized competitors. Wholly-owned non-union subsidiaries have allowed national LTL carriers to overcome their competitive disadvantages in the regional sector. Enhanced regional competition has forced regional LTL carriers to

initiate strategies that have resulted in alliances, partnerships, or mergers to create multiregional carriers and exploit the same market economies as national carriers.

Principle Inputs

Analysis of an industry's principle inputs provides tremendous insight into the foundation of the industry. Inputs determine how an industry functionally provides the services it provides. The largest and most significant cost function coefficients for both TL and LTL carriers are labor, purchased transportation (cost of leased labor), cost of capital, and finally, fuel costs.[11] Drivers make up the principle labor component for all carriers. However, the terminal operations of LTL carriers require substantial additional non-driver labor.

Labor expenses for TL carriers are compounded by training costs, safety problems, and lost business arising from unusually high turnover rates. Currently, approximately 45 percent of all TL revenue goes to labor.[12] The turnover rate among TL drivers can often be 100 percent or more in a year.[13] Compounding this problem is a shrinking labor pool caused both by the demographics of a smaller work force and the job related-issue of poor employee satisfaction. However, research indicates that root of the problem is a lack of human resource strategies to take advantage of the available pool.[14] In other words, turnover is not a problem because of a diminished pool of potential employees, but because of dissatisfaction among employees — a factor somewhat controllable by the TL firm.

Labor expenses for LTL carriers are compounded by work rules stifling productivity and flexibility. Further compounding labor expense, is the additional labor needed to operate terminal facilities. Non-unionized regional LTL carriers often have labor expenses 50 percent below their unionized national LTL counterparts, where labor often comprises 65 percent of revenues.[15] Union wages as well as basic differences in working conditions contribute to lower turnover rates among LTL

drivers than among TL drivers. As a result, LTL carriers do not experience the same cost and managerial problems associated with high turnover rates.

Revenue Trends

Rate competition since economic deregulation in 1980 has affected all modes of freight transportation. Transportation rates are measured in revenue per ton-mile. As a result, changes in either revenues or ton-miles affect the statistics. Since 1980, truck ton-miles have seen an increase of 161 billion, while rail ton-miles increased by 116 billion.[16] During this time, expenditures on freight services also increased by $57 million on trucking and $2 million on rail services.[17] Annual expenditures on truck services as well as the annual freight tonnage hauled by the trucking industry are shown in Table 1.

Table 1. Expenditures on hauling and tonnage hauled by the trucking industry for selected years between 1980 and 1989

Year	Annual Expenditures on Truck Services (millions of dollars)	Annual Tonnage Hauled by Trucking Firms (millions of tons)
1980	$94,551	2,007
1985	$123,200	2,131
1987	$134,800	2,364
1988	$142,700	2,422
1989	$151,290	2,543

Source: Smith, Frank A. *Transportation in America: A Statistical Analysis of Transportation in the United States*, 9th ed. Westport, CT: The Eno Transportation Foundation, 1991. pp. 40 & 46.

In summary, freight rate pressure is extremely high. Revenue per ton-mile statistics show an increase of 6 percent for specialized TL carriers, an increase of 30 percent for Class I LTL carriers, and a 7 percent decrease for rail carriers since 1980.[18] The positive changes in truck revenue per ton-mile statistics are the result of increased ton-mileage. This increase in ton-miles could be caused by either

demand or supply forces. Demand forces include factors such as shippers' response to lower rates (i.e., increased quantity demanded as reflected through demand elasticity) or shifts in demand caused by trade or market factors (e.g., increased trade or other factors that enhance the movement of commodities). An example of a supply force induced increase in ton-mileage could be better utilization of equipment (i.e., less back-hauling) which, in effect, creates additional capacity.

The truck industry, as pointed out previously, is not homogeneous. Some sectors of the industry offer tremendous opportunities for growth while others do not. Trends in private carrier conversion, core-carrier strategies, shorter-haul shipments, and value-added services facilitate growth in the TL sector. Growth in the regional and interregional LTL segment, however, has been derived from the cannibalization of the national LTL customer base.[19] This competitive substitution has eroded most opportunities for growth in the national LTL sector. Some growth opportunities continue to exist in the regional and interregional sectors as marginal carriers exit the industry and further regionalization of the distribution process continues.[20]

Substitute Services

Truck transportation's principle substitute in intercity markets is rail service. Prior to deregulation, a modal market share function relying on relative modal rates, interest rates, and relative modal service was statistically accurate.[21] This explained why service-sensitive shippers utilized trucks and cost-sensitive shippers utilized rail. However, when data from the deregulated-era are incorporated, the previous function no longer holds true.[22] Changes in transportation policy during the 1980s have provided more transportation alternatives for shippers and carriers.

The share of TL carriers in the long-haul shipment market (more than 500 miles) is diminishing. Cheaper long-haul rail intermodal service, improved rail service quality, a shortage of TL drivers, and changes in shipper distribution patterns are contributing to this trend. As a result, TL capacity is moving

from longer-haul to medium-haul markets. This creates excess capacity in shorter-haul markets. Many TL carriers lack the managerial talents to maintain high fleet utilization in these circumstances.[23]

Competitive substitution of national LTL services has become pervasive since economic deregulation in 1980. Much of this competition comes from TL carriers who have designed multiple pickup and drop off services around strategically selected shippers. With a dramatically lower cost structure, partially caused by the lack of terminal facilities, TL carriers are making inroads on the premier shippers in the national LTL market. As shipping patterns continue to regionalize, national LTL carriers face direct competition with regional LTL carriers. The national LTL market is being cannibalized by regional LTL carriers who have developed partnerships with some TL carriers as well as by strategically positioned inter-regional LTL carriers. Recent revisions in pricing structure by traditional package service providers like United Parcel Service and air freight carriers like Federal Express are effectively competing in the LTL market.[24]

Evolutionary Forces

Political and technological change, and socioeconomic forces have interacted to enhance the logistical competency of American business.[25] In the 1980s, drastic changes in regulatory policy occurred in the U.S. and throughout North America. New export markets for American products and foreign competition in domestic markets gave consumers around the world more choices of new, higher quality, and/or less expensive products. Advances in information technology continue to increase the strategic value of information. As a result, industry structures have been forced to change and adapt.

The Staggers Rail Act of 1980 and the Motor Carrier Act of 1980 effectively deregulated the U.S. transportation industry. Rail rate competition intensified and entry into new truck markets was made substantially easier in an attempt to eliminate logistical inefficiencies.[26] Increased competitive pressures forced firms to adopt strategies that were market driven and customer responsive. One a result

was a further evolution of TL services into a distinct segment of the truck industry. Small carriers found it easy to enter and compete for TL services, displacing the large LTL carriers who had historically provided these services.

New firms were attracted by high regulatory rents reflecting decades of excessive regulation. The number of trucking firms, TL and LTL, grew 160 percent between 1980 and 1991, to over 46,000.[27] Almost all of this growth was in the TL segment where smaller capital requirements and tremendous market opportunities existed. New entrants heightened competition, thus reducing profit margins and eliminating excessive profits in the TL sector. However, unsophisticated players continue to enter the TL market, making it difficult to earn economic rents. Excess capacity has led to pervasive low profitability and firm destruction.

Unlike the TL segment, deregulation accelerated consolidation of the national LTL market. In 1991, there were 70 percent fewer intercity LTL carriers than in 1978.[28] Bankruptcy was the primary cause for LTL consolidation. Many inter-regional LTL carriers, lacking the resources (i.e., investment in equipment) of a national carrier and cost-competitiveness of a regional carrier, failed to adapt and change their competitive strategies and were forced out of the industry.[29]

Technological advancements during the 1980s have also impacted the trucking industry. These advancements have dramatically improved the efficiency and accuracy of information management. Competitive pressures will lead firms to use this information to improve their process time and speed of decision making. In addition to using new information technologies for their own benefit, carriers will be required to provide compatible data to facilitate their shippers' heightened information demands. Not all carriers will be capable of collecting or managing this tremendous amount of information.

Global competition is an additional factor forcing businesses to re-engineer processes, improve quality, and eliminate inefficient use of scarce resources. Inventory systems, such as just-in-time (JIT), manufacturing requirement planning (MRP), and distribution requirement planning (DRP), and myriad

quality control programs are results of these initiatives that affect the truck transportation industry. As all participants in the value-chain try to minimize their inventory through programs like JIT, there is an increase in the demand for high quality (i.e., reliable) transportation services.

One strategy shippers have adopted to combat competitive pressures is out-sourcing non-core business functions. Regarding transportation, shippers are implementing variations of the core-carrier concept. This will only become more pervasive in the future as shippers attempt to improve utilization of their limited asset base while also improving the quality of service being outsourced. Current for-hire services, however, have not provided shippers an acceptable alternative to the strategic benefits of a private fleet. However, recent deregulation of dedicated contract carriage and the prospect of a further erosion in state economic regulation may further perpetuate outsourcing among shippers. Criteria for selecting a transportation partner will differ for both the LTL and TL segments. LTL shippers will seek carriers with broad geographic coverage, dependable pickups and transit times, and claims-free services.[30] TL shippers demand equipment when needed, reliable service, and low incidence of damaged goods.

Management Aspects

The extent of management in the truck industry varies widely among firms, especially in the TL segment. The continuum ranges from owner-operators with almost no managerial concerns to very complex management structures in large corporations. An owner-operator owns and operates his/her own truck and is unable to compete with the services provided by LTL carriers. A majority of owner-operators lease themselves to another carrier, effectively outsourcing their managerial requirement. Shippers are unable to distinguish between services provided by leased owner-operators and the carrier's own equipment. Other owner-operators compete as a distinct firm with larger carriers. This group of

owner-operators often relies on freight brokers to provide various managerial functions such as sales support and dispatching.

Independent owner-operators, those who compete against larger carriers, are at a competitive disadvantage to large carriers. Larger carriers have integrated the entire service process, from customer solicitation to driver performance, into a single package. Larger carriers can guarantee customers a consistent service quality while improving asset utilization. Another important characteristic, common in both TL and LTL segments, is that owner-operators typically value the emotional benefits (i.e., work satisfaction) received from trucking, over the financial rewards of a different occupation.[31] As a result, owner-operators perpetuate price competition in the TL segment. Competition between owner-operators ensures low-cost inputs for larger carriers (i.e., the price carriers pay for leasing owner-operators).

Most LTL and large TL carriers (including private fleets) have developed progressive and innovative managers who realize the economic importance of moving away from pure price competition. These carriers have been quick to differentiate the service they provide from simply transporting freight. Differentiation may be in regard to delivery times, tracking services, electronic data interchange (EDI) capabilities, or pickup and drop-off requirements. By differentiating their services, carriers have diminished the competitive pressures in the industry.

Industry Competitiveness

The competitiveness of an industry is determined by the interaction of several factors. Five specific competitive forces have been utilized to analyze both the LTL and TL segments of the intercity truck industry. These are the threat of entry, intensity of competitive rivalry, availability of substitute services, power of buyers, and power of suppliers.[32]

Analyzing these structural forces reveals that the LTL segment is competitive in nature. The availability of substitute services (i.e., TL services) is the major cause of competitiveness in the LTL

segment. Rivalry amongst LTL carriers has resulted in intense competition for market-share and has forced LTL carriers to develop switching costs. Rivalry is further intensified by high fixed costs, excess capacity, and the slow profit growth over the last ten years. A strategic initiative by LTL carriers to develop switching costs among customers is the use of EDI. Emerging information technologies will continue to provide opportunities for service differentiation. Threat of entry is diminished in the LTL segment by high capital requirements and high expectations of competitor reaction to new firm entry.

Slow profit growth and a large number of homogeneous competing firms result in a high degree of competitive rivalry in the TL segment. Further, the TL market environment fosters commodity-like service strategies, hindering innovations that differentiate or create switching costs. Additionally, numerous alternatives are available to shippers, including backward integration (i.e., private fleets), and these have increased buyer power and competitiveness in the segment. Finally, rail can be a viable substitute to some TL services. The primary causes of this environment in the TL segment are a high threat of entry, low exit costs, and a large number of firms.

Industry Structure

The differences between the TL and LTL segments of the trucking industry are so great that one needs to question whether they can be considered a single industry. However, a discussion of this will not be covered in this paper. Since the two segments are so different, however, their structures will be discussed independently, and no attempt will be made to discuss a representative structure for the whole industry.

Truckload Segment

Firms in the TL segment of the trucking industry will have to overcome the fragmentation of the industry to be successful. The unique aspect of this TL environment is the absence of market leaders with the ability to shape industry events.[33] Causes of fragmentation, such as the economic forces that

result in low entry barriers for the TL segment, however, are difficult to neutralize. Creating or enhancing economies of scale, another cause of fragmentation, is difficult as well. The ability to utilize advanced information technologies as well as human resource programs may provide an opportunity for scale economies to be developed in the TL segment. Additionally, the importance of decentralized management and local control are disadvantages to large firms who may have the resources to overcome fragmentation.

Most TL carriers have tried to adopt the "bare-bones" or "no-frills" strategy to cope with fragmentation. This strategy combats intense competition and low profit margins by maintaining low overhead, employing low-skilled employees, practicing extremely tight cost controls, and paying extreme attention to operating details. However, competitors easily imitate these strategies, minimizing their success in overcoming the segment's fragmentation. Another alternative for overcoming fragmentation is to increase the value added. Providing more services with each sale can enhance product differentiation, develop economies of scale, and increase switching costs. These aspects will facilitate overcoming fragmentation and ultimately increase profitability. Schneider National and, more recently, JB Hunt accomplished this with satellite tracking and other advanced technology applications. Additional opportunities may exist for carriers successfully implementing a focused (i.e., niche) strategy.

Less-Than-Truckload Segment

Perhaps the biggest challenge facing LTL carriers, especially the national sector, is not coping with or overcoming fragmentation as in the TL segment, but rather realizing that their segment increasingly resembles the classic "mature industry." Figure 4 depicts life cycle locations for trucking industry segments. In the regulated environment, firms were able to achieve profitability with little attention to competitive strategies. The transition to maturity is characterized by intense competition for market share, a high dependence on repeat buyers, cost and service becoming increasingly more

important to customers, changes in marketing methods, and declining profits. These characterizations appear to be accurate for the LTL segment, and the national sector in particular.

