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16. Abstract

This research evaluated truck lane restrictions in Texas and further developed guidelines for future implementations on the freeway system. The truck lane restrictions on the I-10 East Freeway in Houston have had a long-term (since September 2000) impact in reducing crashes during peak traffic periods. Although vehicle restrictions may not be necessary on all freeways, the restrictions should be implemented 1) if the guidelines are met, 2) if it is the opinion of the local traffic engineers that crashes may be reduced, 3) if commitment of local law enforcement has been assured, and 4) if there are no diverse impacts to truck movement and commerce in terms of goods movement.

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# MONITORING OF TEXAS VEHICLE LANE RESTRICTIONS

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The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the Federal Highway Administration (FHWA) or the Texas Department of Transportation (TxDOT). This report does not constitute a standard, specification, or regulation. The engineer in charge was Darrell W. Borchardt, P.E., (Texas # 62074).

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# 1.0 INTRODUCTION

The purpose of this project is to complete a detailed evaluation of vehicle lane restrictions on Texas roadways. In 1997, the 75th Texas State Legislature created Section 545.0651 of the State Transportation Code, which allows a municipality to create an ordinance that would restrict traffic, by class of vehicle, to two designated lanes of a highway within the jurisdiction of that municipality. A demonstration project was implemented in September 2000 on the I-10 East Freeway in Houston that restricted vehicles with three or more axles from the left lane between the hours of 6:00 a.m. to 8:00 p.m. on weekdays. The initial success of that project increased the awareness of this legislation and the potential long-term benefits for traffic safety. The cities of Houston, Pasadena, Deer Park, and LaPorte worked together on implementing a similar restriction on the SH 225 LaPorte Freeway that began in March 2003. The restriction on the I-45 North Freeway was also implemented in April 2004 in Houston. Similar restrictions were implemented on I-10 East and US 90 West in the City of San Antonio in April 2004. Several municipalities along the I-35 corridor in the Austin and Waco areas are also considering lane restrictions geared to trucks. Although the initial project in the Houston District on the I-10 East Freeway was determined to be successful at the end of a nine-month evaluation period, the long-term benefits and impacts of the restriction have not been determined. Research is needed to evaluate the vehicle lane restriction over a longer time period in terms of benefits, traffic impacts, enforcement, compliance, expansion of the restrictions to rural areas, and other issues as well. A comparison of the restrictions within Texas with those in adjacent states is also in order to determine continuity in traffic laws.

## STUDY GOALS AND METHODOLOGY

This project examines the following issues:

- What are the operational and safety impacts with respect to vehicle (specifically heavy trucks) lane restrictions within Texas?
- Is there any information from similar restrictions in other states that could be beneficial for application in Texas?
- What have been the successes of truck lane restrictions implemented in Texas?

The project work tasks are as follows:

### Task 1. Literature Review

A comprehensive literature search will be conducted to identify publications on lane restrictions, exclusive lane strategies, countermeasures, and guidelines that are being used to address issues related to vehicle lane restrictions.

### Task 2. Identify Texas Issues

This task will identify and document specific issues with regards to vehicle lane restrictions within the State of Texas.

**Task 3. Develop a Profile of Views on Truck Lane Restrictions and Issues from Other States and Industry**

The research team will conduct telephone interviews of state DOT and industry sources regarding truck lane restrictions, as well as gather other information for a survey of state practices. Researchers envision that the initial telephone contact will be general in nature and centered on states identified by the literature review as those most likely to have useful data. The traffic engineering or safety divisions of each state transportation agency will be the source of this initial contact. The basic question to be asked:

*"Has your state used any type of truck lane countermeasure, for example, lane restrictions, either at a point or along a freeway segment, in an attempt to improve traffic flow, traffic safety, increase roadway structural longevity, and/or decrease long term maintenance costs?"*

**Task 4. Determine the Effect of Enforcement on Safety**

In this task, the Texas Transportation Institute (TTI) researchers will isolate the effects of enforcement when combined with lane restrictions. Assuming there will be support from the law enforcement community, TTI will conduct a before-after experiment, and TTI proposes to use the same segment of freeway for the "before" and "after" scenarios. This experiment will compare: (1) lane restrictions with typical enforcement levels, and (2) lane restrictions and increased enforcement levels. Obviously, the location will depend on the availability of increased enforcement levels. The experimental design will determine the length of time each treatment will remain in place based on the specifics of the selected roadway.

**Task 5. Monitor and Evaluate Implemented Lane Restrictions**

In order to begin evaluating the long-term impacts of vehicle lane restrictions, the current deployed projects in Texas should be evaluated and monitored.

# 2.0 LITERATURE REVIEW

## INTRODUCTION

Large trucks are the principal means for moving goods in urban areas, and the number of trucks in the traffic stream is anticipated to increase with the full implementation of the North American Free Trade Agreement (NAFTA). The role of large trucks is vital to the nation's economy; however, the public perceives that the presence of large trucks has a significant impact on road safety.

The differential in size and operating characteristics between trucks and passenger cars creates an intimidating psychological barrier, if not an actual barrier. Trucks have slower braking and acceleration rates than passenger cars, which increase frustration to drivers in congested situations. Additionally, the lack of maneuverability of trucks relative to passenger cars contributes to crashes *(1)*. Due to the large size and weight of trucks, truck crashes generally result in more severe injuries than crashes that do not involve trucks. Truck crashes also receive greater publicity.

The issue of increasing truck traffic is of vital concern to both traffic managers and the general public. Highway traffic operations are the "yardstick" by which the user measures the quality of the facility. The characteristics that matter most to the driver are: safety, speed of travel, comfort, and convenience. As a result of increasing demand on highways, a variety of strategies or countermeasures for trucks have been implemented in an attempt to mitigate the effects of increasing truck traffic. Some of the most common strategies considered are: lane restrictions, time-of-day restrictions, peak period bans, route restrictions, exclusive truck facilities, separation and bypass facilities, and dual facilities. The following sections discuss these operational strategies, feasibility studies, current and past implementation efforts, along with various issues of concern surrounding their implementation.

## TRUCK OPERATIONAL STRATEGIES

### Lane Restrictions

Lane restrictions are a management strategy that limit certain types of vehicles to specified lanes. These restrictions can take the form of time-of-day restrictions, peak period bans, or route restrictions. The most common type of lane restriction addresses truck traffic. A large presence of trucks, both in rural and urban areas, can degrade the speed, comfort, and convenience experienced by passenger car drivers. Some states, to minimize these safety and operational effects, have implemented truck lane restrictions or have designated exclusive truck lane facilities. In 1986, the Federal Highway Administration (FHWA) asked its division offices to conduct a survey and report on experiences encountered by states with lane restrictions. This survey indicated a total of 26 states used lane restrictions. The most common reasons for implementing lane restrictions were:

- improve highway operations (14 states),
- reduce accidents (eight states),

- pavement structural considerations (seven states), and
- restrictions in construction zones (seven states).

It should be noted that some states provided more than one reason for the restriction (*2*).

*Capital Beltway Lane Restriction*

The Virginia Department of Transportation (VDOT) instituted a lane restriction for trucks in December 1984 on a section of I-95 that is part of the Washington, D.C., Capital Beltway. The section is in the southeast quadrant of the Beltway between I-395 and the Woodrow Wilson Bridge (near the Virginia State line). The restriction, which initially was implemented jointly with the State of Maryland, was an attempt to reduce crashes on the Capital Beltway. Following an initial trial period using lane restrictions on its portion of the Capital Beltway, Maryland chose to remove the lane restriction due to a lack of clear evidence of improvement.

*Puget Sound Lane Restriction (Inside Lane Light Vehicle Only, Non-Barrier Separated)*

Mannering, Koehne, and Araucto conducted a study in the Puget Sound region that considered lane restrictions as a means of increasing roadway capacity, improving highway operations, improving the level of roadway safety, and encouraging uniform pavement wear across lanes (*3*). The study region has a truck volume of approximately 5 percent of the total traffic volume. The study consisted of a literature review, an in-depth analysis of the effects of restrictions at a specific site, a site comparison analysis to determine if there was enough consistency among various sites to apply the results of the in-depth analysis to other areas, and surveys of motorists to determine the level of awareness and opinions of the driving public about the lane restrictions.

The literature review revealed that although a number of states had instituted truck lane restrictions, very few states had documented the effects of the restriction. In nearly every instance where a comprehensive examination of a lane restriction implementation occurred, negligible changes in operations and safety were observed (*3*).

The in-depth analysis by the research team examined traffic composition, traffic flow characteristics, safety, enforcement issues, economic impacts, and pavement deterioration. The analysis revealed no significant operational or safety level increases that could be attributed to the restriction. The safety portion of the analysis did reveal that the number of truck-related crashes for each lane were proportional to the number of trucks traveling in that lane. The portion of the in-depth analysis that addressed enforcement issues focused on violation rates. Researchers found that the violation rate for trucks during the restriction was 2.1 percent, which was the same as the proportion of trucks in that lane prior to the restriction. Therefore, the restriction had no noticeable impact on the distribution of the trucks. Researchers also found that the economic impact of the restrictions was minor for motor carriers, and there was only a minimal impact on pavement life. The authors recommended that truck lane restrictions not be implemented in the Puget Sound area (*3*).

## Exclusive Truck Lanes

The operational strategy of exclusive truck lanes provides certain vehicles, usually designated by vehicle type, an exclusive operational lane. Typically, trucks are separated in an attempt to decrease the effects of trucks on safety and reduce conflicts. They are separated from passenger car traffic by operational lanes rather than by a physical barrier.

### *Operational and Geometric Analysis of Truck Exclusive Lanes*

Mason et al. (*4*) described seven types of truck lane configurations in a study performed in 1985. All of these lanes could be constructed within an existing right-of-way. The first truck lane, designated as M-1A, is a minimum median truck lane. Trucks use 12-ft inside lanes that have a 5-ft inside shoulder, while other vehicles utilize the outside lanes. Lanes for trucks and cars are not barrier separated. The second truck lane, designated M-1B, is a desirable median truck lane. The configuration is the same for the M-1A truck lane, with the exception of 10- to 12-ft inside shoulders. The third truck lane, known as M-2, is an outside truck lane. Trucks travel on 12-ft outside lanes that have 12-ft shoulders. These lanes are not barrier separated from the inside car lanes. The fourth type of configuration is the M-3 truck lane that is a four-lane truck facility. Trucks travel on two 12-ft inside lanes that have 5-ft inside shoulders. The trucks are not barrier separated from the outside car lanes. The fifth type of facility is the M-4, which is an inside 12-ft truck lane that has a 10-ft inside shoulder and a depressed median. The truck lane is not barrier separated from the car lanes. The sixth type of configuration is the M-5 protected truck lane with a passing lane. Trucks travel on 12-ft lanes that have a 4-ft inside shoulder and a 10-ft outside shoulder. This facility is barrier separated from the outside car lanes. The final configuration is the M-6 elevated truck lanes. Trucks travel on two 12-ft lanes that have a 4-ft inside (left) shoulder and a 10-ft outside (right) shoulder. This facility is elevated above the passenger car lanes (*4*).

The authors then developed and applied a moving analysis computer program to determine the feasibility for each of the seven truck facilities. The program utilized volume-to-capacity ratios and effective median width as its two major parameters. The authors cited advantages and disadvantages for each of the seven configurations (*4*).

### *EVFS Computer Program*

In a 1990 FHWA study, Janson and Rathi (*5*) examined the feasibility of designating exclusive lanes for vehicles by type. This study, which ultimately resulted in a computer program known as exclusive vehicle facilities (EVFS), evaluated exclusive lane use feasibility by utilizing the following lane-use possibilities:

- mixed vehicle lanes – lanes utilized by all vehicles;
- light vehicle lanes – lanes utilized only by motorcycles, automobiles, pickup trucks, light vans, buses, and trucks weighing less than 10,000 pounds; and
- heavy vehicle lanes – lanes utilized only by single unit trucks weighing more than 10,000 pounds and all combination vehicles.

The authors designed an analysis format that could evaluate the economic feasibility of exclusive lanes for specific sites on high-volume, limited access highways in both urban and rural areas. In order for a highway to be considered, three or more lanes in one direction must be available. The format of the program considered potential benefits and costs, including travel time savings, vehicle operating cost savings, reduced crash costs, travel delay savings, initial construction costs, right-of-way costs, pavement resurfacing costs, and maintenance costs. The program then calculated net present worth, benefit-cost ratio, and other facility performance measures. The design resulted in five possible options, with three options employing designated lane usage or vehicle facility alternatives.

- Option 1: Do nothing.
- Option 2: Designate existing lanes for mixed, light, and heavy vehicles.
- Option 3: Add mixed vehicle lanes.
- Option 4: Add non-barrier-separated lanes and designate the usage for both new and existing lanes.
- Option 5: Add barrier-separated lanes and designate usage for both new and existing lanes (*5*).

Janson and Rathi found that exclusive barrier-separated facilities were most plausible for congested highways where three factors exist. The three factors that warrant a barrier-separated facility are: truck volumes exceed 30 percent of the vehicle mix, peak-hour volumes exceed 1800 vehicles per lane-hour, and off-peak volumes exceed 1200 vehicles per lane-hour (*5*).

*Virginia Evaluation of EVFS*

In 1996 and 1997, a series of studies (*6, 7, 8*) investigated the separation of truck traffic through the use of exclusive facilities. In May 1996, Vidunas and Hoel (*6*) evaluated the strengths and weaknesses of the EVFS program as an analytic tool for transportation planners. The study applied the program to a 31.5-mi segment of I-81 between Hollins and Christiansburg. The authors concluded that there were four basic exclusive vehicle strategies provided by the EVFS program. Each of the following strategies can be implemented using either a non-barrier-separated or barrier-separated design:

- inside lane: light vehicles only;
- inside lane: heavy vehicles only;
- outside lane: light vehicles only; and
- outside lane: heavy vehicles only.

Vidunas and Hoel found that the EVFS program was a valuable analytic tool that provides transportation planners with useful decision-making information. The authors also noted that the most difficult part of performing an economic evaluation of a strategy, such as exclusive lanes, are accounting for all of the costs and savings that are accrued over the life span of the measure (*6*).

In a concurrent study, Wishart and Hoel (*7*) examined problems with mixed vehicle traffic and the four truck traffic strategies described in the EVFS program. The study considered a number of variables with safety, highway operations, and pavement deterioration being the

dominant factors. The authors found that mixed vehicle travel is associated with higher risk, especially for the occupants of smaller or lighter vehicles, and that one contributing factor for crashes is the difference in operating characteristics of trucks and passenger cars. Wishart and Hoel concluded that when properly implemented, adequately publicized, and sufficiently enforced, truck traffic strategies can effectively increase safety, improve traffic operations, and decrease the pavement deterioration rate on interstate highways. The benefits considered in the study included savings in travel delay, reduced vehicle operations costs, decreased environmental impact from exhaust and fuel consumption, and injury and property damage savings from reduced crashes. Costs included engineering costs, construction costs, right-of-way acquisition costs, signage, enforcement costs, and increased maintenance (*7*).

In a 1997 Virginia Transportation Research Council report, Hoel and Vidunas (*8*) examined the economics of exclusive vehicle facilities defined by the EVFS program. The authors found that although no single factor is predominate; there are a number of factors that contribute to the feasibility of exclusive lanes. These factors include: traffic volume, vehicle mix percentage, crash rate, and maintenance and construction costs. Maintenance and construction costs are given more weight in EVFS than other factors (*8*).

Hoel and Vidunas found that the EVFS program had both strengths and weaknesses in its ability to accurately predict the feasibility of exclusive lanes. The strengths include an ability to analyze a number of alternatives for a variety of conditions, and it is inexpensive. Weaknesses noted are an inability to differentiate between lanes and its unsuitability for evaluating alternatives that use barriers (*8*).

*Feasibility Study of Reserved Capacity Lanes in Washington State*

In 1996, Trowbridge et al. considered the impacts that would occur from providing trucks reserved capacity lanes that are in some cases separate from general traffic (*9*). The authors reference a study by BST Associates in 1991 that found that trucks generally make up less than 5 percent of average daily traffic in urban areas, and note that an undue amount of effort is used devising strategies to restrict and manage this small portion of total traffic (*10*). In lieu of strategies restricting truck traffic, the authors propose providing trucks access to reserve capacity lanes – i.e., high occupancy vehicle (HOV) lanes – in order to relieve congestion.

The reserve capacity lanes investigated consisted of two options for roadways in the Seattle area. The first option permitted heavy trucks to use existing HOV lanes, while the second option added a lane for the exclusive use of trucks on all facilities that had an existing or planned HOV lane. The authors attempted to determine the impacts of these options on vehicle travel time and vehicle miles traveled for single occupancy vehicles (SOVs), HOVs, and trucks. The authors collected traffic data and performed a traffic simulation and an estimate of the economic impacts of this type of strategy. This strategy would provide the following estimated benefits:

- estimated $10 million in savings in truck travel time;
- estimated 2.5 minutes time savings per average trip (this is less than the 9 percent savings of an average trip); and
- estimated $30 million in savings for SOVs (*10*).

Estimated costs would be increased expenses due to pavement deterioration in the reserved capacity lane; however, there would be decreased expenses for pavement deterioration in other lanes. The net effect of this would be a small increase in capital expenditures. Trowbridge et al. had estimated that the overall impact on safety of using reserved capacity would be negligible (*9*).

*Feasibility Study for Urban Truck Lanes in the United Kingdom*

In 1985, the Department of Transport with the Civic Society and County Surveyors' Society commissioned a Lorry Management Study (*11*). The study examined ways to reduce the impact of heavy truck traffic on urban areas and on traffic operations. Four areas were selected: Lancaster/Morecambe, Trafford in Greater Manchester, Worcester, and Elstree/Radlett in Herfordshire. An urban truck lane was proposed for the Lancaster area to enable trucks to avoid a congested shopping area. The truck lane was not implemented due to concerns for pedestrian traffic from a nearby bus station. The study did conclude that in some instances priority truck lanes were a feasible alternative and merit consideration (*12*).

*Southern Netherlands Proposed Truck Lanes (Truck Lanes, Non-Barrier Separated)*

In the Netherlands, a number of strategies are being considered in an attempt to relieve severe congestion and ameliorate increasing pollution in the region. One of the strategies being considered is the creation of a truck lane utilizing existing pavement and infrastructure. In areas with severe congestion and bottlenecks, particularly on roads between Randstad (an economic center in the Netherlands), Germany, and Belgium, truck lanes are seen as potentially helpful in combating congestion. Traffic managers are considering utilizing the paved shoulder on the roadway and restriping the existing roadway to allow four narrow lanes instead of the three existing standard width lanes. Another option being considered is separating through truck traffic from automobile traffic. The truck lanes would be 3.25 m in width, and the car-only lanes would be 3.0 m in width (*12, 13*).

**Exclusive Truck Facilities**

The operational strategy of exclusive truck facilities, like exclusive truck lanes, provides trucks with one or more exclusive operational lanes that are physically separated from the rest of traffic. Typically, trucks are separated in an attempt to decrease the effects of trucks on safety and reduce conflicts by the physical separation of truck traffic from passenger car traffic. Researchers noted that until recently, very few truly exclusive facilities existed, and many of those facilities actually restricted trucks and/or buses to specified lanes and allowed other vehicles to use any lane (*14*).

Theoretically, truck facilities could have positive impacts on noise and air pollution, fuel consumption, and other environmental issues. Creating and maintaining an uninterrupted flow condition for diesel-powered trucks will result in a reduction of emissions and fuel consumption when compared to congested, stop-and-go conditions. However, the creation of a truck facility may also shift truck traffic from more congested parallel roadways, thereby shifting the environmental impacts. There may also be increases in non-truck traffic on automobile lanes due to latent demand. Feasibility studies for exclusive truck lanes have also been conducted in

Virginia, California, the United Kingdom, and the Netherlands. However, to date, none of the proposed exclusive facilities have been implemented (*15*).

*EVFS Computer Program*

As noted previously, feasibility studies regarding restrictions and exclusive lanes found that exclusive barrier-separated facilities were most plausible for congested highways where three factors exist. Janson and Rathi noted that these three factors are: truck volumes exceed 30 percent of the vehicle mix, peak-hour volumes exceed 1800 vehicles per lane-hour, and off-peak volumes exceed 1200 vehicles per lane-hour (*5*).

*Feasibility Study for Houston-Beaumont Corridor*

In 1986, a research study (*16, 17*) by TTI examined the feasibility of an exclusive truck facility for a 75-mi segment of I-10 between Houston and Beaumont. The options considered in the study included the construction of an exclusive truck facility within the existing I-10 right-of-way, construction of an exclusive truck facility immediately adjacent to I-10 outside of the existing right-of-way, or construction of an exclusive facility on, or immediately adjacent to, an existing roadway that parallels I-10 (US 90).