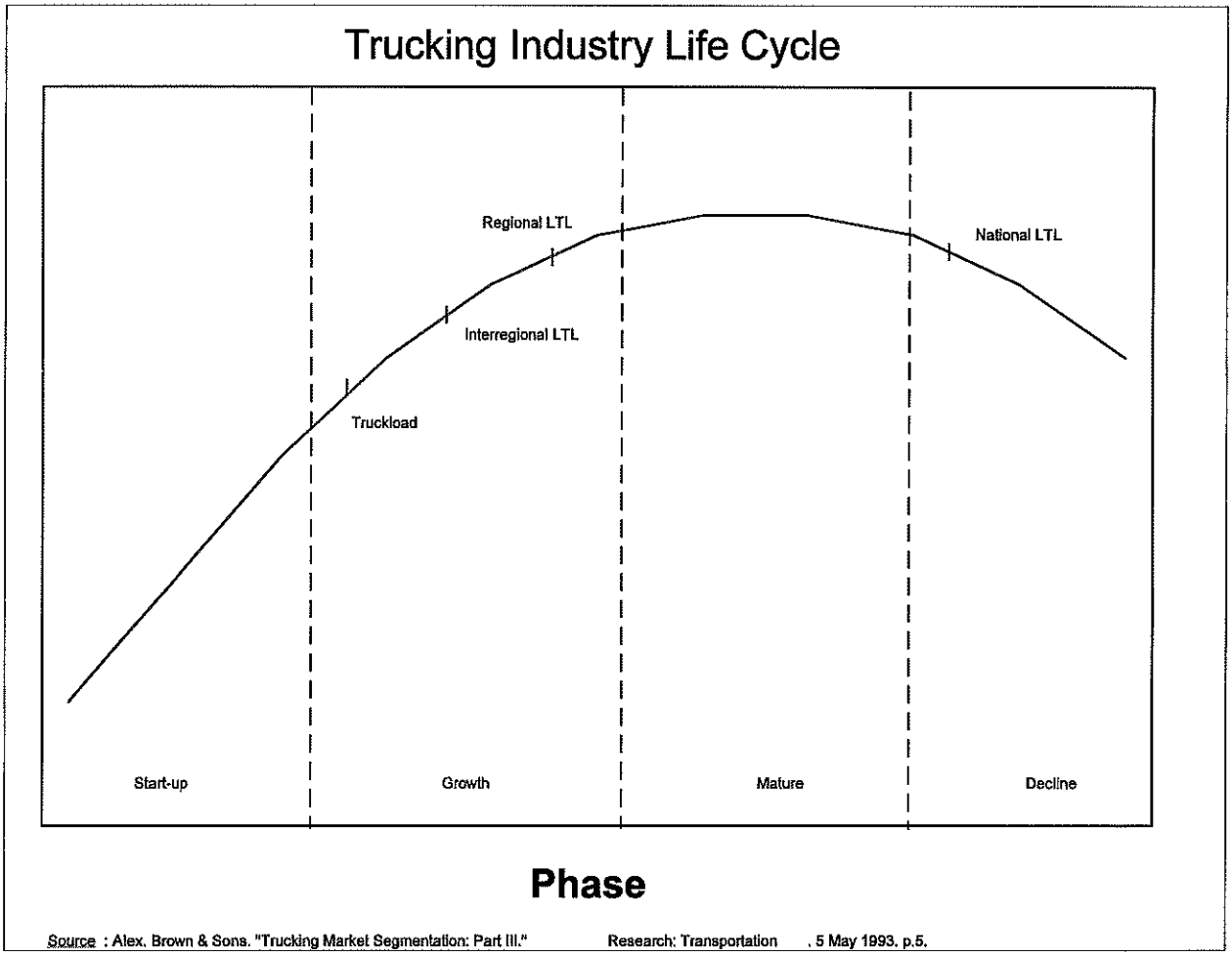

Figure 4. Trucking industry life cycle.

Conclusions

Successful deployment of the intelligent vehicle/highway system for commercial vehicle operations (IVHS-CVO) program requires participation from the trucking industry. Policy makers and public agencies wishing to successfully deploy IVHS-CVO must understand the trucking industry and the implications their decisions will have on this industry. This analysis has provided a macro view of

the trucking industry, apparent trends, and various forces affecting this industry, in an effort to assist policy makers and public agencies.

Many factors identified in the industry analysis impact the deployment of IVHS-CVO activities. The competitiveness of the industry makes any information that IVHS-CVO initiatives collect very valuable to individual carriers. This information, if collected privately, would be considered proprietary. Policy makers must understand the economic importance of data privacy for the trucking industry. Competitiveness also increases the importance and desirability of IVHS-CVO programs that enhance productivity. Currently, industry competitiveness has created an incentive for trucking firms to evade regulatory activities, resulting in a competitive disadvantage for legal trucking firms. Initiatives in IVHS-CVO could help level the playing field for carriers competing in the industry.

This paper is primarily concerned with the role and participation of government regarding IVHS-CVO. Although coordination among carriers, shippers, and government agencies is an integral part of implementing IVHS-CVO, this process will not be included in this paper. Regarding regulatory agency participation in IVHS-CVO, there are four issues that should be dealt with, either when making decisions about system architecture or when determining the basic framework of the government's program.

First, IVHS-CVO initiatives must satisfy the industry's data privacy concerns. Information that may provide competitors, both those for carriers as well as for shippers, insight about services provided are considered proprietary. Carriers and shippers will not participate in government IVHS-CVO programs voluntarily if this results in the dissemination of privileged information to their competitors.

Second, initiatives that improve the productivity of industry need to be prioritized. This is essential for improving the logistical efficiency of American firms. Government should assist industry in competing globally, satisfying consumers, and creating wealth and employment.

Third, there is a "moral" obligation to reduce compliance burdens and eliminate unfair competitive advantages. It is important for decision makers to recognize genuine resistance to programs especially resistance from trucking firms that benefit by evading current regulatory activities.

The fourth issue is more abstract. Regulators at both the state and federal levels must evaluate their initiatives from the industry's perspective. For instance, TL carriers dominate the intercity freight market, which is also where current regulatory activities are concentrated. This results in a higher regulatory burden for the TL segment compared to the LTL segment. However, many of the proposed IVHS-CVO activities appear to be aimed at larger carriers, particularly in the LTL segment, that operate on a somewhat predictable route. The LTL segment's exposure to regulatory activities within a given geographic area is more pervasive and therefore often construed to be greater than it is for TL carriers, whose exposure to regulatory activities is actually just as pervasive, and probably even more pervasive, given their share of the intercity freight market; it is just dispersed across a larger geographic area. There is a fear in the trucking industry, especially among smaller firms, that any new government program, including IVHS-CVO, that is claimed to improve productivity, efficiency, and compliance with existing requirements, will also be used to institute a higher tax burden. This has become a more sensitive issue as many in the trucking industry feel politically vulnerable (e.g., they think the public has a poor opinion of their safety record, and believes they don't pay their fair share, and many trucking firms feel they lack identity in states who have tax authority over their operations, making them easy political targets for revenue). Recent actions raising the industry's tax burden (i.e., fuel tax increases) have heightened this concern considerably. Initiatives will have to adequately and honestly deal with this issue to realize the participation and benefits anticipated from IVHS-CVO.

GOVERNMENT AND INDUSTRY INTERACTION

Government's role, with respect to the trucking industry is four-fold. First, to raise revenue for the construction and maintenance of the highway infrastructure. Second, to make vehicular transportation as safe as possible. Third, to prevent damage to the environment from vehicular transportation. Fourth, to accomplish socioeconomic objectives such as preventing market failure and ensuring fair competition.

Constructing and maintaining highway infrastructure is capital intensive. Policy makers have chosen to finance the highway infrastructure through user fees. Therefore, laws and administrative rules have been made attempting to ensure that highway user fees are assessed on the basis of benefits received by users. Fuel taxes and vehicle registration fees are the major sources of revenue for highway infrastructure.

Safety regulations ensure safe vehicle operation on the highway system. Federal and state governments have established safety rules and regulations covering both the driver and the vehicle. These rules establish requirements and standards for vehicle and driver performance, and also ensure that the highway system works in an orderly manner.

Government has also actively pursued various socioeconomic goals regarding the trucking industry. One major objective has been to ensure broad public access to services. Another has been to protect railroads from negative impacts of truck competition. To accomplish these socioeconomic goals, all levels of government have implemented various restrictions and requirements for individual trucking firms that provide transportation services.

This section describes government's role in the trucking industry. The discussion starts with a background or historical review of the evolution of regulatory activities, and concludes with a summary of current regulations.

Background Information

Congress, through the Interstate Commerce Commission (ICC), began to regulate the trucking industry in 1935. Prior to this time, truck movements were primarily local. Technological advancements and other socioeconomic changes began to make trucks a viable substitute to some rail services. One reason federal truck regulation was begun was to protect the already-regulated railroads from unregulated truck competition.

Investments in more and better highway infrastructure gave trucks greater range and capacity. As a result, business and industry no longer had to locate next to rail lines or ports. A cyclical or upward spiraling trend began, in which innovations in truck transportation allowed business expansion and relocation to occur, which in turn caused more innovation in truck services, followed by even more business expansion and relocation. Truck service and accessibility became uniform across the United States as interstate carriers met the needs of shippers. However, each state maintained its unique regulations and agencies to fit its own needs. The resulting regulatory system was complex, and costly for interstate carriers.

Throughout the 1960s and 1970s, the problems with interstate truck regulation became widely known. Although several attempts to standardize equipment, permitting, and tax reporting requirements were made, bureaucratic inertia, provincialism, and protectionism blocked meaningful efforts at fixing the problem.[34] Tough competition in the trucking industry further contributed to the problem of regulatory reform, as many carriers had a self-interest in maintaining their protected environment. As national and international markets grew, and U.S. businesses needed to become more competitive, emphasis shifted to increasing efficiency by improving productivity and reducing costs. Economic deregulation of interstate trucking eventually occurred in 1980. To further facilitate interstate trucking, uniform size and weight standards were implemented by the federal government for the interstate highway system.

The failure of economic regulation of interstate carriers can not be emphasized enough. Protection from competition generated substantial regulatory rents and significantly higher wages for drivers employed by carriers with operating authority. The total amount transferred by regulation from consumers to carriers and labor (society's net welfare loss) was estimated to be from $2.6 to $3.3 billion in 1972 alone.[35] In addition, regulation prevented resources from achieving their highest value and best use.

Current Regulatory Situation[b]

Currently, federal, state, and local governments each regulate some aspect of the trucking industry. Most of these regulations deal with safety and financing (i.e., generating revenue for highway infrastructure construction and maintenance). The Motor Carrier Act of 1980 effectively eliminated economic regulation of interstate trucking. Intrastate truck movements, however, are still subject to some state economic regulation. Only the states of Alaska, Arizona, Delaware, Florida, Maine, New Jersey, Wisconsin, and Vermont have eliminated all economic regulation of intrastate trucking.[36] In all other states, interstate carriers are unable to perform intrastate services without complying with that state's economic regulations. The intensity of intrastate economic regulation, however, varies drastically among states.

The current regulatory situation is vast and complex. The state and federal regulations intended to accomplish safety and financing objectives that apply to both intrastate and interstate carriers amount to a non-uniform structure of taxes and fees. This discussion will identify and describe the most pervasive regulatory activities. These activities deal with operating authority, vehicle registration, fuel

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b Information in this section is drawn from the May 14, 1993, draft interim report *Systems Planning for Automated Commercial Vehicle Licensing and Permitting Systems* prepared for Federal Highway Administration by Cambridge Systematics, Inc. et al.

use taxation, weight-distance taxation, vehicle size and weight requirements, driver and vehicle safety requirements, and environmental safety requirements.

Operating Authority

All interstate carriers, with the exception of private fleets and exempt commodity carriers, must receive authorization from the ICC in order to operate. As a result of deregulation, authority is granted to practically every carrier who meets the federal minimum insurance requirements. Along with proof of insurance, the ICC requires carriers to specify commodities carried and the states in which they will operate. This authority is valid until revoked by the ICC.

States also require interstate carriers, with the exception of ICC exempt carriers and private fleets, to obtain state operating authority. States maintain this requirement to ensure that interstate carriers have ICC approval to operate in their jurisdiction. In addition, states require carriers to show proof of insurance even though ICC approved carriers have, by definition, already complied with the federal government's more stringent requirements.

Most states also require intrastate carriers to obtain operating authority. Only the states of Alaska, Arizona, Delaware, Florida, Maryland, New Jersey, Vermont, Wyoming, and the District of Columbia do not require intrastate carriers to obtain operating authority.[37] In all other states, intrastate carriers must show proof of insurance, at a minimum, to obtain this authority.

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) has mandated that states reform the operating authority requirements for interstate carriers. A base-state system of recording operating authority and insurance status has been mandated. Under this system, the base state would collect all information and remit it to the other applicable states. This will substantially reduce carrier compliance burdens while maintaining a mechanism for states to ensure insurance regulation compliance.

Enforcement of operating authority is usually not a high priority. Operating authority may or may not be checked when a carrier is stopped for another reason. Currently, it is very difficult to verify operating authority, especially if issued by another agency within the state.

Vehicle Registration

All power units and trailers are required to be registered in the states they travel. Registration procedures are similar from state to state but differ for interstate and intrastate vehicles. These registration fees are the second largest source of transportation revenue for states.[38] In all states the fee structure for truck registration includes a weight component. Other common components used by states include vehicle age, number of axles, or load capacity. In addition, proof of insurance, payment of the Federal Heavy Vehicle Use Tax (FHVUT), and payment of any other state specific taxes may be required prior to registration being issued.

Intrastate truck registration is very similar to personal vehicle registration. License plates and the proper paperwork are issued for a specific vehicle after the fee is paid and all state requirements are met. For the most part, vehicle registration must be renewed annually in all states, though, some states differ in registration requirements for special classes of vehicles (e.g. trailers, converter dollies, and government vehicles).

Interstate registration of vehicles is much more complex. An interstate vehicle must be registered in every state it plans on traveling in. It is not uncommon for a vehicle to carry registration for all of the 48 contiguous states and even some Canadian provinces.

The International Registration Plan (IRP), a multistate cooperative agreement, was created to make interstate registration less burdensome for carriers. The IRP essentially allows a vehicle's registration to be apportioned by the mileage traveled in participating jurisdictions. A carrier only interacts with its base state, which in turn issues a license plate and paper credentials to the carrier.

Although the information required by different states may vary, the base state is responsible for collecting the appropriate information and communicating it to the other states. Base states are also required to audit the mileage records of 25 percent of the IRP carriers in their state.[39] Although a majority of states currently participate in the IRP, ISTEA has mandated all states to participate by 1996. This will greatly ease the trucking industry's compliance burden while maintaining a revenue mechanism for states.

Interstate carriers who perform services in a state where they are not registered (or apportioned) must obtain a temporary trip permit from that state. States collect a fee for these permits which is based on a flat rate plus a calculation for the vehicle's weight. Some states require these permits to be acquired at the first available permit agent, while others require that permits be acquired prior to arrival in the state. Most states allow permits to be purchased on the spot at ports of entry and weigh stations. The issuance of trip permits to vehicles on the road or at truck stops and other locations has been expedited by fax and wire services.

Enforcement of registration, like operating authority, typically occurs only when a vehicle is stopped for another purpose. An enforcement official must physically look at the paper cab card to determine if the vehicle is apportioned in that state and has no way of determining the accuracy of that carrier's apportionment. In addition, it is almost impossible for roadside enforcement officials, especially those from other jurisdictions, to access computer data on apportioned registrations because they usually are not integrated with other vehicle registration data for the state.

Fuel Use Taxation

Currently, the highway system in the United States is financed through a levy on the consumption of fuel.[c] Although distance traveled and fuel consumption are directly related, advances in fuel economy and the exemption of certain fuels from being taxed have seriously distorted the relationship between user benefits and system costs or infrastructure usage. As a result, even though certain externalities may warrant a "price" for poor fuel economy or an "incentive" to use a certain fuel, a fuel tax is a poor basis for financing the construction and maintenance of the highway infrastructure.

The basis for the benefit of using the highway system is place utility. Place utility involves at least two dimensions: the distance a truck travels and weight of the shipment carried. The current pricing scheme for the highway infrastructure relies on a fuel tax, corresponding to distance, and weight regulations to control the quantity.

States have devised different procedures for collecting the fuel tax from interstate and intrastate carriers. Intrastate carriers, who by the nature of their operation consume all fuel within that state, pay fuel taxes at the pump. States collect fuel taxes from interstate carriers, however, on the mileage traveled in each particular state, rather than on the amount of fuel purchased in that state.

States have created the International Fuel Tax Agreement (IFTA) and the Regional Fuel Tax Agreement (RFTA) to facilitate collection of fuel taxes based on mileage between participating jurisdictions. The ISTEA has mandated all states to participate in IFTA by 1996, which will greatly improve the ability of states and carriers to efficiently secure infrastructure financing. With IFTA, carriers keep track of fuel taxes paid at the pump, mileage traveled, and fuel economy. The carrier then files a quarterly tax statement with the base state. This statement indicates the net tax liability for each

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[c] Conceptually, there are two main principles that apply to the distribution of cost for a government-provided service. These are ability-to-pay and benefits received. The presumption behind a fuel tax is that the benefits of using the road network vary directly with the consumption of fuel.

affected jurisdiction. The carrier remits any payments necessary to the base state, which is responsible for transferring the funds between states. Temporary fuel tax permits are required for travel in non-apportioned states and are handled similarly to temporary registration permits.

Roadside enforcement of IFTA compliance, like registration and operating authority, usually only happens when a vehicle is stopped for another reason. Furthermore, enforcement officials do not have ready access to IFTA data at the roadside. As a result, enforcement efforts are limited to confirming the presence of valid decals and credentials, which provide no verification of the vehicle's mileage or fuel reporting accuracy. To maintain credibility and accuracy, IFTA states are required to audit 15 percent of their carriers every five years (3 percent annually). However, the complexity of the fuel tax system creates tremendous incentive and opportunity for carriers to evade and avoid the tax.

Weight-Distance Taxation

Weight-distance tax is the most recent application of taxation to the trucking industry. This tax is based on the vehicle's weight and the distance traveled in the state. To comply with such a tax, carriers must keep accurate records of both in-state and total miles, as well as the applicable weight of the vehicle on each trip. In 1993, weight-distance taxes were in effect in Arizona, Idaho, Kentucky, New Mexico, New York, and Oregon.[40]

Enforcement and participation requirements are state-specific, as no consortium has developed to facilitate compliance. In Oregon, which relies on self-reporting and auditing, carriers are required to keep records on trip origin and destination, Oregon entry and exit points, Oregon miles traveled, routes of travel, dates of each trip, pickup and delivery points, daily odometer readings, bills of lading, and identification of exempt miles.[41] The complexity of weight-distance taxes, and controversy over its constitutionality, have contributed to extremely high evasion rates in states with this tax.[42]

Vehicle Size and Weight Requirements

Vehicle size and weight regulations were introduced for two reasons. First, to limit the trucking industry's ability to effectively compete against large-volume rail service. Second, as a necessary component of the highway infrastructure financing mechanism. Given that the infrastructure is disproportionately used or damaged by "large" and "heavy" vehicles, governments were unwilling or unable to devise mechanisms of collecting fees from these users to compensate for their damage. This is the primary reason excessively large and/or heavy vehicles are prohibited from using the highway system.

The federal government has taken away from state and local governments the authority to determine the maximum vehicle weights and lengths for the Interstate and Primary Highway system. This was done to allow the efficient and unimpeded movement of goods across state lines. Additionally, the federal government has created a "bridge formula" to maximize the life and use of highway bridges. This formula calculates the maximum weight allowable given a vehicle's axle configuration. States have their own size and weight limitations that apply to routes other than the Interstate and Primary Highway system.

There are occasionally special situations that require carriers to travel overweight or oversize. For these circumstances, states issue oversize and overweight permits. Before an oversize/overweight permit can be issued, states must verify whether the carrier has paid the FHVUT. Requirements for special permits vary vastly between states as local geography, weather, population, or highway and bridge construction methods dictate acceptable oversize and overweight limits. However, most permit issuances are routine and could be standardized within a given region of the country. Efforts are under way to standardize the process through regional permitting consortiums.

State fee structures for special permits are designed to cover administrative costs as well as to compensate for the expected infrastructure damage caused by the particular load. Fixed weigh stations

and portable scale units are the primary tools used to enforce these permits. Special permit offices lack the capability to easily verify a vehicle's compliance with registration, fuel tax, or other regulatory information. Further, enforcement officials often lack the ability to communicate with the office that issued the oversize/overweight permit.

Driver and Vehicle Safety Requirements

Driver error and mechanical defects contribute to a substantial number of commercial motor vehicle accidents. In an effort to increase the trucking industry's safety, the federal government has developed minimum safety requirements for drivers and vehicles. Through the Motor Carrier Safety Assistance Program (MCSAP), which provides federal funds for state enforcement efforts, most states have implemented the federal government's requirements. The major driver requirements are that drivers possess one (and only one) valid Commercial Drivers License (CDL), that they follow specified limitations on the hours of service they can operate without rest, and that they possess a medical examiner's certificate.

Vehicles are required to pass a minimum safety fitness inspection annually and are also subjected to periodic inspections by enforcement officials. A standardized inspection process has been developed and is known as the North American Standard Inspection process. The Commercial Vehicle Safety Alliance (CVSA) continues to improve the efficiency and effectiveness of commercial motor vehicle inspections.

Safety inspections are time consuming for both enforcement officials and the trucking industry. There are two ways to increase the effectiveness of safety inspections: increase the number of inspections made, or eliminate safe vehicles from the selection pool (thereby increasing the probability of inspecting an unsafe vehicle). Given the limited resources public agencies can devote to safety inspection, and the high cost of compliance for safe vehicles, the second alternative must be

implemented if a true improvement in safety is desired. However, attitudes toward safety vary widely among states. Some states are genuinely concerned about eliminating unsafe carriers while others are simply interested in generating revenue from safety violation fines.

There has been some innovation in the area of vehicle safety. States, as members of CVSA, work uniformly to eliminate inefficiencies in safety enforcement. Under CVSA, participating states are to recognize the validity of another state's inspection process. As a result, vehicles that have passed a CVSA inspection will not be subject to further inspections during a specified time period. This allows enforcement officials to more effectively target and remove unsafe vehicles. The federal government provides MCSAP grants to states in an effort to increase the inspection effort. Under MCSAP, a prodigious amount of information on inspections is collected; however, it is not readily available for use by enforcement officials in the field.

Environmental Safety Requirements

Federal, state, and local government agencies regulate hazardous material movements for public health and safety reasons. In addition to identifying and providing information on hazardous material trucking firms, hazardous material permits generate revenue for safety or cleanup related activities. These permits also establish criteria for both trucking firms and shippers for the shipping of hazardous materials. Interstate and intrastate movements of hazardous materials are subject to the same regulatory process.

Certain carriers and shippers of hazardous materials are required to register with the U.S. Department of Transportation (DOT). Registration is required for carriers who transport large quantities of radioactive materials, explosives, materials extremely poisonous by inhalation, bulk shipments of hazardous materials, or large shipments of small packages containing hazardous materials.[43] The annual registration fee is $300, of which $250 is allocated toward a nationwide emergency response and training

grant program.[44] In addition, the carriage of some hazardous materials requires a federal permit. The exact requirements as to whether a carrier needs to be registered, permitted, or both, is beyond the scope of this project.

State regulation of hazardous material shipments varies widely. Some states have no regulations, while others have stringent requirements. Within states, overlapping jurisdictions and conflicts between state agencies compound the compliance burden for the trucking industry. Annual fees for state registration of hazardous material shipments can range from $25 to $250 and are assessed either on a per-vehicle or per-carrier basis.[45]

Efforts to create a uniform program for regulating hazardous material shipments are under way. Under the proposed program, registration will be similar to IRP and fees will be based upon apportioned miles and percentage of hazardous material activity.[46] Additionally, in the new program, annual permits will be issued to registered carriers from base states, no single permits will be issued, government agencies and their shippers will be subject to these regulations, and MCSAP grants will be available to fund roadside enforcement.[47] Current penalties, training for enforcement officials, and enforcement resources vary vastly between states.[48]

Summary

The regulatory system that has been created over the years and adapted to fit current needs is vast, burdensome, and confusing for both the trucking industry and government regulators. Additionally, many of the regulations are ineffective. For many of these regulations it is difficult to see where the objectives of safety, infrastructure finance, or even some discrete socioeconomic goal come into play.

The issue of how best to finance the highway infrastructure has been debated extensively. What has become apparent, however, is that the current method is conceptually flawed. That is, the fuel tax does not correlate to use, and weight limits are ineffective in constraining place utility. Perhaps

countering the demand for place utility with a true price that correlates with government's cost of facilitating place utility would be more effective than the current inherently adversarial relationship caused by regulation and enforcement.

COST OF CURRENT REGULATORY ACTIVITIES

There are several problems associated with current truck regulations. One problem is the cost of compliance. Excessive compliance costs increase pressures for regulatory evasion. When some trucking firms have to comply with current regulatory processes while other firms are able to operate without complying, the competitive balance in the industry is disrupted. In addition to affecting industry costs, evasion costs society by negating regulatory goals. The pervasiveness of evasion in the trucking industry is well known. An analysis of the costs of current regulatory practices to the trucking industry will now be presented.

Compliance burdens are caused by enforcement activities, by acquisition of various permits and registrations, and by keeping required records. The burden of acquiring permits and registrations and keeping required records, although assumed to be very large, is very difficult to quantify. The number of permits required and the number of jurisdictions responsible for issuing those permits varies by geographic location as well as by the nature of the carrier. As a result, determining a meaningful typical burden for all carriers in the nation is beyond the scope of this project or any other. Record-keeping burdens also vary by carrier type and management information requirements. For these reasons, this analysis will primarily focus on quantifying the enforcement burden.

It is assumed that an analysis of the weight and safety enforcement process will suffice in quantifying the enforcement burden on the trucking industry. In every state, weight and safety compliance are the primary emphasis of all enforcement activities. Although myriad other regulations exist, they are often enforced at the same time as weight and safety regulations.

Determining the value and amount of time spent on weight and safety enforcement activities by the trucking industry is fundamental to this analysis. However, there are several factors diminishing the accuracy of an analysis for the entire trucking industry. Two steps were taken to improve the accuracy of the results of the analysis completed in this project. First, data have been analyzed separately for the TL

and LTL segments of the trucking industry. This helps account for the drastic differences between the operations of carriers in these two distinct segments. Second, the time burden is analyzed separately for weight and safety enforcement activities. This accounts for differences between these two activities as well as any differences that may exist between these two enforcement activities in the TL and LTL segments. The cost of labor was used as the basis for calculating enforcement costs. However, in order to determine the total economic cost of the enforcement activity, an opportunity cost for the trucking industry was also included. These simplifying assumptions will help ensure that the results are not overstated.

Value of Time

Truckload Segment

Labor was used as the primary cost driver in the value-of-time calculation. Two methods were then used to determine the value of a TL carrier's time. The first, referred to as the average hourly income method, was to divide average annual income by the average annual hours worked and then multiply by the time spent at the weigh station or during a safety inspection. The second, referred to as the equivalent mileage method, was to multiply an average rate earned per mile by the miles that could have been traveled had the stop not been made.

The TL segment is made up of company drivers and owner-operators. Taking into account current income surveys, carrier responses to job satisfaction surveys, and consultations with industry experts, the annual compensation for both owner-operators and company drivers used in this analysis was $28,500. The average annual income range for company drivers currently ranges from $20,000 to $30,000.[49] Incidentally, owner-operator income also falls into this same range.[50] To further support the compensation assumption, ICC regulated TL carrier data indicates an average compensation of $28,500 annually.[51]

To estimate average hourly income, the average annual hours worked must be computed for TL carriers. Since the amount of time a driver can legally work is heavily regulated, the analysis will use an annual driver time of 2,190 hours. This value is based on an evaluation study of the hours of service regulations for the TL industry.[52] This study utilized the following assumptions in its analysis: 292 annual driving days, an average speed of 50 miles per hour, annual mileage of 109,500, and average pay of $28,470.[53] These assumptions are both realistic and supportive of the assumptions made for this project. Dividing annual income by hours worked yields an income of $13.00 per hour for TL drivers.