Lamkin and McCasland (*17*) examined the existing traffic conditions, geometric design, land development and usage, truck services and usage, and pavement structures for the exclusive facility alternatives. Benefits and costs of an exclusive truck facility that were considered during the evaluation included: safety, improved capacity and operations, time travel savings, pavement life, construction costs, right-of-way acquisition, conversion costs, and impact to local environment. The authors concluded that existing and future trends in traffic volumes did not warrant an exclusive facility along the I-10 corridor.

*Bologna-Firenze Freeway in Italy (Exclusive Separate Truck Facility)*

The Bologna-Firenze Freeway is an exclusive truck facility that was proposed as a result of concern about increasing traffic flow and congestion and a 40 mph cap on truck speeds. Italian engineers were charged with building the exclusive truck facilities to bypass areas with the greatest congestion problems. The Bologna-Firenze Freeway, a direct link between Northern and Southern Italy, was selected as the initial project (*18*).

The proposed exclusive truck facility, traversing the Appennine Mountains, was built to improve the operating and safety conditions of the Bologna-Firenze Freeway. Freeway management found that the freeway was subjected to irregular traffic flows due to the terrain; that routine maintenance contributed to congestion and effective operations; and that there were high traffic volumes that included a high percentage of trucks. The recommendation for increasing effectiveness of the freeway consisted of constructing a new complementary freeway that would be reserved for heavy vehicles. The exclusive facility, which is a 33-mi section from Barberino del Mugello to Sasso Marconi, was designed with features to reflect the characteristics of trucks and area terrain. These design features included: no sharp curves or undulations that limit sight distance; maximum grade of 2 percent, peak elevation of 490 m; and extensive use of tunnels and bridges to traverse the mountainous terrain. Eighty percent of the truck facility is tunnels and bridges, with one tunnel that is 8000 m in length (*18*). Unfortunately, due to political

and cost considerations, the implementation of the facility as an exclusive truck facility did not occur.

**Separation and Bypass Lanes**

The separation or bypass lane is a treatment for a specific section or segment of roadway. Several areas have successfully used this management strategy that often addresses a roadway segment that has the following characteristics: weaving area, a significant grade, high percentage of truck traffic, and/or congestion. Weaving areas are segments of freeway formed when a diverge area closely follows a merge area. Operationally, weaving areas are of concern because the "crossing" of vehicles creates turbulence in the traffic streams. Trucks limit the visibility and maneuverability of smaller vehicles attempting to enter and exit the freeway system. An indication of the barrier effect is an over-involvement of trucks in weaving area crashes, rear-end collisions, and side collisions. Some studies have shown that this problem may be magnified when a differential speed limit is present (*19, 20*).

*Portland, Oregon Truck Bypass Lanes (Truck Separation Lanes)*

A truck bypass facility exists on a section of northbound I-5 near Portland, Oregon, at the Tigard Street interchange; it is similar to some of the California facilities. The bypass lane requires trucks to stay in the right lane, exit onto a truck roadway, and reenter traffic downstream of the interchange. Passenger cars are also allowed to use the bypass facilities (*21*).

One reason this facility is needed is a significant grade on the mainlanes of I-5. Without the truck roadway, larger vehicles would be forced to climb a grade and then weave across faster moving traffic that is entering the mainlanes from their right. The resulting speed differentials caused by trucks performing these maneuvers created operational as well as safety problems prior to the implementation of the bypass facility. Observations of trucks traveling northbound indicated that nearly every truck uses the truck bypass. There is no before and after crash data for the truck bypass lane. However, Oregon Department of Transportation officials indicated that the removal of the slow-moving trucks from the complex-weaving section has substantially eliminated the operational problems at this site. Truck speeds are now typically 50 mph in the merge area; prior to implementation of the bypass lane, truck speeds were 20 to 25 mph. There were no specific cost data available for construction of the bypass lane (*21*).

*Los Angeles Truck Bypass Lanes (Truck Separation Lanes)*

I-5 north of Los Angeles is a corridor with a very heavy volume of truck traffic. In the 1970s, Caltrans built truck bypass lanes on I-5 near three high-volume interchanges. The lanes were built to physically separate trucks from other traffic and to facilitate weaving maneuvers in the interchange proper. The first truck facility encompasses the section of I-5 that includes the Route 14 and Route 210 interchanges. The other truck facilities are at Route 99 near Grapevine and at the interchange of Route 110 and I-405. Although these facilities were built for trucks to bypass the interchanges, automobiles and other vehicles also use the lanes to avoid the weaving sections (*21*).

Detailed information regarding the construction cost of the bypass lane is scarce. However, the reason cited by Caltrans engineers for building the truck lanes was to reduce

weaving problems. The truck bypass lanes are typically two lanes and have received mixed reviews. Many passenger car drivers use them instead of going through the interchange in order to avoid weaving. Truck drivers would prefer to restrict the bypass lanes to trucks only due to differences in vehicle operating characteristics between the two vehicle classes and because of an apparent lack of understanding by auto drivers of truck operating characteristics (*21*).

*Paris Planned A86 Ring Motorway (Truck Bypass)*

The A86 ring motorway is a tollway built near Paris and is managed by a private toll entity. The plans for the motorway call for the construction of two separate tunnels to bypass Versailles. The Westside tunnel, between Rueil and Bailly, will serve mixed traffic (trucks and cars); the eastside tunnel, between Rueil and Versailles, will be reserved for light vehicles only (*12*). The mixed tunnel will have two lanes, will be slightly shorter than the light vehicle tunnel, and will have standard tunnel dimensions. The cars-only tunnel will consist of two levels (one on top of the other), with three lanes in each direction. According to proposed cross-sections, it will be built with a height of 8 ft 6 inches and lane widths of 10 ft. Construction on the tunnels is underway, but anticipated completion dates were not provided (*22, 23*).

### Dual Facilities

Dual facilities are lane operation strategies that have physically separated inner and outer roadways in each direction. The inner roadway is reserved for light vehicles or cars only, while the outer roadway is open to all vehicles. The New Jersey Turnpike has a 35-mi segment that consists of interior (passenger car) lanes and exterior (truck/bus/car) lanes within the same right-of-way. For 23 mi, the interior and exterior roadways have three lanes in each direction. On the 10-mi section that opened in November 1990, the exterior roadway has two lanes, and the interior roadway has three lanes per direction. Each roadway has 12-ft lanes and shoulders, and the inner and outer roadways are barrier separated. The mix of automobile traffic is approximately 60 percent on the inner roadways and 40 percent on the outer roadways (*22*).

These facilities, referred to as dual-dual segments, were implemented to relieve congestion. Other truck measures that have been implemented on the turnpike are lane restrictions and ramp shoulder improvements. The New Jersey Turnpike Authority (NJTA) was one of the first jurisdictions to impose restrictions for trucks. The restriction implemented in the 1960s does not allow trucks in the left lane of roadways that have three or more lanes by direction. On the dual-dual portion of the turnpike from Interchange 9 to Interchange 14, buses are allowed to use the left lane. The resulting effect is that the left lane becomes a bus lane, with the right lane(s) occupied by trucks. The NJTA rates compliance for truck lane restrictions as high (*19*).

## ISSUES REGARDING IMPLEMENTATION OF STRATEGIES

### Operational Issues

The major goal of transportation systems management is to improve vehicular flow and increase the efficiency of the roadway system. Successful implementation of an operational strategy should result in decreased congestion, increased average travel speeds, increased safety, and reduced travel time (*15, 24*). As previously stated, exclusive lane facilities and lane

restrictions are most often designated for buses and trucks. Agencies must consider a number of operational considerations when implementing this type of operational strategy. Highways are designed for a mix of vehicle types; however, an increased presence of large trucks on a roadway may result in serious degradation of flow quality for the following reasons: trucks are significantly heavier than passenger cars, trucks are considerably longer than other vehicles, and trucks have lower rates of deceleration and acceleration (*25*). In urban areas, the demand on the highway system has grown much more rapidly than the corresponding increases in available capacity. This increase in demand has led to high levels of congestion and an increased awareness for traffic operations. Correspondingly, studies concerning the effect of trucks on highway operations have also increased (*26*).

*Effects of Truck Restrictions in Texas*

In 1990, Zavoina et. al. examined the effects of truck restrictions on rural interstates in Texas (*27*). This study analyzed the operational effects of restricting trucks from the left lane in Texas. Study sites were six-lane rural interstate highway sections with speed limits of 65 mph for automobiles and 60 mph for trucks. Vehicle distributions according to classification, vehicle speeds, and time gaps between vehicles were examined. The study found no definitive safety improvements that could be attributed to the truck restriction. Although the lane distribution of trucks changed significantly due to the restriction, no safety effects were found that could be attributed to the truck restriction in terms of the lane distribution of cars, speeds of either cars or trucks, or the time gaps between vehicles. The authors also concluded that even though truck lane restrictions should theoretically improve the capacity and safety of a roadway, the research evidence did not support this assumption (*27*).

*The European Perspective*

A 1992 study by the Organization for Economic Co-operation and Development (OECD) regarding truck roads examined operational issues regarding dedicated truck lanes and exclusive truck routes. The authors concluded that truck-only lanes appear to be of limited value because they reduce the operational flexibility of the road. Particular problems may arise when trucks attempt to overtake other trucks or where the road is heavily congested and trucks are traveling faster than vehicles in nonexclusive lanes. Another fear is that designating one lane exclusively for trucks would result in the saturation of that lane by trucks, resulting in little or no operational benefit. Conversely, the lane would receive limited use during holidays and weekends when truck traffic is relatively light (*12*). A study conducted in the Netherlands found that the designation of a truck lane is feasible only when truck traffic density is in the range of 600-1000 trucks per hour. Densities lower than this would be inefficient lane usage, whereas higher truck traffic densities would result in bottlenecks (*28*).

*Demonstration of Truck Restrictions in Houston*

In an effort to improve truck safety on Houston freeways, the City of Houston in cooperation with the Texas Department of Transportation (TxDOT) decided to conduct a demonstration project restricting trucks from traveling in the left lane on one freeway. TxDOT and the Texas Transportation Institute developed the demonstration project, which consisted of an 8-mi section of I-10 East Freeway between Waco and Uvalde Streets. The criteria used for site selection included the requirement that the site be a radial freeway section within the city

limits of Houston, the minimum length of the section be 6 mi, and the truck volume be at least 4 percent (*29*). TTI researchers were charged with monitoring and evaluating the restriction for the duration of the demonstration project. In September 2001, the TTI research team published a report that outlined and described the monitoring, evaluation, and findings of the study. The research team monitored the following areas: compliance, enforcement, crash records, freeway operations, public perception, and status of the project. The team reported that compliance rates for the restriction were between 70 and 90 percent. The team also found that vehicle crash rates were reduced during the 36-week monitoring period, although several factors including increased enforcement may have contributed to that reduction. Traffic studies conducted during the evaluation revealed that there was no significant impact on freeway operations, travel time, frequency of lane changes, or traffic patterns. Public opinion was extremely positive, with 90 percent of automobile users in favor of the restriction (*29*).

**Safety Issues**

The concern for highway safety parallels the historic development of the modern U.S. highway system. As the industrial revolution produced motor vehicles in considerable numbers, the demand for roadways increased, and governments at all levels came to realize that roadway financing, construction, and safety were matters for their concern. Safety was given a new focus with the passage of the National Highway Safety Act and the National Traffic and Motor Vehicle Safety Act of 1966. These acts began the development of safety standards and authorities that guide today's transportation manager. As the use of technology increases along with operational concerns such as congestion and increased demand, it is important to remember that safety is paramount. The major safety consideration in implementation of operational strategies can be summed up by the old physician's caution: Primum non nocere, which is loosely translated as "Above all, do no harm."

*Truck Issues in Texas*

In 1984, McCasland and Stokes examined truck traffic characteristics and problems on urban freeways in Texas (*30*). The study evaluated six truck restrictions and regulatory practices through information obtained from a literature review and a survey of state policies. The regulations and restrictions examined included: lane restriction, time-of-day restrictions, speed restrictions, route restrictions, driver licensing and certification programs, and increased enforcement of existing regulations. Results indicated that the restriction of truck traffic to one mixed-flow lane would probably not improve freeway safety or operations based on associated constraints and limitations. The authors also concluded only reduced speed limits for all vehicles, improvement of driver licensing/training, and incident management techniques appear capable of producing any substantial improvement in the safety and operational aspects of truck usage of urban freeways in Texas. However, it should be noted that all assessments and recommendations are based on findings of the literature review and state policy survey (*30*).

One area of particular concern when implementing truck restrictions on urban freeways is the creation of a "barrier effect" in weaving areas. Weaving areas are segments of freeway formed when a diverge area closely follows a merge area. Operationally, weaving areas are of concern because the "crossing" of vehicles creates turbulence in the traffic streams. When trucks are restricted to the rightmost lanes of a freeway and are of significant numbers, a barrier composed of trucks can form in the weaving areas. Trucks limit the visibility and

maneuverability of smaller vehicles attempting to enter and exit the freeway system. An indication of the barrier effect is an over-involvement of trucks in weaving area crashes, rear-end collisions, and side collisions. Some studies have shown that this problem may be magnified when a differential speed limit is present (*19, 30*).

*Capital Beltway Lane Restriction*

The Highway and Traffic Safety Division of VDOT conducted a study of crashes, speeds, and volumes for one year prior to implementation of lane restrictions on I-95. The objective of the before/after study was to assess the impact of the truck restriction on this segment of I-95 by comparing traffic volume, speed, and crash data prior to the restriction with that during the restriction (*2*). Findings indicate that the lane restriction caused a redistribution of trucks in the non-restricted lanes, while passenger vehicles using the left lanes increased slightly. An opinion survey of drivers indicated that the majority of users of the Beltway support a truck-free lane.

The number of crashes along the restricted area of the Beltway remained constant. However, the crash rate declined slightly with the restriction, and there was a 20-percent reduction in injury crash severity. It should be noted that the 20-percent reduction in crash severity is actually only a reduction of injury crashes by eight (41 versus 33). Property-damage-only crashes increased during the time period by nine (60 versus 69). Therefore, the reduction is probably insignificant. The overwhelming public support for the restriction and the perception of the benefits, in conjunction with the slight reduction in crash rates, resulted in a recommendation that the truck lane restriction be maintained (*31*).

Follow-on studies of the Virginia I-95 data continued to evaluate crashes, speeds, and volumes to determine the effects of the restriction (*32, 33*). In 1987, the Traffic Engineering Division of VDOT updated the initial 1985 Capital Beltway study. This update determined that the crash rate increased 13.8 percent during the restriction; however, there was no change in fatal and injury crash severity. Traffic volume increased nearly 8 percent during the time the restriction was in place. The only significant change for the segment was the lane restriction. The crash rate for the section consisting of the I-95, I-495, and I-395 interchange was the primary contributor to the overall crash rate increase. Researchers found that crashes were redistributed by lane of occurrence, type of maneuver, and collision type during the restriction.

Although the data showed an increase in crash rates, the authors noted that there was no change in fatal or injury crash severity. This maintenance of crash severity level along with various intangible benefits such as favorable public perception and continuity of the lane restriction with Maryland, resulted in a recommendation to retain the restriction (*32*).

The Traffic Engineering Division of VDOT issued a final study update in June 1989. This study included the results of a field study of interchange ramps and loop geometry. The field study was conducted to determine if these locations were properly posted with a maximum safe speed for the existing superelevation. Crash frequency and characteristics were then analyzed to determine the interface between drivers, vehicles, and roadway condition. Finally, the study team performed an exploratory evaluation of the Northern Virginia (NOVA) Freeway Management Team (*33*).

An analysis of the data showed that the crash rate increased for trucks on southbound I-95 during the truck lane restriction. The four most prevalent factors in crashes involving trucks were: weather/visibility, vehicle defect, speeding, and road defect. Trucks were involved in 49 percent of the sideswipe collisions and 16 percent of the rear-end collisions. As a result of the increases for two consecutive years, the authors recommended that the truck lane restriction be lifted (*33*).

*Effectiveness of Restrictions in Illinois and Wisconsin*

Hanscom addressed the operational effectiveness of restricting trucks from designated lanes on multilane highways (*34*). His study involved sites near Chicago and in rural Wisconsin. Measures of lane restriction effectiveness included voluntary truck compliance, traffic congestion as determined from speeds and platooning of vehicles following trucks, and an all-vehicle sample of differential speeds between the restricted and adjacent lanes. The author concluded that favorable truck compliance effects were evident at all three locations. However, violation rates were higher at the two-lane site as a result of increased truck concentrations due to the truck restriction. Reduced speeds of impeded vehicles following trucks were also more prominent at the two-lane site. At the three-lane sites, the results of the lane restriction were beneficial traffic flow effects and reduced congestion. No speed changes (between the restricted and adjacent lanes) were observed to indicate an adverse effect of implementing the truck lane restrictions.

*Simulation of Truck Operations*

Garber and Gadiraju used a simulation technique to examine the effects of increased truck operations from implementing different strategies on multilane highways (*35*). The primary study objective was to provide information about the nature and extent of the impact of specified truck traffic control strategies. The strategies included lane restrictions and differential speed limits. The study found that: (1) the combination of lowering the speed limit for trucks and restricting the trucks to the right lane increased the interaction between cars and trucks and therefore, the potential for passenger car/truck crashes; (2) the restriction of trucks to the right lane decreased the vehicular headway in this lane; and (3) the combination of lowering the speed limit for trucks and restricting the trucks to the right lane resulted in a change in the distribution of vehicle spot speeds and a slight, but statistically insignificant, increase of crashes on the right lane.

*Effects of Truck Restrictions on Operations and Safety*

In research sponsored by the Maryland State Highway Administration, Sirisoponsilp and Schonfeld (*19*) in 1988 reported on the strategies used by state highway agencies to restrict trucks from certain lanes and the impact that those restrictions had on traffic operations and safety. The authors concluded that although truck lane restrictions have been imposed by a number of states for many years, the effects of the restrictions on traffic operations and safety are still not well known, and cost effectiveness is uncertain. The goal of restricting truck lane usage appears to have shifted from traffic operations to traffic safety. This shift stems from public perceptions of increased truck-related crashes. Truck lane restrictions have not been accepted as a potential solution to the congestion and crash problem on urban freeways.

*Truck Crashes in Virginia*

In 1989, Garber and Joshua examined large truck crashes on interstate highways in Virginia for the period from 1983 to 1985 (*36*). The following characteristics of truck crashes were documented.

- Thirty-five percent of non-large truck crashes involve one vehicle, while only 22 percent of large truck crashes involve one vehicle.
- Sixty-nine percent of large truck crashes involve two vehicles, and 59 percent of non-large truck crashes involve two vehicles.
- Nine percent of large truck crashes involve three or more vehicles, and 6 percent of non-large truck crashes involve three or more vehicles.

The authors also found that when a large truck is involved in a two vehicle crash, non-large trucks were involved 94 percent of the time. There is a temptation to conclude that this over-representation is due to the high percentage of non-large trucks. Therefore, the analysis used a binomial theorem to compare the actual and expected proportions of crashes based on vehicle-miles traveled. The proportion of non-large trucks involved in two vehicle crashes with large trucks was indeed larger than expected, so safety may be enhanced by reducing interaction between the two vehicle types (*36*).

Garber and Joshua also investigated fatal crashes. They found that, for non-large trucks, 68 percent of the fatal crashes were one-vehicle crashes. However, when large trucks were involved in fatal crashes, there were two vehicles involved in the crash 60 percent of the time. In multiple vehicle crashes involving a large truck, fatalities are 40 times more likely than when the crash involves only non-large vehicles. Garber and Joshua therefore concluded that reducing interactions between the two types of vehicles could enhance safety, and the number of fatal crashes could be reduced (*36*).

**Economic Issues**

In recent years, greater scrutiny has been placed on the economic side of transportation. It has become apparent that transportation facilities must provide acceptable service under the strains of increasing demands while meeting the test of financial prudence and limited funding. Aggressive transportation systems management strategies, such as truck facilities and land restrictions, reduce congestion and delay by as much as 25 percent, if properly implemented. This reduction provides a significant impact on demand that translates into sizable savings (*37*).