The second method of calculating time value requires determination of the miles that could have been traveled if the stops hadn't been made. Weight and safety inspection stops occur when the vehicle is traveling at average highway speeds. Assuming an average speed of 55 miles per hour, every minute of delay is equivalent to 0.9167 miles. This method will yield more accurate results as fewer simplifying assumptions have been made, and as most company TL drivers are paid on a per-mile basis, averaging $0.23 per mile.[54]

Less-Than-Truckload Segment

In determining the LTL segment's value of time spent on weight and safety enforcement activities, the equivalent mile method was not utilized in this analysis. Decreasing travel time for intercity LTL shipments, primarily between fixed location terminals, is a worthy objective. However, LTL operations will not be able to turn this travel time reduction into a greater travel distance, as TL operations can. Instead, the value of reduced travel time for the LTL segment comes from enhanced service quality and service product differentiation. For shippers, this translates into greater flexibility in pickup and delivery options and/or more predictable and consistent pickup and delivery services. This project did not attempt to determine the value of this to shippers and therefore to LTL carriers. For this analysis, an hourly rate of $24.60 for LTL labor was used to determine the value of time calculation.

The 1991 International Brotherhood of Teamsters' National Master Freight Agreement provides a base hourly compensation for LTL drivers of $17.10 with a cumulative benefit increase of $7.50 per hour.[55]

Weight Enforcement

Time Burden

Current weight enforcement strategies are time-consuming, negatively impact highway safety, are redundant, and are ineffective. Although enforcement varies from state to state, enforcement officials generally agree that fixed station enforcement is less effective than strategies incorporating portable units.[56] No matter what strategy is employed, however, the enforcement process remains the same; trucks pull off the mainline, stop, and then proceed back onto the mainline. This analysis assumes that a commercial vehicle in compliance with weight regulations could save five minutes for each weight enforcement stop bypassed; three minutes for queuing and weighing and two minutes for deceleration and acceleration.[57] Multiplying the number of vehicles weighed, found in Table 2, by the assumed five minutes, indicates that the trucking industry as a whole spends almost 10 million hours annually on weight compliance activities. In addition, the merging of commercial vehicles on and off the mainline negatively affects highway safety. Furthermore, enforcement activities, which are operated completely autonomously from each other, have become redundant both within states and between them. As for effectiveness, experts conservatively estimate that 15 percent of all commercial vehicles on the Interstate System are overweight.[58] Table 2, however, clearly shows that only 0.6 percent of commercial vehicles subjected to current enforcement activities are found to be illegal.

Table 2. Weight enforcement occurrences by scale type, citations issued for overweight violations, and percent of vehicles cited for fiscal years 1989 through 1991[a]

Year (FY)	Fixed	Semi Portable	Portable	Total	Citations	Percent (%)
1989	115,677,884	1,312,059	1,187,339	118,177,282	692,673	0.586%
1990	113,240,574	1,174,532	1,153,196	115,568,302	667,954	0.578%
1991	114,271,426	1,233,139	1,254,532	116,759,097	663,305	0.568%

[a] Vehicles weighed by weigh-in-motion (WIM) scales are not included in these numbers.

Source: Secretary of Transportation. *Overweight Vehicles - Penalties & Permits.* FHWA-MC-93-001. Washington, DC: Federal Highway Administration, April 1993. p. 8 & 11.

Labor Cost

Multiplying the value of time and the amount of time spent by carriers on weight enforcement will yield the cost burden borne by the TL and LTL segments. As was discussed previously, the TL and LTL segments will be analyzed separately using two different methods. The average hourly income method estimates a TL carrier's cost of $1.08 for each weigh stop. The more reliable and accurate equivalent mile method results in a weigh stop cost of $1.05. Using the LTL assumptions, each weigh stop costs LTL carriers $2.05.

Safety Enforcement

Time Burden

Safety enforcement strategies are similar to weight enforcement. Some states operate fixed inspection facilities while others conduct inspections at random roadside locations or even at a motor carrier's place of business. The federal government has standardized the inspection process by creating

five specific levels or types of inspections. Levels I, II, and III[d] are the most common and are all performed on vehicles en route. The other levels are special inspections or are conducted at business sites and may or may not include the driver. Comparing the cost and time of an inspection against the probability of detecting a defect which is shown to be a leading cause of accidents, reveals that only Level I and III roadside inspections are efficient.[59]

Safety inspections are very time-consuming and, as a result, can be very costly for the trucking industry. Unnecessary inspections waste productive time, result in inefficient use of labor and assets, negatively affect customer service through delays, and contribute little to improving highway safety. Although disagreement exists over what constitutes an unnecessary inspection, traditionally an inspection placing a vehicle or driver out of service (OOS) is considered successful. The number of inspections performed by level as well as the percentage of OOS violations issued for either drivers or vehicles are listed in Table 3. The average times of inspections are 33.86 minutes for Level I, 28.61 minutes for Level II, and 20.20 minutes for Level III.[60] Multiplying the average time of an inspection by the number of inspections conducted indicates that carriers spend over 564,000 hours on Level I, 226,800 hours on Level II, and 51,200 hours on Level III inspections for a total of over 842,200 hours on safety inspections. Furthermore, summing the vehicle and driver OOS rates indicates that only 56 percent of the inspections were successful; over 44 percent were unnecessary.

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[d] Level I - North American Standard includes extensive vehicle and driver checks (including brake systems and hours of service)
Level II - Covers both driver and vehicle (without inspecting underneath vehicle)
Level III - Driver only

Table 3. Number of roadside inspections by level and the percentage of vehicles and drivers placed out of service (OOS) for fiscal year 1992

Inspection Level	Number of Inspections	Vehicle OOS Rate	Driver OOS Rate
Level I	999,556	35%	21%
Level II	475,760	21%	8%
Level III	152,331	NA	15%

Source: Office of Motor Carrier Field Operations. *Annual Report on Program Quality and Effectiveness, Fiscal Year 1992.* FHWA-MC-93-022, Washington, DC: Federal Highway Administration, June 1993. p. Attachment III-5.

Labor Cost

By analyzing the data and assumptions given, the trucking industry's cost of current safety enforcement efforts can be determined. For the TL segment, under the average hourly income method, each Level I inspection costs $7.34, each Level II costs $6.20, and each Level III costs $4.38. The equivalent mile method results in $7.14 for each Level I, $6.03 for each Level II, and $4.25 for each Level III safety inspection of a TL carrier. Using the LTL assumptions, each Level I inspection costs $13.88, each Level II $11.73, and each Level III $8.28.

Carrier's Opportunity Cost

Although the costs detailed previously attempt to quantify the lost productivity and efficiency from weight and safety enforcement activities, they are in no way complete or all-inclusive. Weight and safety enforcement activities, by lengthening the time required to perform a given service, result in greater equipment requirements. A tractor used in the intercity freight market could require an investment anywhere between $60,000 and $130,000, not including the trailer.[61] Trucking firms have a finite supply of capital available for use in their businesses. Failing to account for the opportunity cost of this investment would result in an incomplete and inaccurate analysis. The opportunity costs for weight

and safety enforcement activities is the potential return of using the capital tied up in extra equipment for other activities.

Determining the opportunity cost of weight and safety enforcement activities for carriers in the trucking industry is very difficult. A simplified approach is to determine the opportunity cost per mile and multiply by the equivalent miles lost by having to stop. However, this approach may not accurately encompass all that constitutes the opportunity cost of enforcement activities for motor carriers in compliance with weight and safety regulations. This project will utilize this approach and will not evaluate alternative methods for calculating the opportunity cost. To simplify the analysis, assume the average investment is $90,000 per tractor-trailer rig. A rate of 10 percent will be used to represent the opportunity cost of carriers in the industry. Further, average annual mileage for a rig in the intercity freight market is 110,000 miles.[62] Using these assumptions, the opportunity cost per rig is just over $0.08 per mile. Earlier, it was determined that weight and safety inspections cost carriers 10,572,000 hours. Making another simplifying assumption of 55 miles per hour, this time is an equivalent of over 581 million miles. Using $0.08 opportunity cost per mile results in a total opportunity cost for the industry of approximately $47.6 million annually. Table 4 summarizes both the total and per stop opportunity costs attributable to weight and safety enforcement activities.

Table 4. Opportunity cost of enforcement activities for the trucking industry

Enforcement Activity		Total Opportunity Cost	Average Time/Stop	Opportunity Cost per Stop
Weight		$43,784,661	5 min.	$0.38
Safety	Level I	$2,538,372	33.86 min.	$2.54
	Level II	$1,020,862	28.61 min.	$2.15
	Level III	$230,781	20.20 min.	$1.52

Summary

The previous analysis has calculated the costs of current enforcement activities to the trucking industry. Per-stop costs for TL and LTL carriers delineated in Tables 5 and 6 show safety inspection to have substantially higher costs. Current weight enforcement activities cost industry from $167 million to $283 million annually. Safety enforcement activities cost industry between $14 million and $25 million annually. The minimum occurs when it is assumed that the total enforcement burden falls on the TL segment and the maximum when the total burden falls on the LTL segment. A more accurate summary of these costs, however, requires the allocation of enforcement burden between the TL and LTL segments.

Table 5. Summary of the truckload segment's labor and opportunity costs from weight and safety enforcement activities on a per occurrence basis (per stop)

Enforcement Activity		Labor		Opportunity	Total	
		Equivalent Mile	Hourly Income		Equivalent Mile	Hourly Income
Weight		$1.05	$1.08	$0.38	$1.43	$1.46
Safety	Level I	$7.14	$7.34	$2.54	$9.68	$9.88
	Level II	$6.03	$6.20	$2.15	$8.18	$8.35
	Level III	$4.25	$4.38	$1.52	$5.77	$5.90

Table 6. Summary of the less-than-truckload segment's labor and opportunity costs from weight and safety enforcement activities on a per occurrence basis (per stop)

Enforcement Activity		Labor	Opportunity	Total
Weight		$2.05	$0.38	$2.43
Safety	Level I	$13.88	$2.54	$16.42
	Level II	$11.73	$2.15	$13.88
	Level III	$8.28	$1.52	$9.80

Although over 80 percent of the intercity freight market is TL, this does not necessarily correlate with the distribution of TL and LTL vehicles subjected to weight and safety enforcement activities. Data on carrier type (i.e., TL or LTL) is not collected by weight and safety enforcement officials. Furthermore, during the course of this project no sources containing empirical data regarding the distribution between TL and LTL operations and enforcement activities were found.

This project will use an assumed distribution of vehicles, between TL and LTL carriers, subjected to current weight enforcement activities. The following allocation of vehicle weights will be used: 75 percent of fixed scale, 70 percent of semi-portable scale, and 60 percent of portable scale are assumed to be of intercity TL carriers. These assumptions are based on the routing and operational characteristics of the two segments, as well as the intercity freight market share. Extreme caution must be used when viewing this analysis, due to the lack of supporting empirical evidence. Table 7 indicates the number of stops TL carriers and LTL carriers would make for weight enforcement, based on the aforementioned assumptions. Combining these assumptions results in an estimated annual trucking industry burden of $152 million to $155 million for weight enforcement activities. A sensitivity analysis of the cost of current weight enforcement activities for alternative distributions between TL and LTL carriers is presented in Table 8.

Table 7. Allocation of weight enforcement occurrences between truckload and less-than-truckload carriers

Scale Type	Total Occurrences	TL Percent	LTL Percent	TL Occurences	LTL Occurences
Fixed	114,271,426	75	25	85,703,570	28,567,856
Semiportable	1,233,139	70	30	863,197	369,942
Portable	1,254,532	60	40	752,719	501,813
Total	116,759,097			87,319,486	29,439,611

Table 8. Sensitivity analysis of the cost burden of current weight enforcement activities for various distributions between TL and LTL carriers

Scenario	Percent Occurences TL			Percent Occurences LTL			Total Cost
	Fixed	Semi-portable	Portable	Fixed	Semi-portable	Portable	millions of dollars
1	75	70	60	25	30	40	$152 to $155
2	25	30	40	75	70	60	$243 to $244
3	25	25	25	75	75	75	$243 to $244
4	50	50	50	50	50	50	$203 to $205
5	75	75	75	25	25	25	$163 to $166

Safety inspections will also be distributed between TL and LTL carriers. The distribution of safety inspections will be based on the same assumptions used in distributing the weight enforcement occurences. The simplifying assumptions are that 75 percent of all Level I inspections, 70 percent of Level II inspections, and 60 percent of Level III inspections are of TL carriers. Table 9 indicates the number of stops TL carriers and LTL carriers would make for safety inspections using the aforementioned assumptions. Using these allocation assumptions, current safety enforcement activities cost the trucking industry $17.2 million to $17.4 million annually. A sensitivity analysis of the cost of current weight enforcement activities for alternative distributions between TL and LTL carriers is presented in Table 10.

Table 9. Allocation of safety inspections between truckload and less-than-truckload carriers

Level	Total Inspections	TL Percent	LTL Percent	TL Inspections	LTL Inspections
Level I	999,556	75%	25%	749,667	249,889
Level II	475,760	70%	30%	333,032	142,728
Level III	152,331	60%	40%	91,399	60,932
Total	1,627,647			1,174,098	453,549

Table 10. Sensitivity analysis of the cost burden of current safety enforcement activities for various distributions between TL and LTL carriers

Scenario	Percent Occurences TL			Percent Occurences LTL			Total Cost
	Level I	Level II	Level III	Level I	Level II	Level III	millions of dollars
1	75	70	60	25	30	40	$17
2	25	30	40	75	70	60	$22
3	25	25	25	75	75	75	$22
4	50	50	50	50	50	50	$20
5	75	75	75	25	25	25	$17

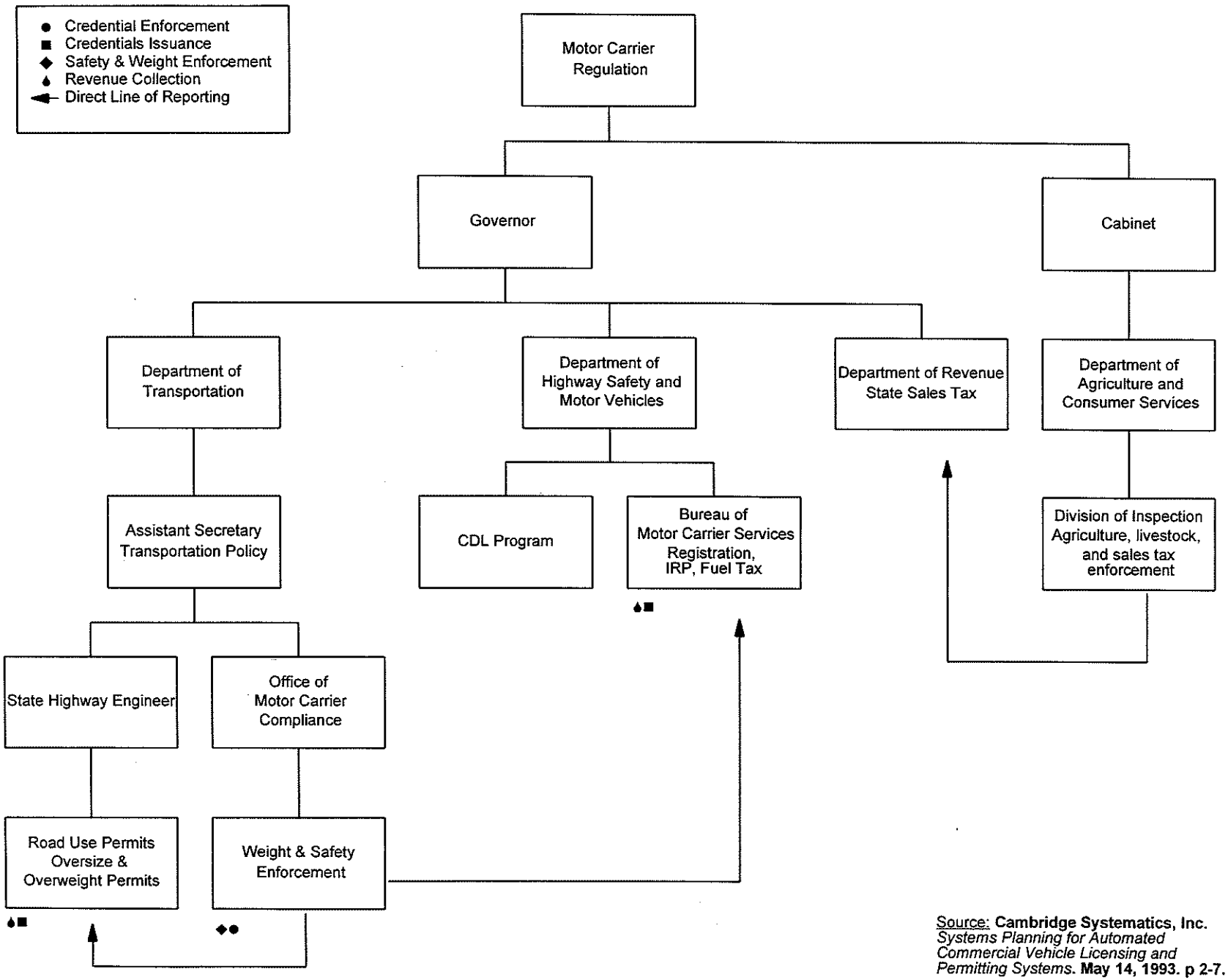
Credential and Permit Acquisition Burden

In addition to the time carriers spend having their credentials verified, considerable time is spent acquiring all of the various permits required. In most states, the agency that is responsible for the regulatory function also issues permits or credentials. This results in carriers having to make application to multiple agencies and even several divisions within the same agency to comply with all regulations. Although this project did not quantify the cost of the credential and permit acquisition burden, Table 11 summarizes the transactions between carriers and state agencies in complying with various regulatory functions. Furthermore, Figures 5, 6, and 7 provide a few examples of the organizational structures adopted by the states to regulate the trucking industry.

Table 11. Current motor carrier tax and regulatory transactions

Tax & Regulatory Areas	Application & Issuance Proceedures	Ongoing Reporting Transactions		Enforcement Activity	
		Between Motor Carriers & States	Among States	Between Motor Carriers and States	Among States
State Operating Authority	Individual State: Interstate Intrastate Exempt Private	Individual State: Annual Renewal Annual Renewal Annual Renweal Annual Renewal		Roadside, Audit Roadside, Audit Roadside Roadside	
Registration of ICC Authority	Individual State: Bingo Stamp Base State (1994)	Annual Renewal Annual Renewal		Roadside Roadside, Audit	
Insurance	Individual State: Insurance Filing	Annual Renewal			
Vehicle Registration	Base State: IRP Individual State: Intrastate Full Fee One-Time Trip Permit	Individual State: Annual Renewal Annual Renewal N.A. N.A.	Base State: IRP	Roadside, Audit Roadside Roadside Roadside	Audit
Fuel Use Tax	Base State: IFTA RFTA Individual State: Regular Trip Permit	Base State: Quarterly Filing Quarterly Filing Individual State: Quarterly Filing N.A.	Base State: IFTA RFTA Individual State: Regular	Roadside, Audit Roadside, Audit Roadside, Audit Roadside	 Audit Audit
Weight-Distance Tax	Base State: OR, AZ Individual State: Regular Exempt Trip Permit	Base State: Quarterly Filing Individual State: Periodic Filing Periodic Filing N.A.		Audit Roadside, Audit Roadside Roadside	
Size & Weight	Base State: IRP Individual State: Registration Annual Permit Trip Permit Regional Permit	Base State: Annual Renewal Individual State: Annual Renewal Annual Renewal N.A. N.A.	 Regional	Roadside, Audit Roadside, Audit Roadside Roadside Roadside	
Vehicle Safety	Individual State: CVSA Roadside Terminal	Quarterly Inspection Annual Review	CVIS Proposed	Roadside Terminal, Roadside	
Driver Safety • CDL • Hours of Serive • Medical Cert.	Individual State: Examination Driver's Log Certificate	Renewal Every 2 Years Ongoing Documentation Renewal Every 2 Years	CDLIS Federal Rating CDLIS	Roadside Roadside Roadside	CDLIS Audit CDLIS
Environmental Safety • Hazmat (Cargo, Tank) • Air Quality (Engine)	Individual State: Annual Permit Trip Permit Federal: DOT Registration DOT Permit Individual State: Inspection (CA)	Annual Renewal Annual Renewal Annual (In Rulemaking)		Roadside Roadside Roadside Roadside? Station (CA)	
Agricultural Control (Produce, Livestock)	Individual State: Permit Inspection (CA, FL)	Individual State: Annual Each Trip		Roadside Inspection Station	
Customs and Immigration Control (Driver, Vehicle, Cargo)	Federal: Import/Export Documents	Federal: Each Crossing		Borders	

Source: Cambridge Systematics, Inc. *Systems Planning for Automated Commercial Vehicle Licensing and Permitting Systems*. DTFH61-92-C-00021, Washington, DC: Federal Highway Administration, May 1993. p. 2-3.



Source: **Cambridge Systematics, Inc.** *Systems Planning for Automated Commercial Vehicle Licensing and Permitting Systems.* **May 14, 1993. p 2-7.**

Figure 5. State regulatory bureaucracy for the trucking industry: example 1.

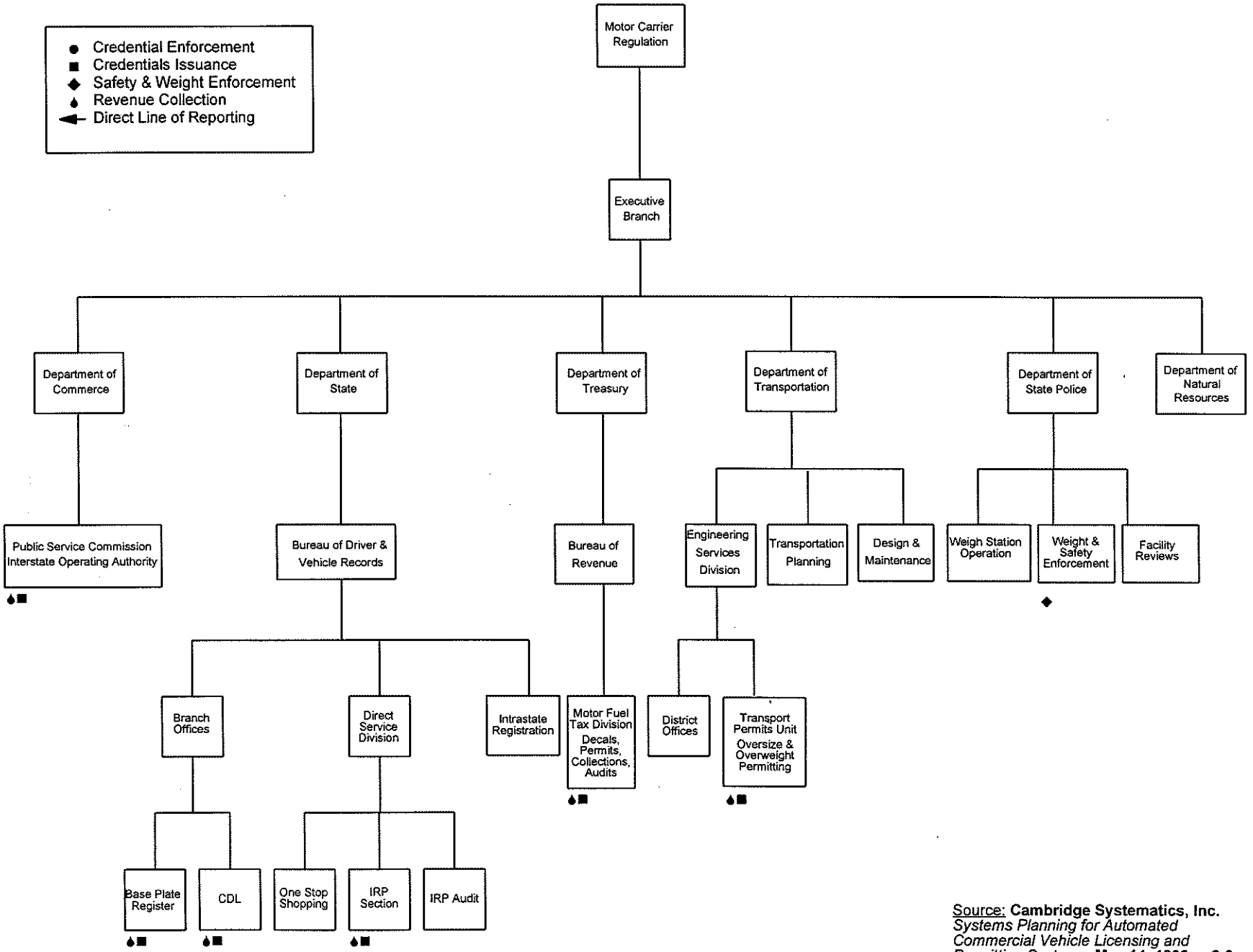
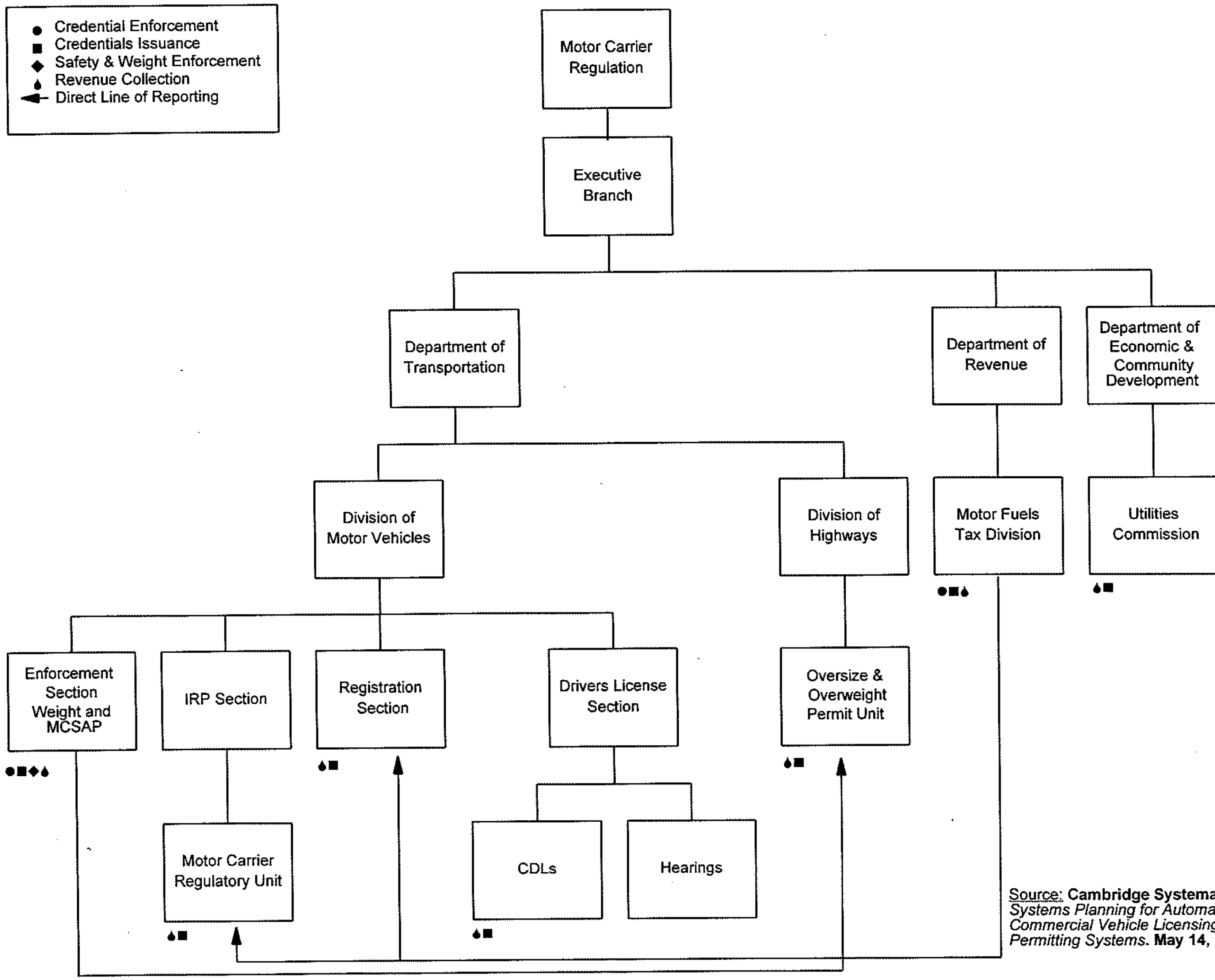


Figure 6. State regulatory bureaucracy for the trucking industry: example 2.