*Large Trucks on California Freeways*

Cambridge Systematics, Inc. assessed the impacts of large trucks on freeway congestion in a 1988 study sponsored by the California Department of Transportation (*37*). Sites for the study consisted of Los Angeles, San Francisco, and San Diego. The objectives of the study were to assess the impacts of large trucks on peak-period freeway congestion; evaluate the effects of freeway and traffic management techniques on congestion reduction; and identify the economic impacts of freeway and traffic management techniques. The study found that the volume of large trucks on freeways does not have an inordinate impact on peak period congestion;

however, truck-involved crashes and incidents do have a significant impact on freeway congestion. The four strategies proposed to reduce congestion were a traffic management program, an improved incident management program, night shipping and receiving policies, and peak-period truck bans.

Peak-period truck bans would temporarily reduce congestion on core freeways; however, congestion would correspondingly increase on parallel arterial routes. Although the authors judged that peak-period truck bans would not be legal under the federal Surface Transportation Assistance Act of 1988, possible impacts of bans were examined due to the favorable perception of bans by the media and general public. The study found that the ban, which would cost the Los Angeles study site alone $22 million in direct costs, would improve speeds slightly on freeways, but adjacent surface street speeds would drop. The estimated reduction in total California business sales due to a peak-period ban was $27 million (*37*).

*Exclusive Truck Facilities in Virginia*

When Wishart and Hoel (*7*) investigated exclusive truck facilities in Virginia using EVFS, they described a list of expected benefits and costs. Broad intended benefits of separating truck traffic from automobiles included improved operations, reduced crashes, less severe crashes, and fewer and shorter delays. Other expected benefits are savings from reduced travel delay, reduced vehicle operation cost, decreased environmental impact from exhaust and fuel consumption, and injury and property damage savings. These benefits are offset by expected costs in engineering, construction, additional right-of-way, signage, enforcement, and maintenance (*7*). Researchers noted that although expected costs may outweigh the benefits, many of the costs are one-time costs, whereas the benefits are recurring.

**Legal and Policy Issues**

As previously noted, the tasks of planning, designing, funding, constructing, operating, and enforcing regulations regarding roadways and transportation systems became a governmental responsibility. Policy issues regarding transportation have evolved over the last 50 years as the needs and demands on transportation systems have grown. Legal issues involving truck restrictions often cover such varied topics as access, authority, taxation, enforcement, and free trade. It is important to remember that policy and legislative actions are often the result of reaction to a specific issue or public opinion. The following sections include cases describing legislation, court decisions, and policies resulting from management decisions.

Truck restrictions have been implemented by a number of states in an attempt to increase safety, decrease congestion, and improve operations. The most prevalent form of restriction, by far, is lane restrictions. State transportation officials usually have the authority to implement lane restrictions. In many instances, local jurisdictions have the authority through existing legislation to implement restrictions on state highways.

It should be noted that the Surface Transportation Assistance Act (STAA) in 1982 and Tandem Truck Safety Act (TTSA) in 1984 established a national network of highways as a designated large truck network. The law is insistent that state regulations should not interfere with interstate truck movements, as long as the trucks conform to size and weight limits established by STAA and TTSA (*38*).

In May 1997, the 75th Texas Legislature passed legislation that permits a local municipality to request lane restrictions on certain highways within the municipality's jurisdiction. TxDOT must approve the request for a lane restriction. Specific criteria must be met prior to TxDOT approval of a municipality's request. For example, the highway must be a state-maintained controlled-access facility with at least three through-lanes in each direction, and an engineering study must be conducted by TxDOT to determine the feasibility of the proposed lane restrictions. To comply with this legislation, Jasek et al. developed guidelines to aid TxDOT in the implementation of requested truck lane restrictions in urban areas (*39*).

The guidelines provided TxDOT with the necessary information to evaluate a municipality's request for lane restrictions. Researchers recommended a 12-step process to provide guidance on information related to the proposed lane restrictions that must be contained in the ordinance. The process would include conducting a traffic study, removing/installing the appropriate traffic control devices, and periodically reviewing the lane restrictions to prevent any negative impacts that may result from the lane restrictions. Researchers recommended that TxDOT monitor the extent to which municipalities request truck lane restrictions (*25*).

Problems arise with the 1997 laws. First, only municipalities in Texas have the authority to establish lane restrictions based on vehicle class, and then only during the peak periods of the workday and to only two lanes. The number of lanes can present problems on facilities with more than three through lanes (*39*). Requiring TxDOT to rely on the implementation of this managed lane strategy only at the municipal level, and only during peak travel periods during the workday, reduces the potential benefits of this treatment. Also, Texas has no specific statutes that give TxDOT the authority to establish exclusive truck lanes or facilities for the purposes of alleviating congestion, require trucks to use them, or exclude passenger cars from such lanes or facilities. However, given the potential benefits of such facilities, TxDOT should have the authority to create and operate truck-exclusive facilities and establish restrictions for the purposes of congestion mitigation.

Recent legislation passed by the 78th Texas Legislature in May 2003 broadened the powers of TxDOT and other entities to establish lane restrictions and exclusive lanes. Senate Bill 514 added Section 545.0652 to Subchapter B of Chapter 545 of the Transportation Code to extend this authority to counties in Texas, specifically to restrict through traffic, by vehicle class, to two or more lanes on a highway in the county outside a municipal jurisdiction (*40*). As with the municipal law, it requires TxDOT approval of the restrictions to prevent inconsistent designated lane restrictions between adjacent counties or municipalities.

House Bill 1208 defines exclusive lanes and restricted lanes, and authorizes the Texas Transportation Commission (TTC) to designate one or more lanes on a state highway facility (*41*). The primary reasoning behind this designation is to enhance safety, mobility, or air quality. Also, the law allows for the adjacent lanes or an adjacent multilane facility to be designated as exclusive lanes/facility for the use of vehicles that are prohibited from using the exclusive lane. This bill also authorizes the TTC to restrict, by class of vehicle, through traffic to two or more designated lanes of a highway if that facility has three or more travel lanes in one direction (*41*). If the highway is in a municipality, then the TTC shall consult with the municipality before adopting the restrictions. The law also corrects the problem in the municipal law allowing municipalities to restrict vehicles to two or more lanes rather than just two. Finally, House Bill

3588 allows TxDOT to dedicate one or more lanes of a highway on the Trans-Texas Corridor to the exclusive use of designated classes of vehicles (*42*).

**Environmental Issues**

Environmental issues are concerns for most urban areas. Congestion requires vehicles to move more slowly, thereby worsening noise and pollution levels. Vehicles moving in a free-flow traffic environment generate a minimum amount of exhaust pollution, and fuel consumption is minimized. Traveling the same mileage under congested conditions results in significantly increased pollution levels and fuel consumption.

A study by the OECD examined the impact of truck facilities and truck lanes on the environment (*12*). The environmental issues considered were noise and vibration pollution, fuel consumption, and air pollution. According to this study, the air pollution produced by trucks is quite different from the pollution produced by cars. Trucks are primarily powered by diesel engines that operate with higher air/fuel ratios than the gasoline engines that power most cars. Diesel engines produce less carbon monoxide and unburned hydrocarbons than gasoline engines. However, diesel engines produce more smoke and solid particles due to the rich fuel/air mix than automobile engines. Vehicle emissions and energy consumption increase with traffic congestion and speed variations. Speed variations can increase both emissions and fuel consumption by 25 to 40 percent, whereas traffic congestion can increase emissions and fuel consumption by 50 to 100 percent (*12*).

The European Conference of Ministers of Transport held a special conference on the environment in 1989 (*43*). The reports presented to the conference discussed various concerns regarding environmental damage caused by traffic and traffic congestion. The conference compared the pollution due to trucks versus automobiles. One conclusion reached was that given the current state of traffic, a 10 percent reduction in traffic congestion for trucks would result in a significant decrease in environmental pollution, whereas a 10 percent decrease in traffic congestion for automobiles would be inconsequential (*43*).

**Social and Public Opinion Issues**

Societal and public opinion regarding the implementation of truck restrictions may be the single most important non-operational factor. Unfavorable public opinion can result in either the curtailment or cancellation of projects or provide a preconceived notion of the effectiveness of a strategy that may affect future projects. A marketing strategy and public education campaign are therefore paramount for successful implementation of any managed lane strategy.

The most significant obstacle to exclusive truck facilities may be public opinion. In the reserved capacity feasibility study by Trowbridge et al., an attitudinal study of motorists and the general public examined opinions regarding the use of HOV lanes by trucks. The response by the general public indicated considerable resistance to any strategy that was perceived as a special benefit to truck traffic. However, researchers noted that the general public was favorable to truck lane restrictions. Individual comments included responses (19 percent) that trucks were unable to maintain constant speed or traveled at different speeds. Some individuals (13 percent) viewed trucks as dangerous or unsafe (*9*).

The OECD report on truck roads (*12*) verified that exclusive truck lanes would be unpopular with the general public. Public acceptance of a facility depends on whether individuals find the facility useful. In the case of an exclusive truck road, people living near the facility do not perceive a direct benefit and may oppose the facility. Once again, although public opinion is negative toward exclusive facilities, the public generally favors the restriction of trucks to specific lanes (*12*). This acceptance of restrictions is consistent with public input on the Capital Beltway truck lane restrictions. In this specific case, public opinion was so favorable that lane restrictions were maintained even though there was no indication of improved traffic operations or a reduction of crashes (*12, 32, 33*).

**Project Financing Issues**

As briefly discussed in the Economic Issues section of this report, the costs associated with implementing separate truck facilities can be cost prohibitive. Some entities have used innovative means to finance such projects. The New Jersey Turnpike Authority was created by the New Jersey Legislature in 1948 "…to construct, maintain, repair, and operate Turnpike projects" (*44*). The New Jersey Turnpike consisting of 148 mi of roadway, including the portion that is a dual-dual roadway discussed in a previous section, is a self-supporting operation. Turnpike construction projects are financed through the issuance of bonds. The bonds are repaid by revenue from tolls, turnpike concessions, and investments. No tax dollars have ever been used for turnpike operations (*44*).

A similar method has been successfully used to finance the Bolonga-Firenze, as well as other Italian toll facilities and the Paris Ring Motorway facilities. In Italy, the Societé Autostrada was formed in 1956 to build and manage a toll facility between Milan, Rome, and Naples. Motorway funding was provided by bonds, which were guaranteed by the Italian government. Revenue from tolls and concessions were used to repay the initial costs and maintain the roadway (*45*). The Paris Ring Motorway is similarly financed.