Source: **Cambridge Systematics, Inc.** *Systems Planning for Automated Commercial Vehicle Licensing and Permitting Systems.* **May 14, 1993. p 2-8.**



Source: **Cambridge Systematics, Inc.** *Systems Planning for Automated Commercial Vehicle Licensing and Permitting Systems*. **May 14, 1993. p 2-9.**

Figure 7. State regulatory bureaucracy for the trucking industry: example 3.

ECONOMIC IMPLICATIONS FOR IVHS-CVO

The IVHS-CVO program has two main components. These were identified earlier as one-stop shopping and transparent borders. The analysis presented in this paper deals primarily with the transparent borders concept. Implementation of the transparent borders concept requires the development of a nationwide system for preclearing trucks at weight and safety enforcement points. Trucks participating in the preclearance program would be outfitted with a transponder compatible with roadside reading devices. As the truck approached an enforcement point, vehicle-to-roadside communication (VRC) would take place and the necessary data would be queried to determine if the truck was in compliance. If the truck was found to be in compliance, then the driver would be signaled to bypass that particular enforcement point. If the vehicle was not in compliance or there were problems with the associated data, the driver would be signaled to stop at the enforcement point. A specific technology is not relevant to this analysis.

Industry

Among other things, preclearance provides an opportunity to improve the trucking industry's productivity. Unproductive time is defined, for this portion of the analysis, as the time spent by legal and compliant carriers on safety and weight enforcement activities. The time illegal carriers spend is not considered unproductive because they, unlike their legal counterparts, are not in compliance with the law. This definition represents a theoretical maximum because there is no way to know if a carrier is legal or not unless it is subjected to enforcement. Additionally, it ignores the value of subjecting legal vehicles to enforcement activities (i.e., deterrent); such an analysis is beyond the scope of this project. However, enforcement agencies can actively pursue activities, methods, and innovations such as IVHS-CVO that decrease the probability of legal vehicles being subjected to enforcement.

By drawing upon the analysis conducted earlier, the benefits of industry participation in preclearance can be determined. Maximum benefit would occur if all vehicles were equipped with the appropriate technology, so only illegal vehicles would be subjected to specific enforcement activities. In this scenario, the benefit to industry would be $166 million to $282 million annually for weight enforcement (the total weight enforcement burden for both legal and illegal carriers is $167 to $283 million annually). For safety enforcement under this scenario, the trucking industry would benefit $7.8 million to $13.2 million annually (the total safety enforcement burden for both legal and illegal carriers is $14 to $25 million annually). These costs are determined by multiplying the cost of each weight and safety enforcement activity by the number of occurrences that could be avoided. Table 10 summarizes the number of unnecessary stops for weight and safety enforcement (i.e., legal vehicles subjected to enforcement) as well as the corresponding costs. Determining the number of vehicles likely to participate in IVHS-CVO preclearance programs as well as the number of weight or safety enforcement stops that could then be avoided is beyond the scope of this analysis. Furthermore, distributing both occurrences and violations between the two industry segments, TL and LTL, at this time, is beyond the scope of the project. However, since costs are presented on a per-stop basis, both individual carriers and policy makers can determine the benefits from a certain number of vehicles participating in preclearance programs.

Table 12. Cost of unnecessary weight and safety enforcement activities to the trucking industry[a]

Enforcement Activity		Total Occurrences	Unnecessary Occurrences	Value (Million $)
Weight		116,759,097	116,095,792	$166 - $282
Safety	Level I	999,556	439,804	$4.3 - $7.2
	Level II	475,760	337,789	$2.8 - $4.7
	Level III	152,331	129,481	$0.7 - $1.3

[a] Unnecessary is defined, for purposes of this analysis, as any enforcement activity conducted on a legal vehicle. It should be noted that this definition ignores any deterrent value associated with subjecting legal vehicles to enforcement activities.

State Regulatory Agencies

Regulatory agencies could utilize IVHS-CVO programs to improve the effectiveness of weight and safety enforcement activities. These enhancements occur through better labor productivity, decreased accident rates, and improved service value and quality provided to taxpayers. These areas will be discussed in this section.

Enhancement to Productivity

Economic deregulation and other socioeconomic changes have increased truck traffic levels. Increased traffic has caused fixed-site enforcement facilities (e.g., weigh stations and ports of entry) to operate at levels exceeding their designed capacity. State budgetary constraints and, in some instances, geographic limitations (i.e., land availability) have practically eliminated a state's ability to expand capacity at these locations. Fixed-site enforcement locations are labor-intensive and also require a substantial portion of the enforcement agency's personnel. The state of Oregon has indicated that 60 percent of their enforcement field staff are assigned to ports of entry.[63]

The state of Oregon has been an innovator in automating truck regulatory functions. Automation has provided Oregon with long-term increases in labor productivity, better data, and improvements in

both the efficiency and effectiveness of enforcement. The individual tasks required for weight enforcement in Oregon have been reduced from 13 to 4.[64] A 70 percent reduction in tasks, none of which apparently added value, is a significant accomplishment for any organization attempting to improve quality and value. Oregon's current computer system allows weighmasters (weight enforcement personnel) to input vehicle data directly into the state's database. Vehicles equipped with transponders further automate all or part of the data entry process, eliminating even the need for the weighmaster to keypunch data. In addition to traditional data entry employees having more time now for alternative uses, data entry errors decline. As a result, tax auditors and other data users have more timely and accurate data. Additionally, Oregon has been able to decrease port-of-entry crew size by 11 percent (from 18 to 16) as well as to reduce daily staffing requirements during weekdays by 17 percent (from 6 to 5) and for weekends by 25 percent (from 4 to 3).[65] Smaller crews have been able to increase their coverage by 50 percent (from 4 locations to 6).[66] Oregon has also witnessed a substantial decrease in the amount of sick leave taken by weighmasters, perhaps indicating an improvement in job satisfaction or working environment.[67] All of these aspects would contribute to the enhanced enforcement of a state's regulations.

Enhancements to Safety

States will also benefit through improved commercial vehicle safety by automation of the safety inspection process. Although some technologies could dramatically alter the physical inspection process, for all practical purposes they are far from deployment. The technologies are either still in development or their cost is too prohibitive for widespread use. For purposes of this discussion, automation of safety enforcement activities will be limited to improved access to information by safety enforcement personnel. The physical inspection process is assumed to remain unchanged.

Technology is currently available that would allow an enforcement official to select and inspect only those vehicles or carriers deemed most at risk of having an accident. A statistical analysis of accidents and carriers could greatly enhance the inspection selection process. Using various criteria and historical data about the carrier, inspectors could ascertain which vehicles would have the highest probability of a safety violation. Providing this information to the inspector at the roadside would not only improve safety by inspecting the most dangerous vehicles but would also decrease the time wasted inspecting safe vehicles.

A casual analysis of truck safety data from the Federal Highway Administration's Motor Carrier Management Information System (MCMIS) reveals that carriers with a vehicle OOS rate less than 34 percent have a significantly (at the 0.0001 significance level) lower reported accident rate than carriers with a vehicle OOS rate exceeding 34 percent.[e,68] The analysis also found that, although not statistically significant, reportable accident rates are lower for carriers with a driver OOS rate less than 10 percent than for carriers with a driver OOS rate exceeding 10 percent.[f,69]

From this casual analysis of safety data, vehicle and driver inspection criteria seem to reflect accident rates. This analysis indicates that it is possible to develop an efficient system for selecting vehicles for inspection that results in a higher probability for inspection of unsafe carriers and a lower probability of inspection of safe carriers. This would decrease the unproductive time spent by legal carriers on safety enforcement activities. Furthermore, automation of safety information and roadside

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[e] The analysis was conducted on 14,371 carriers that had a safety review between January 1990 and August 1993 and three or more roadside inspections in the two years prior to that review. The mean reportable accident rate for carriers with a vehicle OOS rate less than 34% (n=8,825) was 0.74320 accidents per million miles while the mean reportable accident rate for carriers with a vehicle OOS rate greater than 34% (n=5,546) was 1.05746 accidents per million miles.

[f] The same set of carriers used in the vehicle OOS analysis were used in the driver OOS analysis. The mean reportable accident rate for carriers with a driver OOS rate less than 10% (n=9,482) was 0.84102 accidents per million miles while the mean reportable accident rate for carriers with a driver OOS rate greater than 10% (n=4,889) was 0.90998 accidents per million miles.

access to it could provide tremendous improvements in truck safety, an obvious benefit to both states and society.

Improved Service Quality and Taxpayer Value

Quantifying the benefits of improved service quality and value to the taxpayer is very difficult. Government, unlike the private sector, cannot monitor the reaction of sales and profitability to differing levels of quality. However, there is a widespread initiative among many government agencies to improve the quality of their services. The difficult question is how much state agencies are willing to invest to improve their quality.

The IVHS-CVO program offers state agencies a chance to improve their effectiveness, reduce some operating costs, improve the availability and accuracy of data for planning, as well as bring tremendous improvements in the quality of services provided. Reducing the compliance burden on private industry as well as improving enforcement effectiveness is beneficial to society. Taxpayers can benefit greatly from government initiatives that accomplish these objectives.

Summary

All state agencies participating in the IVHS-CVO program will benefit. The degree to which benefits will impact each state, however, varies dramatically. States with large truck volumes and inadequate enforcement budgets will benefit the most. States with large truck volumes and adequate enforcement budgets will also benefit either through real labor savings or enhanced strategies, further improving the enforcement effectiveness of regulatory programs.

Prior to implementing any IVHS-CVO programs, society, through its legislative representatives and bureaucrats, should assess its regulatory objectives. The goals of federal commercial vehicle regulations are primarily to 1) achieve an acceptable level of safety on highways and 2) ensure an equitable relationship between users (or between user fee and amount of infrastructure damage). Simply

automating current activities only treats the symptoms of inefficiencies and not the causes. That is, doing an activity better will not result in the further achievement of societal objectives if the wrong activity has been instituted to begin with.

Before society invests a substantial amount of scarce resources in improving the current weight and safety enforcement programs perhaps they should consider alternative methods of achieving financial equity and safer highways. If current IVHS-CVO programs simply result in the optimization of current activities without regard to regulatory objectives, sub-optimization of society's scarce resources will result.

CASE STUDY OF STATE AGENCY BENEFITS

A case study of the benefits a particular state could expect from the deployment of selected IVHS-CVO programs was undertaken as a part of this project. The case study encompassed electronic clearance in North Dakota. There were several reasons for the particular selection of both the activity and the state. These include:

Activity:

- Technologically ready for deployment
- Operational tests have been and are being conducted
- Deployment initiatives are beginning to surface
- Presents the greatest benefits to society by simply automating a current government program (i.e., is not a new program or regulatory requirement)

State:

- Data availability and familiarity
- Willingness to cooperate with researcher
- Currently looking at alternative investments regarding enforcement activities
- Low truck traffic and resource allocation for enforcement represents a worse-case scenario for IVHS-CVO

The results of the case study are presented as follows. First, a description of current enforcement strategies in North Dakota and of the electronic clearance activity as it is assumed to be implemented are presented. This is followed by an evaluation of the benefits of implementation. Three major benefits for North Dakota were identified and evaluated. These were improvements in enforcement, quality of service, and safety. The primary benefits are improvements in productivity, data collection, and enforcement effectiveness.

Current Enforcement Activities

The process for collecting fuel taxes is relatively simple for a state. Retail outlets collect and remit to the state the tax on all fuel sold in that state. The IFTA coordinates the exchange of tax liabilities and payments among the various cooperating jurisdictions for participating interstate carriers. North Dakota simply has to audit a portion of carriers based within its jurisdiction. The weight limit component, however, is more difficult to ensure compliance with.

There are currently only two economic detriments to traveling overweight. One is a decline in fuel economy resulting in the payment of more fuel taxes. However, the increased fuel tax is usually inconsequential compared to the value of the additional place utility provided (i.e., the movement of a greater quantity of goods to a demand location). The second economic cost of traveling overweight is simply the probability of being cited. Since the value of place utility is one determinant of shipper's demand for trucking services, carriers have an incentive to travel heavier, especially when the probability of enforcement is low. However, there is a profound relationship between weight and infrastructure damage.[g] Given this relationship and the failure of a tax on fuel to correlate with use, ubiquitous enforcement of weight limits is necessary.

The financial impacts of pavement rehabilitation are substantial. As a result, these unavoidable future financial expenditures should be planned and coordinated so the burden can be spread evenly over time. However, the life of a pavement is not impacted by time but by the accumulation of equivalent single axle loads (ESALs). When actual ESALs accumulate faster than projected, the pavement will deteriorate faster than projected, and will need rehabilitation sooner. ESALs can accumulate faster than projected due to two main courses: 1) poor forecasting of traffic patterns and 2) overweight vehicles. Of

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[g] Pavement deterioration is an exponential function of equivalent single axle loads (ESALs). The greater the ESAL the greater the damage to the infrastructure. The weight of a vehicle and its axle configuration will determine its ESAL.

these two, obviously only the allowance of overweight traffic is relevant to this discussion. At any rate, the accelerated rehabilitation of a given pavement is expensive and either requires additional funds to be allocated or diverts resources away from planned rehabilitations.[h]

Description

Weight enforcement in North Dakota is accomplished primarily through existing ports of entry. North Dakota also utilizes portable scales for weight enforcement. However, portable scales have not been an integral part of the enforcement strategy. Currently, there are 10 ports of entry in North Dakota.

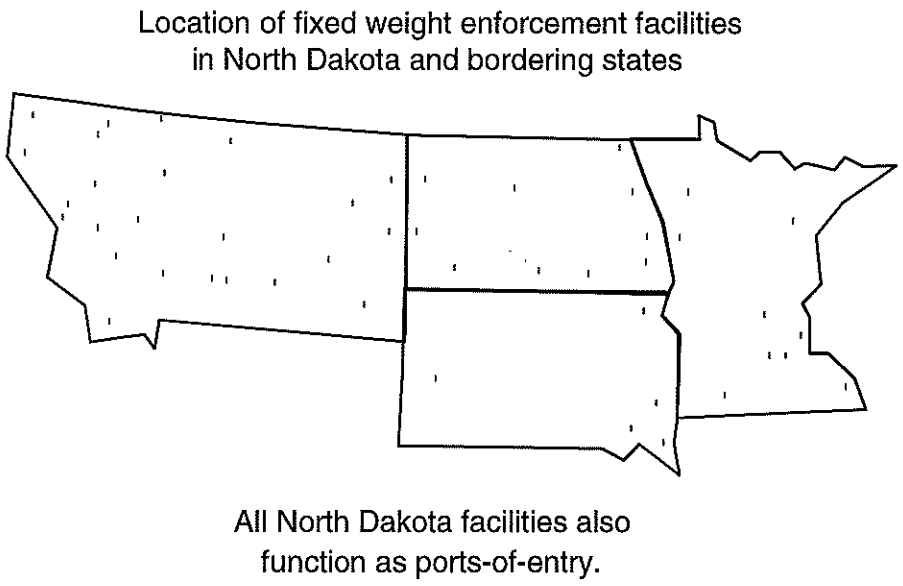

Figure 8. Location of fixed weigh stations in North Dakota and bordering states.

h For example, assume a pavement is projected to need rehabilitation in 20 years at a cost of $300,000 per mile. Further, weight enforcement activities were ineffective in eliminating overweight vehicles and this section of pavement is projected to need rehabilitation after a life of 15 years (5 years less than designed). The present value of reconditioning this pavement in 15 years is approximately $71,800 per mile, assuming a discount factor of 10 percent. The present value of reconditioning this pavement in 20 years, as originally planned, is only $44,600 per mile. Therefore, the cost of not enforcing weight limits on this section of pavement is $27,200 per mile. These funds are no longer available for other highway infrastructure improvement projects.

Minnesota, South Dakota, and Montana, the three states bordering North Dakota, also use fixed stations for weight enforcement. Figure 8 indicates the location of these stations in North Dakota and bordering states.

North Dakota's fixed stations are located on Interstate and Primary Highways; the traditional major truck routes. Truck traffic levels near a given station determine the staffing levels for that station. Figure 9 shows the number of trucks that pass through, number of trucks weighed, and staff assignments for each fixed station in North Dakota. For purposes of this analysis, the 10 facilities have been classified as either a less than 24-hour operation, meagerly staffed 24-hour operation, or adequately staffed 24-hour operation. Table 11 displays the staffing levels and the daily operational hours for each classification of station. Additionally, Table 11 indicates how many stations are in each classification. Three of North Dakota's stations, Hague, Ellendale, and Bowman, always operate less than 24-hours per day. The remaining seven stations attempt to be open 24-hours every day.

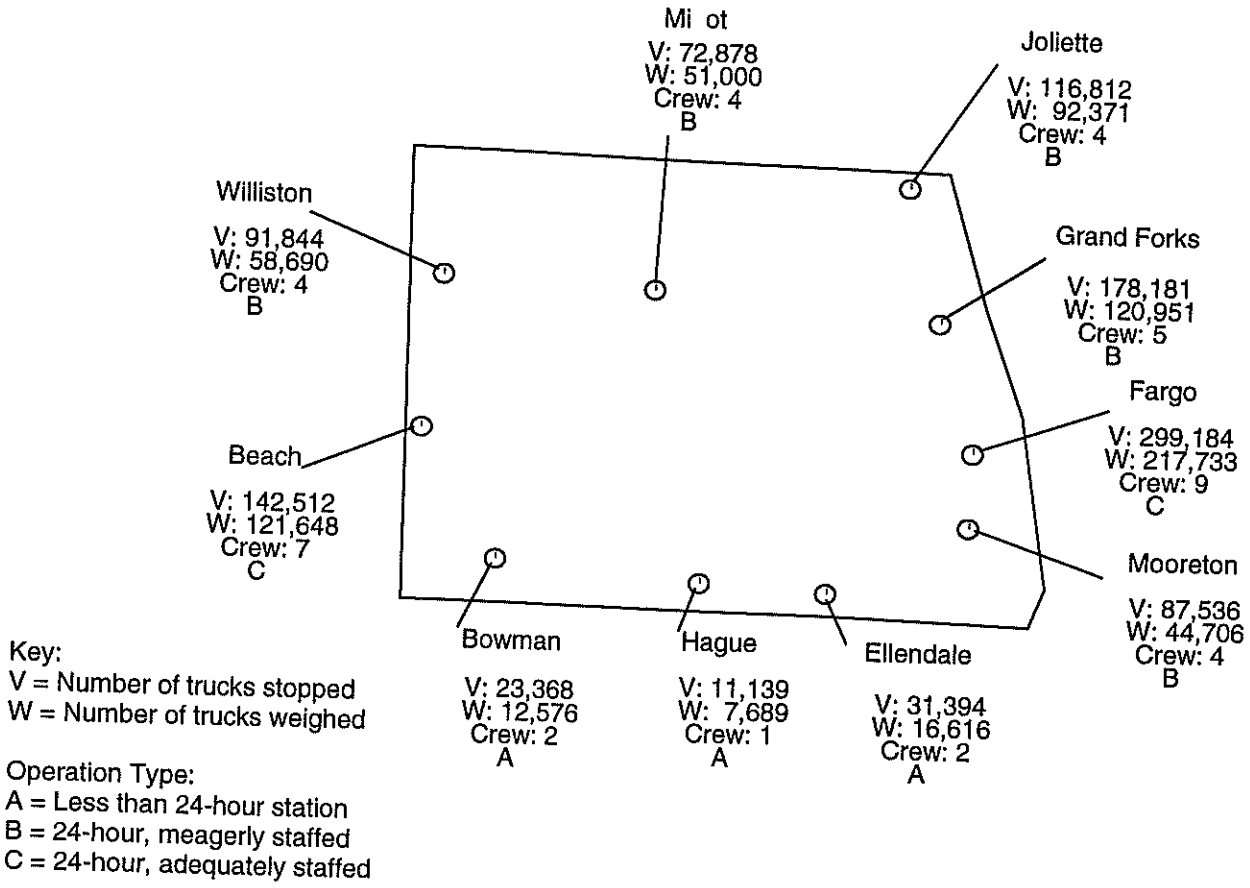

Figure 9. **Number of trucks stopped, number of trucks weighed, crew size, and operation type for all fixed weigh stations in North Dakota.**

Table 13. Staffing levels, daily operational hours, and number of stations in each weigh station classification for North Dakota

Weigh Station Classification	Staffing Level (FTE)	Daily Operational Hours[a]	Number of Stations
Less than 24-hour	1-2	8-16	3
Meagerly Staffed	4-5	20-24	5
Adequately Staffed	7-9	24[b]	2

[a] Sick leave and vacation time are not taken into account.
[b] In this classification, most work shifts are assigned two full-time equivalents (FTEs).

Source: Personal Interview. Sgt. Ken Halldarson. North Dakota Highway Patrol. March 14, 1994.

The North Dakota Highway Patrol (NDHP) is responsible for enforcing weight regulations in the state. However, the NDHP relies on financial support from the North Dakota Department of Transportation (NDDOT) for facility construction and equipment to carry out weight enforcement activities. This organizational arrangement will inherently have many institutional issues to resolve. Some issues simply result from the different perspectives, environments, and missions of the two agencies. The fact that enforcement efforts require real financial expenditures now while the benefits of that investment are difficult to compute and are not realized until some future point in time creates additional institutional barriers. This relationship and the corresponding institutional problem it creates is common in other states as well. As state budgets are further strained, these institutional barriers will become more apparent as enforcement activities seek funding from traditional construction and maintenance funds.

Problems

Governments do not possess the resources necessary to replace substantial portions of the infrastructure at any given point in time. Accelerated pavement deterioration is extremely problematic for highway officials who are faced with rehabilitating additional miles of pavement. Given that resources are limited, only a certain number of miles can be rehabilitated in a certain time period. However, as pavements deteriorate faster than projected, the number of miles in need of rehabilitation grows faster than the rate at which pavements are rehabilitated. Exacerbating the problem is the fact that as a pavement deteriorates further as it awaits rehabilitation, the cost of rehabilitation increases substantially.

North Dakota's current weight enforcement strategy (like that of most other states) is ineffective. The demand for "heavier" shipments is satisfied (i.e., these vehicles are operating and damaging pavements) while corresponding higher user fees are not collected. This is caused by a failure of infrastructure financing mechanism which assumes that vehicle weights (demand for "heavy" shipments) will be controlled, allowing user fees to be based simply on distance traveled (i.e., fuel taxes). Practically every truck that enters the highway system is able to use the system (i.e., nationally, only 0.5 percent of trucks subjected to weight enforcement are overweight while 15 percent of all truck traffic is suspected of being overweight[i]).

Fixed station enforcement can only be effective in a closed system where every vehicle is "certified" prior to entering the road network. This would require a fixed station at every point of entry to the system, a solution that is both infeasible and impractical. Instead, enforcement and regulatory agencies have located a small number of facilities (relative to the road network's numerous entry points) at strategic locations in an attempt to maximize compliance with weight regulations. However, once the

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[i] As reported earlier in the Cost of Current Regulatory Activities section of this project.

location decision is made, it becomes a static enforcement effort in a dynamic system. That is, once a fixed station has been located, it can not ensure compliance with weight regulations by traffic that does not pass by the station.

Traffic patterns change over time as economic forces in various sectors of the economy interact and determine the demand for a given transportation service. This has become extremely apparent in North Dakota where changes in the economies of grain production, storage, and transportation during the 1980s have shifted the proportion of "heavy" truck traffic from Interstate and Primary Highways to low-volume roads.[70] Rationalization of rail service and the development of the subterminal-satellite elevator system are the major contributors to this trend.

Two observations from this trend in traffic patterns have been collected. First, premature road deterioration is inevitable on low-volume roads not designed and maintained for the new traffic pattern. Premature deterioration, however, does not imply that "heavy" truck traffic on low-volume roads exceeds established weight limits. Accelerated road deterioration is a consequence of excessive reliance on the "traffic approach" for highway impact assessment rather than a "transportation system analysis."[71] As a result, planners were unable to forecast changes in demand for grain transportation services and the corresponding impacts on traffic patterns and pavement life.

The second observation is that there has been no change in North Dakota's weight enforcement strategies. This has, in part, been caused by the financial commitment necessary to operate existing fixed stations. However, just as one can not assume the "heavy" traffic on low-volume roads exceeds legal limits, one can not assume this traffic is less likely to be out-of-compliance than traffic currently passing fixed stations. In fact, given grain shipper's desire to fully utilize cubic capacity (i.e., grain trucks are typically loaded to capacity even though different weight and space densities exist), the probability of non-compliance may actually be higher for this traffic.

These problems with weight enforcement strategies are not unique to North Dakota. Every state relies in some part on fixed stations for weight enforcement. This being so, they are all subject to problems caused by changes in traffic patterns especially amongst their intrastate carriers. Furthermore, the federal government, at least indirectly, encourages states to use a fixed station enforcement strategy through its certification requirements. That is, states are encouraged to weigh a large number of trucks and fixed stations provide an efficient mechanism to weigh numerous trucks inexpensively.

Application of Electronic Clearance to North Dakota

Electronic clearance would allow legal interstate and intrastate trucks to pass North Dakota's fixed weight enforcement facilities without having to stop and prove compliance. Also, a considerable amount of data regarding vehicles passing the station would be collected automatically. Weight data are one example that would be of tremendous value to transportation planners and engineers. Furthermore, North Dakota could operate additional scales, thereby expanding enforcement without increasing personnel.

Electronic clearance could be deployed under several scenarios. One scenario would be to completely automate an existing fixed station (or the creation of a new site that provides the identical function of a fixed station). Another scenario would be to expand the enforcement of selected functions (e.g., weight) through additional sites collectively monitored from a remote location (i.e., a single enforcement agent could monitor several scale-only sites equipped with real-time communication of video and data from a remote control center). North Dakota could implement any number of, or combination of, technologies that will be described in this project. For purposes of this project, however, the automation of a fixed station (whether existing or new) that enforces all commercial vehicle regulations currently enforced will be analyzed (i.e., weight, safety, operating authority, fuel tax, etc).

Operational Concepts

The implications of electronic clearance on the operation of a fixed weigh station depends upon the trucking industry's level of participation. If all trucks are mandated to participate, it would be possible to completely automate a fixed weigh station. However, it has been stated that participation by the trucking industry and even by individual states will be voluntary.[72] As a result, states will have to design enforcement strategies that accommodate both participant and non-participant motor carriers. This will be particularly relevant to the benefits North Dakota could hope to receive from electronic clearance. Current staffing levels are already at a minimum level and even with the implementation of electronic clearance North Dakota will need to sustain this staffing level.

Implementation of electronic clearance can accomplish vehicle identification, classification, and weighing upstream of the fixed station. This information, communicated to a computer system at the fixed station, would be evaluated against pre-set criteria to determine if the vehicle warrants stopping. The criteria may include safety information such as fitness rating, date of last inspection, and history of out-of-service violations; credential information such as operating authority, vehicle registration, and fuel tax registration; and weight information ascertained from a weigh-in-motion (WIM) scale such as gross vehicle weight, axle weight, and actual weight versus registered weight. Vehicles violating the established criteria will be directed to stop at the fixed station. The system will also inform the enforcement official why this vehicle was selected for inspection.

Technology Required

The electronic clearance of trucks at North Dakota's fixed stations requires technologies that support the electronic exchange of vehicle information. Vehicle to roadside communication (VRC) is fundamental to this activity. For VRC to take place, the vehicle requires a transponder capable of communicating with roadside devices. Although several alternative transponder technologies exist,

which technology is ultimately selected as a standard is not relevant to this analysis. All that is assumed is that the vehicle can be identified as it passes the enforcement site. To complete VRC, the fixed station will have to be equipped with compatible infrastructure. This infrastructure will include both hardware (i.e., something to read transponders and an on-site computer for analysis) and the associated data interchange protocols for the information exchange.

State and national information on vehicles must be accessible by the enforcement site for electronic clearance to be useful. Relevant to this analysis is only that the on-site computer is capable of accessing this data from some information system. The ownership (i.e., public or private) or level (i.e., state, regional, and/or national) of this information system is not important to this analysis. This capability would allow safety and credential information to be available for enforcement regardless of where the vehicle or carrier was from (i.e., interstate or intrastate).