**Enforcement Issues**

Enforcement, as defined in *Webster's New Collegiate Dictionary*, provides five definitions (*46*). The fifth definition, *to carry out effectively <~laws>*, provides the key thought of the role of enforcement for truck operational strategies. Once operational requirements are decided for a truck management strategy, enforcement becomes the means by which the strategy is implemented and effectively carried out (*46*).

Mannering, Koehne, and Araucto conducted a study in the Puget Sound region that considered lane restrictions as a means of increasing roadway capacity, improving highway operations, improving the level of roadway safety, and encouraging uniform pavement wear across lanes (*3*). The study region has a truck volume of approximately 5 percent of the total traffic volume. The portion of the in-depth analysis that addressed enforcement issues focused on violation rates. Researchers found that the violation rate for trucks during the restriction was 2.1 percent, which was the same as the proportion of trucks in that lane prior to the restriction. Increased enforcement did not alter the percentage (*47*).

The truck bypass facility on a section of northbound I-5 near Portland, Oregon, at the Tigard Street interchange requires trucks to stay in the right lane, exit onto a truck roadway, and

reenter traffic downstream of the interchange. Observations of trucks traveling northbound indicated that nearly every truck uses the truck bypass, with little to no need for additional enforcement (*19*).

## SUMMARY

The literature review indicates that many jurisdictions are concerned with increasing truck traffic and its effect on operations and safety. Many types of strategies have been examined for feasibility including exclusive facilities, truck lanes, and lane restrictions. Lane restrictions and exclusive truck lanes that are non-barrier separated from the mainlanes are similar. Feasibility studies regarding restrictions and exclusive lanes found that exclusive facilities were most plausible for congested highways where three factors exist. The three factors that warrant a barrier-separated facility are: truck volumes exceed 30 percent of the vehicle mix, peak hour volumes exceed 1800 vehicles per lane-hour, and off-peak volumes exceed 1200 vehicles per lane-hour (*5*).

The review also found that very few truly exclusive facilities exist. Most facilities restrict trucks and/or buses to specified lanes, but allow other vehicles to use any lane. In almost every instance where restrictions or truck lanes were implemented, there were negligible changes in operations and safety. However, it should be noted that no comprehensive before and after studies have been conducted regarding the implementation of truck lanes or truck restrictions. Consequently, there is little documentation that could be used for a true cost/benefit analysis of the strategy.

Theoretically, truck facilities could have positive impacts on noise and air pollution, fuel consumption, and other environmental issues. Creating and maintaining an uninterrupted flow condition for diesel-powered trucks will result in a reduction of emissions and fuel consumption, when compared to congested, stop-and-go conditions. However, the creation of a truck facility may also shift truck traffic from more congested parallel roadways, thereby shifting the environmental impacts. There may also be increases in non-truck traffic on automobile lanes due to latent demand.

Generally, public opinion is favorable to truck restrictions and unfavorable to exclusive truck facilities or special truck lanes. Public acceptance to any strategy is paramount to successful implementation; therefore, it is important to correctly market any strategy prior to implementation. Presently, research staff have been able to identify 23 states with some degree of truck restrictions (Table 1).

**Table 1. Truck Restrictions by State.**

| State | Restriction |
|---|---|
| Arkansas | Restricts trucks to leftmost lane(s). Voluntary not enforced. |
| California | Restricts trucks to rightmost lane(s). Restricts trucks with 3 or more axles on roadways that have a minimum of 2+ directional lanes. |
| Colorado | Restricts trucks in certain areas to rightmost lane(s). |
| Connecticut | Restricts trucks to rightmost lane(s) on freeways with 3+ directional lanes statewide. |
| Florida | Restricts trucks with 3 or more axles from leftmost lane(s) in certain areas. (Broward and Palm Beach Counties). Operational 7:00 a.m. to 7:00 p.m. |
| Georgia | Restricts trucks to rightmost lane(s) if trucks are allowed by permit to travel within the I-285 perimeter freeway in Atlanta area. |
| Idaho | Restricts trucks in certain locations with minimum of 2+ directional lanes to leftmost lane(s). |
| Illinois | Restricts trucks on facilities with a minimum of 3+ directional lanes to rightmost lane(s). |
| Indiana | Restricts trucks on facilities with minimum of 2+ directional lanes to rightmost lane(s). |
| Kentucky | Restricts trucks with a gross vehicle weight (GVW) of 30,000 lbs to the rightmost lanes on roadways with 3+ directional lanes. |
| Louisiana | Restricts trucks in some areas to rightmost lane(s). |
| Maryland | Restricts trucks in some areas with grades to rightmost lane(s). |
| Massachusetts | Restricts trucks with a GVW of 10,000 lbs in certain areas to rightmost lane(s). |
| Missouri | Restricts trucks on all urban freeways with a minimum of 3+ directional lanes to rightmost lane(s). |
| Nevada | Restricts trucks in certain areas to leftmost lane(s). Voluntary restriction. |
| New Jersey | Restricts trucks with a GVW of 10,000 lbs to rightmost lane(s) on urban freeways with 3+ directional lanes. |
| New York | Restricts trucks with a GVW of 10,000 lbs to rightmost lane(s) on certain urban freeways with 3+ directional lanes. |
| North Carolina | Restricts trucks to leftmost lane(s). |
| Oregon | Restricts trucks with a GVW of 8000 lbs to rightmost lane(s) on urban freeways with 2+ directional lanes. |
| Pennsylvania | Restricts trucks to rightmost lane(s) on grades. |
| Texas | Restricts trucks to two or more lanes on highways with 3+ directional lanes. |
| Virginia | Restricts trucks to rightmost lane(s) on limited access facilities with 2+ directional lanes. |
| Wisconsin | Restricts trucks in certain rural areas to leftmost lane(s). |

# 3.0 TEXAS ISSUES

The major issue in the State of Texas in terms of vehicle lane restrictions is the law with regards to how truck restrictions were originally written, interpreted, and ultimately utilized. The original law was written by the Texas State Legislature in 1997 to address a specific problem in the Dallas area; ironically, the law was never applied to resolve that issue. It was not until 1999, in an effort to improve traffic safety on urban freeways, that City of Houston Councilman Carroll G. Robinson began the process of utilizing the law for the first time. That law was fairly restrictive in that it could only be implemented within the limits of a municipality during peak traffic periods on six-lane urban freeways. The demonstration project on the I-10 East Freeway served as a test-bed for the law, and several short-comings were realized. Specifically, allowing the restriction on freeways with only three truck lanes, allowing only peak traffic period restrictions, and applicability within municipalities limits the freeways in which the law could be applied.

The initial success of the restriction served as a springboard for the 2003 Legislature to revise the law such that it could be implemented consistently on a wider scale throughout the state. Revisions to the transportation code to modify the current law were included in more than one piece of legislation. At the end of the legislative session, the new truck restriction laws were included in House Bill No. 1208, which included several changes to the State Transportation Code. One of these included modifications to Section 545.0651 – Restriction on Use of Highway (Figure 1), which addresses many specific issues to truck lane restrictions in the State. This law allows the Texas Transportation Commission to restrict vehicles on state highways. Specific changes to the law, which made it more flexible to implement, include the following:

- no longer restricted to freeways with only three travel lanes, but can be implemented on freeways with at least three lanes;
- implementation allowed on freeways with an upper and lower deck;
- restriction not required to be applicable in peak periods only, i.e., will allow 24/7 time periods;
- TxDOT and the cities must jointly work on developing the restriction in municipalities; and
- adjacent municipalities should work together to assure a systematic approach.

All of these changes in the legislation provide for a more standard application of the restriction such that it can be more consistently applied throughout different parts of the state. The legislation also developed a law that allows a county commissioner's court to implement similar restrictions on freeways. This legislation is included in the State Transportation Code as Section 545.0652 – County Restriction on Use of Highway (Figure 2) and was also enacted by the 2003 State Legislature. The laws are basically the same, except that the county version does not allow for application on double-decked freeways as the state version does. One of the most important points of the legislation is that both of the laws provide that the municipalities, counties, as well as TxDOT must work together to provide that a systematic approach be applied when developing and implementing vehicle lane restrictions. This will result in consistency in applications of the law.

§ 545.0651. RESTRICTION ON USE OF HIGHWAY.

(a) In this section:

(1) "Commission" means the Texas Transportation Commission.

(1-a)"Department" means the Texas Department of Transportation.

(2) "Highway" means a public highway that:

(A) is in the designated state highway system;

(B) is designated a controlled access facility; and

(C) has a minimum of three travel lanes, excluding access or frontage roads, in each direction of traffic that may be part of a single roadway or may be separate roadways that are constructed as an upper and lower deck.

(b) The commission by order may restrict, by class of vehicle, through traffic to two or more designated lanes of a highway. If the lanes to be restricted by the commission are located within a municipality, the commission shall consult with the municipality before adopting an order under this section. A municipality by ordinance may restrict, by class of vehicle, through traffic to two or more designated lanes of a highway in the municipality.

(c) An order or ordinance under Subsection (b) must allow a restricted vehicle to use any lane of the highway to pass another vehicle and to enter and exit the highway.

(d) Before adopting an ordinance, a municipality shall submit to the department a description of the proposed restriction. The municipality may not enforce the restrictions unless the department's executive director or the executive director's designee has approved the restrictions.

(e) Department approval under Subsection (d) must:

(1) be based on a traffic study performed by the department to evaluate the effect of the proposed restriction; and

(2) to the greatest extent practicable, ensure a systems approach to preclude the designation of inconsistent lane restrictions among adjacent municipalities.

(f) The department's executive director or the executive director's designee may suspend or rescind approval of any restrictions approved under Subsection (d) for one or more of the following reasons:

(1) a change in pavement conditions;

(2) a change in traffic conditions;

(3) a geometric change in roadway configuration;

(4) construction or maintenance activity; or

(5) emergency or incident management.

(g) The department shall erect and maintain official traffic control devices necessary to implement and enforce an order adopted or an ordinance adopted and approved under this section. A restriction approved under this section may not be enforced until the appropriate traffic control devices are in place.

Added by Acts 1997, 75th Leg., ch. 384, § 1, eff. May 28, 1997.
Amended by Acts 2003, 78th Leg., ch. 1049, § 9, eff. June 20, 2003.

Note: Above accessed from http://www.capitol.state.tx.us/statutes/tn.toc.htm - August 30, 2004 *(48)*.

**Figure 1. State Transportation Code – Restriction of Highway.**

§ 545.0652. COUNTY RESTRICTION ON USE OF HIGHWAY.

(a) In this section:

(1) "Department" means the Texas Department of Transportation.

(2) "Highway" means a public roadway that:

(A) is in the designated state highway system;

(B) is designated a controlled access facility; and

(C) has a minimum of three travel lanes, excluding access or frontage roads, in each direction of traffic.

(b) A county commissioners court by order may restrict, by class of vehicle, through traffic to two or more designated lanes of a highway located in the county and outside the jurisdiction of a municipality.

(c) An order under Subsection (b) must allow a restricted vehicle to use any lane of the highway to pass another vehicle and to enter and exit the highway.

(d) Before issuing an order under this section, the commissioners court shall submit to the department a description of the proposed restriction. The commissioners court may not enforce the restrictions unless:

(1) the department's executive director or the executive director's designee has approved the restrictions; and

(2) the appropriate traffic-control devices are in place.

(e) Department approval under Subsection (d) must to the greatest extent practicable ensure a systems approach to preclude the designation of inconsistent lane restrictions among adjacent counties or municipalities.

(f) The department's executive director or the executive director's designee may suspend or rescind approval under this section for one or more of the following reasons:

(1) a change in pavement conditions;

(2) a change in traffic conditions;

(3) a geometric change in roadway configuration;

(4) construction or maintenance activity; or

(5) emergency or incident management.

(g) The department shall erect and maintain official traffic-control devices necessary to implement and enforce an order issued and approved under this section.

Added by Acts 2003, 78th Leg., ch. 846, § 1, eff. Sept. 1, 2003.

Note: Above accessed from http://www.capitol.state.tx.us/statutes/tn.toc.htm - August 30, 2004 (*48*).

**Figure 2. State Transportation Code – County Restriction on Use of Highway.**

Another issue that arose was how to specifically implement the restriction on I-35 through downtown Austin with regards to the upper and lower decks of the freeway. This specific issue was resolved by specific wording in the legislation that provides for summing the number of lanes on both decks in determining if the three-lane minimum requirement is met.

# 4.0 PROFILE OF VIEW FROM OTHER STATES

The TTI research team conducted a survey regarding states' views and experiences on lane restrictions. There have been a number of similar surveys previously conducted in recent years. In 1986, FHWA asked its division offices to conduct a survey and report on experiences encountered by states with lane restrictions. The survey found that a total of 26 states used lane restrictions. The most common reasons for implementing restrictions were:

- improve highway operations (14 states);
- reduce accidents (eight states);
- pavement and structural considerations (seven states);
- restrictions in construction zones (seven states); and
- a combination of the above reasons (55).

In 1997, TTI researchers conducted a survey of practices by states regarding truck restrictions. That survey found that 28 states used restriction in one form or another, while 22 states did not use restrictions. Of the states that did use restrictions, the following comments were noted:

- use on interstate highways (14 states);
- use in work zones (two states);
- use only on non-interstate highways (one state); and
- considering use of restrictions (two states) *(49)*.

This survey also recognized that very little hard data were collected to evaluate the effectiveness of restrictions. Several reports documented restrictions in place in Florida and on the Virginia portion of I-95 *(49)*.

For Research Project 0-4761, the research team compiled a list of state transportation departments as candidates of the telephone interviews. The states selected for contact included: Louisiana, Illinois, Washington, Florida, Georgia, California, Virginia, Maine, Arkansas, and New Jersey. These states were selected because of literature indicating a history of managing lanes through truck restrictions or exclusive truck lanes, their geographical location, and/or the amount of truck traffic associated with highways traversing that particular state. Reviews of the states' web sites were conducted to find the appropriate contact. Most contacts selected were in either the traffic operations or safety office for the DOT. The interviews were general in nature. If the initial questions resulted in a positive response regarding lane restrictions, the contact was then asked a series of questions about the restriction. During both the initial and subsequent contacts, California, Virginia, Arkansas, and New Jersey did not provide responses to the survey. Table 2 provides a summary of the responses for the states that did respond to the survey.

As indicated in Table 2, most states implemented restrictions in an effort to improve operations or safety. All of the states contacted indicated that the restriction had the desired effect on traffic flow. However, only Georgia and Florida are conducting formal studies to determine the effectiveness of the restriction. Reports presenting the findings of these studies should be available in late 2004.

**Table 2. State Survey Responses.**

| State | Usage | Number of Lanes in Each Direction on Restricted Routes | Number of Lanes Truck is Restricted to | Safety or Operational Problems on Route | Criteria | Studies |
|---|---|---|---|---|---|---|
| Louisiana | Specific (Atchafalaya Basin Bridge 17 mi in length) | Two | Trucks are restricted to right lane. | In 2003, Gov. Mike Foster ordered the lowered speed limit and lane limitation after an 18-wheeler smashed into a line of slow-moving cars killing five people. | None Specified. | No |
| Washington | Statewide on I-5 and I-90 | Three except in areas with numerous left exits | Trucks are restricted from the left lane. | Safety issues in Central Puget Sound area. | No specific, Legislation driven. | No |
| Florida | Specific to I-95 and I-75 on a per case study in seven districts | Three | Trucks are restricted to right two lanes. | Safety problems on routes included gapping and weaving, which were alleviated by restrictions. | Implemented on a per case study in seven districts. | Formal studies are being conducted at Florida A&M University and Florida State University, which is expected to be available in 2004. |
| Georgia | Statewide on Interstates and access restricted State Roads (Freeways) | Two | If three lanes or more, trucks are restricted from the leftmost lane. If two lanes, trucks restricted from left lane. | Safety issues including gapping and weaving. | | Study conducted by StreetSmarts. |
| Illinois | Specific to Expressways in the Chicago area | Three | Trucks are restricted to the right two lanes. | Operationally helps to keep traffic flowing at an optimum level. | None. Decision was made to try to improve traffic flow. | No |
| Maine | Specific to Tollway | Two | Trucks are restricted to right lane. | None. | Restrictions were implemented for air quality credits. | No |

# 5.0 DETERMINE THE EFFECTS OF ENFORCEMENT ON SAFETY

## INTRODUCTION

In 2000, the Texas Transportation Institute conducted an evaluation of traffic safety on the I-10 East Freeway in Houston, Texas (*29*). This freeway was the first and, at that time, only freeway in the state where trucks were restricted from using the left lane. Established in July 1999, the Houston Police Department had begun deploying its Truck Enforcement Unit (TEU) to inspect trucks on Houston roadways to ensure compliance with commercial carrier laws. The TEU is a contingent of 28 police officers who are specially trained and certified to conduct commercial truck flatbed and box van, haz-mat, cargo tank, and motorcoach safety inspections; this is specifically geared towards federal regulations. The TEU officers are authorized to inspect 57 items in and on a truck, including inspections underneath the truck and trailer, inside the cab, and inside the trailer (*50*). The mission statement of the TEU is "safe trucks driven safely" (*51*).

The results of the preliminary analysis on the I-10 East Freeway truck restriction indicated a significant improvement in safety through a reduction of vehicle crashes. During much of this time period, there was an increased level of enforcement patrols on the freeway by routine traffic enforcement as well as concentrated levels of TEU presence along the limits of the restriction. The degree to which these increased patrols may have had an impact on driver behavior and compliance is not known. This task of this research project was initiated as an effort to differentiate the beneficial impacts of the truck restriction versus the truck enforcement patrols.

## RESEARCH APPROACH

The research approach is to evaluate crash records for two periods of time on a freeway that has both truck restrictions in the left lane and truck inspections conducted by a certified TEU. During one of these time periods, the truck inspections would be active, i.e., provide an increased level of enforcement. During the other time period, the TEU would not be present, and the freeway would receive only the typical level of enforcement afforded by non-TEU police traffic patrols. The evaluation of the crash records for these time periods would provide an indication of the impact that the elevated enforcement has on freeway traffic safety.

Because of the approximate four-year history of the restriction being in place, the ideal candidate for this task is the I-10 East Freeway in Houston. However, that freeway is presently undergoing reconstruction and is not suitable for study. The SH 225 LaPorte Freeway is not a good choice in that the truck restriction encompasses four municipalities; some of these cities operate TEUs and others do not. The levels of TEU deployment vary on SH 225 in that some operate only very sporadically, while others are deployed on a daily basis. In this latter case, such consistency was not conducive to the experimental design in that there was never a weekday in which the TEU was not active on at least a portion of the freeway. Although segments of I-10 and US 90 in San Antonio have truck lane restrictions, enforcement is not available by a dedicated TEU and are therefore not usable subjects for this research.

The 8-mi section of I-45 North in Houston is the best and arguably only good candidate for this research in that it is the only freeway that has a TEU and a truck restriction law, and it does not suffer from any of the features that kept the other freeways from being the subject of this research.

As described in the work plan, a before-and-after experiment would be conducted, *"assuming there will be sufficient support from the law enforcement community . . ."* As the project was initially developed, it was hoped that research staff would be able to work closely with a law enforcement agency such that a cooperative effort for deploying enforcement could be developed to satisfy the work task. However, it was not possible to be able to work with law enforcement in this capacity. Although a sufficiently meaningful duration for the before-and-after study periods was not made available, the Houston Police Department did aid the efforts of this research in two ways:

- The TEU agreed to provide police accident reports for every crash on the freeway for both the "before" and "after" periods.
- The TEU agreed to deploy their units on I-45 North for a one-week period and deploy it elsewhere, i.e., not on I-45 North, during the other one-week period.

While periods longer than one week were desired, the researchers used the crash data during a time period in which motorists were operating in the presence of a typical level of enforcement and one in which there was an increased level of enforcement to determine if there were significant differences. Specific time periods for which the Houston Police Department TEU provided no enforcement was July 11-17, 2004; the period for the TEU enforcement was July 18-24, 2004.

## FINDINGS AND CONCLUSIONS

During the week in which the TEU was not deployed, crashes were reported at various locations throughout the freeway segment. Table 3 compares characteristics of the crash experiences of the week without the additional truck enforcement with those of the week with the additional truck enforcement. In addition to crash severity (property damage only versus injury), the table lists the number of crashes that occurred during the hours of TEU operation. Specifically, the Houston TEU operates from 6:00 a.m. to 6:00 p.m. on weekdays and from 6:00 a.m. to 2:00 p.m. on weekends.