Technologies that could determine a vehicle's weight and classification would also be required for complete implementation of electronic clearance. Weigh-in-motion and automatic vehicle classification (AVC) technologies can provide this capability. Both gross weight and bridge formula compliance could be ascertained with these technologies.

Improved Enforcement

Electronic clearance has the potential to improve enforcement of weight and safety regulations in North Dakota. State employee productivity, data collection, and enforcement effectiveness will all be positively impacted by electronic clearance.

Productivity

Improvements in weight enforcement productivity are difficult to measure. Generally, productivity is the level of performance achieved from a given allocation of resources. Labor comprises the largest resource in the weight enforcement process. Using this general definition, productivity

enhancements should either increase the number of trucks weighed or decrease the amount of labor needed to weigh the same number of trucks.

Under the scenario of complete automation of existing fixed stations and voluntary participation by the trucking industry, electronic clearance will marginally benefit North Dakota. Only the two stations with multi-employee shifts, Fargo and Beach, would be able to reduce staffing requirements. Approximately 10 percent of the state's weight enforcement full-time equivalents (FTEs) (4 out of 42 total FTEs) would be available for redeployment. These FTEs could then be assigned to other enforcement operations (i.e, to obtain full 24-hour operation at other stations or for enhanced portable enforcement) thereby increasing the number of trucks weighed with the same manpower. Another alternative would be to eliminate these positions. However, given North Dakota's current inadequate staffing levels and ineffective enforcement strategies, this is not be a recommended action.

Innovative deployment of selected technologies and enforcement agent freedom could provide substantial additional benefits to North Dakota. For example, an enforcement official stationed at an existing fixed station could monitor several remote sites. These remote sites could at a minimum monitor the weight of vehicles passing and, if properly equipped, could collect all of the credentials from vehicles whose identification could be ascertained (either visually through video equipment or electronically from VRC). Even if credential information cannot be enforced, North Dakota would greatly benefit from increased weight compliance on routes where enforcement is currently non-existent. When a non-compliant vehicle is detected at the remote site, the enforcement official could personally apprehend the violator or dispatch a roving agent (e.g., certified state trooper currently in the area or one of the re-deployed FTEs). This scenario greatly increases the productivity of North Dakota's enforcement personnel.

North Dakota will also benefit from increased enforcement agent morale. Operational changes allowing enforcement agents at fixed stations to interface directly with the computer for data entry has

proven to significantly reduce sick leave among weigh station employees.[73] These employees will be able to make a larger contribution to successful weight enforcement in North Dakota. Furthermore, additional information provided by electronic clearance to enforcement agents will greatly improve the accuracy of their decisions and provide them added satisfaction from making better decisions.

Data Collection

North Dakota currently collects very limited data from its weight enforcement activities. These data are primarily collected to conform with the federal government's requirements on state weight enforcement activities. This information is usually limited to the number of vehicles weighed and the type of scale used. Other states may record the vehicle's identification number, weight, and commodity transported. This information would be extremely valuable to policy makers as well as to transportation planners. This data would greatly improve forecasts about transportation demand, and would thereby, improve pavement maintenance management.

Electronic clearance enables the collection of data desired without the burden, accuracy problems, and lack of comprehensiveness of current collection methods (e.g., surveys). Furthermore, the dimension of the data that can be collected through electronic clearance is enormous. For example, type of operation and commodities hauled data could be easily integrated over time with weight and frequency data to determine the evolution of an area's transportation system. This would have allowed North Dakota to recognize the impact of changes in the grain industry on its highway system.

In addition to new data being accessible, existing data collection processes would be improved. Currently collected data can be automatically entered into the computer, eliminating key punch errors and allowing easier manipulation for various reporting needs. Access to the data would also be enhanced, allowing more users to access data faster.

Enforcement Effectiveness

Enforcement effectiveness ensures compliance with regulations. Compliance, the ultimate measure of enforcement effectiveness, can be obtained either through apprehension or deterrence. Apprehension requires physical interaction between the enforcement agency and the violator. Deterrence is a much more elusive concept and as such is more difficult to evaluate. Simply, deterrence is achieving compliance out of fear of apprehension. Many transportation officials purport that fixed stations are necessary simply for their deterrent value. Given the costs of fixed stations to both states and industry and the lack of data on their deterrent effect, this argument is highly speculative and controversial.

North Dakota's current fixed station weight enforcement strategy may suffice for the federal government's requirement for proof of compliance. However, the locations of all 10 stations result in a disproportionate enforcement burden placed on interstate traffic. However, interstate traffic has a lower risk of being overweight. The probability that an overweight interstate vehicle, which has crossed several state lines on predictable and heavily traveled routes, will enter North Dakota is small. The changes in truck traffic that have become apparent in recent years in North Dakota further contribute to an ineffective enforcement situation. A growing portion of truck traffic in North Dakota appears to be intrastate, traveling on low-volume roads rather than on Interstate and Primary Highways. The lack of enforcement on these non-traditional routes indicates that determinants of compliance, apprehension and deterrence, are being ignored. Automating existing enforcement facilities would allow the redeployment of four full-time equivalents to enforce weight regulations on these routes. It would logically follow, then, that the deterrent effect would increase as well.

The enforcement of government regulations must constantly address the issues of fairness and equity. Weight enforcement is no different. To be equitable, all commercial vehicles should have an equal probability of being subjected to weight enforcement activities. Governments have a moral obligation to increase the fairness and equity of their actions. From a pragmatic standpoint, North

Dakota should increase its enforcement on vehicle inspections on intrastate vehicle routes as they are as likely, if not more, to operate overweight. Furthermore, the damage caused by overweight trucks on secondary roads is exponentially greater than the comparative damage they would cause to Interstate highways.

Improved Quality of Service

Enforcement agencies need to discover that cooperation and less adversarial relationships may lead to more successful attainment of their objectives. Electronic clearance can facilitate North Dakota's service quality, reducing the adversarial relationship and improving compliance. As service quality improves, taxpayers will receive more value for their financial contributions. This is especially true for the relatively small number of truck firms that pay a substantial amount of highway user fees.

Improved Safety

Enforcement officials will be able to improve the safety of North Dakota's highways with the deployment of electronic clearance. It is difficult to ensure that unsafe vehicles (i.e., those placed out of service during a safety inspection) will remain off the highways until their safety violations are corrected. Electronic clearance would allow safety information to be presented to enforcement agents at upcoming roadside locations along the vehicle's route, so the vehicle could be identified and apprehended if the violation is still valid.

Safety inspection officials could utilize electronic clearance in their vehicle selection process. This would enable inspectors to bypass those trucks that appear to present lower risk for accidents and concentrate their limited resources on trucks where the greatest improvements in safety could be achieved. Not only would this increase the number of high-risk trucks inspected, but it also would economically encourage trucking firms to operate safely. These firms would be able to decrease their probability of being subjected to a random inspection (provided their safety information continued to

indicate that they are a low safety risk) and therefore decrease the enforcement cost burden on safe vehicles.

Projected Costs

The deployment of electronic clearance in North Dakota will require substantial investment. Furthermore, benefits which are real and substantial, but difficult to quantify, are difficult to justify during the funding process. In this project, the costs of implementing electronic clearance in North Dakota will be identified. The costs of data communication, software, and pavement rehabilitation necessary to install electronic clearance will not be included in the analysis.

The costs associated with electronic clearance are predominantly equipment or capital expenditures. This means a large financial commitment must be incurred in the short-run while the benefits are incremental over a relatively long period of time. The annualized cost of implementing electronic clearance has been determined by using an investment life of five years. Although this may not seem like a long time, and in relation to the life of the equipment it may not be, the rapid rate of technological change and advancement justifies an accelerated useful life. Table 14 summarizes the costs of implementing electronic clearance in North Dakota.

Table 14. Estimated costs of implementing a site capable of electronic clearance in North Dakota

Category	Item	Total Cost ($)
Scale	Mainline WIM	$100,000
Advanced Vehicle Identification	Reader at Mainline WIM	15,000
	Reader at Scalehouse	15,000
	Reader/Camera after Scalehouse	15,000
Installation	Cabling/Conduit/Power	100,000
	Pavement Reconditioning[a] 100 feet before & 50 feet after WIM	
Data Processing	Personal Computer	5,000
	Software[b]	
	Data Communications[b]	
Total		$250,000
Annualized Cost[c]		$65,950

[a] Although pavement rehabilitation expenses required for the installation of electronic clearance will be substantial, estimating the costs directly resulting from this implementation is beyond the scope of this analysis.

[b] Software and data communications expenses will depend considerably upon the system architecture chosen and the market for providing electronic clearance data services.

[c] A discount rate of 10 percent and five year useful life were assumed when determining the annual cost.

Summary

Installation of electronic clearance at all 10 of North Dakota's fixed weight enforcement facilities appears to be cost prohibitive. Although North Dakota had $144 million in fiscal 1992 to spend on highway construction and maintenance activities, North Dakota has more road miles per capita than any other state in the nation, and 31 percent of the state's highways are older than their designed life, and 42 percent are classified as in fair to poor condition.[74] All available resources are needed to support this existing infrastructure. Funding for implementation of electronic clearance must show considerable

financial benefits to the state in order to justify diverting funds away from basic infrastructure maintenance.

Electronic clearance would definitely benefit North Dakota. However, in the short-run it will be difficult for North Dakota to decide if the benefits outweigh the costs, which include forgoing infrastructure maintenance. The two largest financial benefits that North Dakota would receive from electronic clearance are 1) reduction in system labor requirements and 2) enhanced enforcement effectiveness and the corresponding reduction in pavement damage.

This research has estimated that North Dakota could reduce the system labor requirements for weight enforcement by four FTEs. This reduction is not uniformly distributed over all existing facilities. Instead, three FTEs would be eliminated from the Fargo facility and one FTE from the Beach facility. In other words, implementation of electronic clearance at these two facilities would provide the same benefit to North Dakota as implementation at all 10 facilities, in terms of total system labor requirements. The second major benefit, improved enforcement, is difficult to estimate as it depends entirely upon what the state does with the extra FTEs that electronic clearance generates. If electronic clearance simply replaces and automates existing enforcement levels, there will be no benefit derived from improved enforcement (i.e., every truck that passes the scale is already weighed, so electronic clearance will not result in more trucks being weighed). If, however, the FTEs freed-up by electronic clearance are reassigned to other stations, which could then operate a full 24-hour shift, or if they are deployed to an expanded remote and random operation, there is no doubt that effectiveness will increase.

North Dakota could implement electronic clearance at Beach and Fargo for approximately $132,000 per year (for five years). The question then becomes, will the four full-time equivalents made available for redeployment be effective in reducing pavement damage throughout the state by at least this amount. That is a question North Dakota's policy makers will ultimately have to make. However, in light of the state's traffic patterns, vast road network, relatively ineffective current enforcement efforts,

and the relative magnitude of pavement rehabilitation expenditures, it would seem logical that North Dakota could recoup this limited investment in electronic clearance.

RECOMMENDED RESEARCH

In completing this project, a lack of research into several aspects of commercial vehicle regulation became apparent. Three primary areas that need further research are the cost to states of enforcing regulations, the optimal level of enforcement expenditures (considering that increasing investments in enforcement ultimately lead to a diminishing increase in benefits such as reductions in pavement damage), and the viability of alternative mechanisms to achieve similar benefit levels at less cost. Technology is currently being touted as the way to correct problems in commercial vehicle regulation. However, technological solutions will not fix the underlying causes of problems. Technology will only mask or hide problems by making the process more efficient or even transparent.

Federal, state, and local governments regulate commercial vehicles for three reasons: to maintain safety on the highway, to generate revenue to construct and maintain the highway infrastructure, and to accomplish various socioeconomic goals as discussed earlier in this paper. For the most part, the federal government has removed itself from socioeconomic regulation, allowing the marketplace to work more freely. Most states, however, have maintained a system of economic regulation to accomplish unique socioeconomic goals applicable to their intrastate traffic. The majority of current regulatory activities, and those that impact interstate commerce, are primarily confined to safety and revenue generation.

The federal government has both an interest and a regulatory obligation to not only ensure that safety and revenue objectives are addressed, but that regulations established to accomplish these objectives are efficient and effective. This justifies the federal government's involvement in initiatives that potentially solve current regulatory problems. One such initiative is the Intelligent Vehicle/Highway Systems for Commercial Vehicle Operations (IVHS-CVO) program.

Through IVHS-CVO, the federal government is coordinating cooperation among government agencies and private industry to address problems of enforcing and complying with current regulations. However, instead of masking the inherent inefficiencies that result from enforcing or complying with

poor regulations, attention should be devoted to developing better regulations. Given the political basis of regulatory activity in the United States, this may be too idealistic notion, and, in that sense, it is appropriate to pursue the IVHS-CVO initiative feverishly. Furthermore, IVHS-CVO has the potential to enhance the achievement of regulatory objectives through evolution (i.e., technology could facilitate regulatory evolution by eliminating, in effect, the problems of current regulations and allowing better regulations to take their place).

Additional research in the IVHS-CVO program is necessary. There are three aspects that need to be given considerable attention: marketing, integration, and value. Marketing IVHS-CVO to the non-homogeneous trucking industry whose firms are not uniformly impacted by current regulatory activities will be difficult. True customers of various IVHS-CVO services must be identified. Integrating the entire IVHS program, which encompasses many concepts including CVO, will be difficult. Developing technological and operational standards is only a part of what needs to take place for complete integration. Research should address the value actually derived by the user of a given service, and how best to quantify this value as well as to determine how significant or valid it is.

Implementing IVHS-CVO by government agencies will be difficult. An assessment of alternative mechanisms to ensure that a majority of states participate in compatible IVHS-CVO services must be developed. This research needs to address the concerns of different states (e.g., some states are concerned about adequately enforcing their regulations, others are concerned about the revenue generated from regulatory requirements, and still others are genuinely concerned about truck safety or some other regulatory objective) as well as how best to ensure nationwide service and compatibility. This analysis needs also to consider the impact of government involvement in the trucking industry.

Finally, research must continually address the basis of governmental involvement in the trucking industry. Societal goals, as well as the alternative mechanisms to achieve them, must be continually

evaluated. Government must recognize the dynamic forces of socioeconomic changes and facilitate economic prosperity and competitiveness in the world economy.

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