**Table 3. Crash Summary for I-45 North Enforcement Study.**

| Crashes by Type | Without Truck Enforcement (July 11-17, 2004) | With Truck Enforcement (July 18-24, 2004) |
|---|---|---|
| Injury Crashes | 7 | 8 |
| Property Damage Only Crashes | 7 | 15 |
| Total | 14 | 23 |
| Truck-Involved Crashes | 1 | 2 |
| Crashes during TEU Hours of Operation | 10 | 13 |

In addition to the two truck-involved crashes that occurred during the week with the TEU deployed, there were two additional accident reports that indicated "truck." Narrative information was inconclusive as to whether this term, in these reports, referred to pick-up trucks, i.e., non-trucks for the purposes of this study, or larger commercial trucks.

The results of this comparison indicate that there was an increase in mainlane traffic crashes during the week in which the TEU was deployed on the 8-mi section of I-45 North, relative to the preceding week in which the freeway did not experience the increased level of enforcement.

The overall findings for this task are inconclusive. The time periods for the before-and-after study were much too small to provide a meaningful comparison. In addition, the applicability of only one freeway for this study further limited the ability to achieve any meaningful evaluation of the effectiveness of enforcement on safety.

In addition to the review of the crash records, compliance studies were completed during the same time periods, as well as approximately 30 days later to determine any long-term impacts of the increased enforcement. A compliance count location had previously been established south of Little York on I-45 North. This is near the mid-point of the limits of the truck restriction. The level of compliance compares the number of trucks (in this case, 18-wheeler tractor-trailer type vehicles) using the left restricted lane prior to the restriction compared to the number observed at specific time periods. Table 4 presents the results of the compliance studies completed on I-45 North.

**Table 4. I-45 North Compliance Rates for 18-Wheelers Observed South of Little York.**

| Study Date | Northbound/Inbound | | | Southbound/Outbound | | |
|---|---|---|---|---|---|---|
| | AM Peak | Mid-Day | PM Peak | AM Peak | Mid-Day | PM Peak |
| May 2004 | 88% | 69% | -- | 68% | 76% | 80% |
| July 14, 2004 | 85% | 93% | 61% | 74% | 96% | 91% |
| July15, 2004 | 98% | 85% | 90% | 82% | 71% | 83% |
| July 21, 2004 | 92% | 77% | 73% | 88% | 96% | 84% |
| July 22, 2004 | 96% | 87% | 67% | 74% | 71% | 83% |
| August 19, 2004 | 84% | 91% | 90% | 65% | 84% | 82% |

The average compliance rate across all time periods for each of the study scenarios are as follows:

- 84.1 percent – routine enforcement;
- 82.3 percent – TEU enhanced enforcement; and
- 82.0 percent – routine enforcement (30 days later).

Although the compliance rates do vary among the days and study periods, there are only minimal differences between the study periods. Hence, it can be concluded that different levels of enforcement have limited impact upon truck compliance. The compliance rates are more likely a function of the driver's propensity for obeying the law as opposed to the increased likelihood of being ticketed for violating the ordinance.

# 6.0 MONITORING OF IMPLEMENTED PROJECTS

This project also served as a means to monitor and evaluate truck lane restrictions that were either already operational when the project began as well as those that became operational during the project itself. As the laws that governed the implementation of truck lane restrictions changed during the research project, this proved to be a challenge. On one hand, researchers hoped that many more projects would be operating to provide for a thorough evaluation effort. However, there are concerns about implementing too many projects statewide before more experience in truck restriction operations and impacts could be measured. Therefore, the monitoring of the truck lane restriction operations mostly concentrated in the Houston area. There are other projects operating or planned in the state, as presented in Table 5.

**Table 5. Status of Truck Restriction Lanes in Texas.**

| Location | Description of Restriction | Effective Date |
|---|---|---|
| I-10 East Freeway in Houston District | 8-mi restriction between Waco and Uvalde Streets in the City of Houston | 09/25/2000 |
| SH 225 LaPorte Freeway in Houston District | 14-mi from near Goodyear Street to Sens Road in the Cities of Houston, Pasadena, Deer Park, and LaPorte | 03/28/2003 |
| I-45 North Freeway in Houston District | 8-mi from north of I-610 to Greens Road in the City of Houston | 04/2004 |
| I-10 East in El Paso District | 22-mi from east of SH-20 (North Mesa) to west of FM 659 (North Zaragoza) in the City of El Paso | under study |
| I-35 in Austin District | Within city limits of Austin, Round Rock, and Georgetown | under study |
| US 90 West and I-10 East in San Antonio District | Scheduled to be six-month pilot project, 17-mi in length | 04/01/2004 |

## COMPLIANCE MONITORING

The projects in the Houston urban area were monitored for compliance and traffic operations issues throughout the duration of the research project. The compliance monitoring task is the major focus in terms of evaluating the effectiveness of the restriction. Figure 3 identifies the sections of freeways for which the restrictions are in effect. The portions of the I-10 East and the SH 225 La Porte freeways were implemented under the "old law", hence, the restriction on those roadways is in effect during peak traffic periods only. In those instances, traffic studies have defined the peak traffic periods to be from 6:00 a.m. to 8:00 p.m. on weekdays. The restriction on the I-45 North Freeway was implemented based upon the new laws as passed by the 2003 Texas Legislature; therefore, no peak period designation is required, and the restriction is in effect for 24-hours each day, seven-days per week.

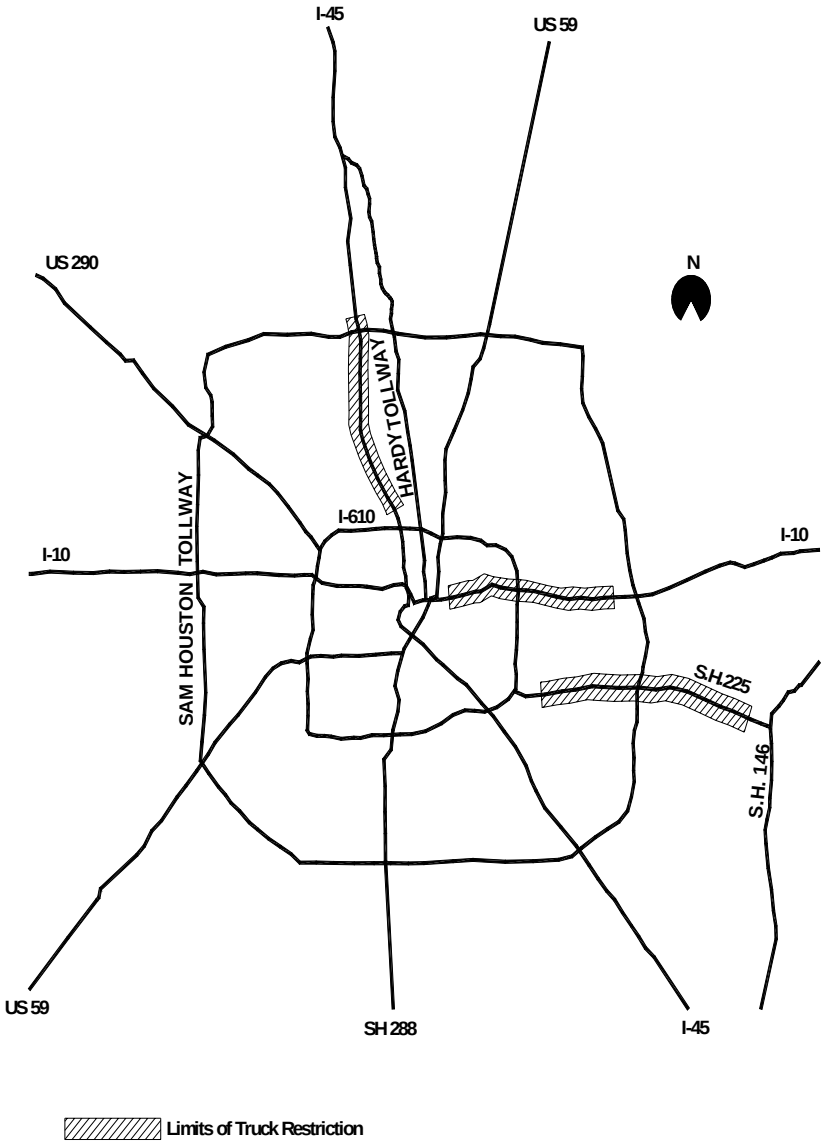


**Figure 3. Current Truck Lane Restrictions in Houston.**

The measure of success of the project that is most commonly used for comparison is the compliance rate. For this project, the compliance rate compares the number of trucks (usually defined as 18-wheelers) using the inside restricted lane prior to the restriction compared to the number observed at various times during the restrictive period. For example, if the "pre-restriction" number of 18-wheelers for a given time period was observed to be 100, and later studies during the restricted period observed 12 18-wheelers in violation, the compliance rate would be reported as 88 percent. Compliance rates in excess of 70 percent are termed as acceptable, while those at 85 percent or higher are desirable and considered as a high-level of compliance. The 85 percent levels should be the benchmark for determining if the project is successful in terms of driver compliance. One should also consider that these studies are completed at a stationary location along the freeway. As the Texas law allows trucks to use the restricted lane to safely pass other vehicles, the compliance rate as reported could be lower than

actual should a "violator" be observed in the left lane while completing a pass. From the observation site of the data collection activities, it is not possible to observe traffic over a longer distance such that it could be determined if the trucks in the left lane were completing a passing maneuver or were using the lane as a travel lane.

As the restriction on the I-10 East Freeway has been in place since 2000, there has been more opportunity for data collection and monitoring over a longer time period. However, roadway construction on the freeway mainlanes in the area of the compliance study site has caused the discontinuance of any additional studies until the construction is completed. A total of 13 studies (Table 6) have been completed on the I-10 East Freeway at Wayside during the morning (6:00 a.m. to 9:00 a.m.), mid-day (11:00 a.m.-1:00 p.m.), and afternoon (3:00 p.m. to 6:00 p.m.) peak periods. The compliance rates have been fairly steady throughout the duration of the monitoring efforts. Although the presence of the construction project along the freeway has curtailed research data collection activities along I-10 East, there are still sufficient traffic lanes to allow for the lane restriction and the enforcement of the ordinance.

**Table 6. I-10 East Compliance Rates for 18-Wheelers Observed at Wayside.**

| Month of Study | Eastbound/Outbound | | | Westbound/Inbound | | |
|---|---|---|---|---|---|---|
| | AM Peak | Mid-Day | PM Peak | AM Peak | Mid-Day | PM Peak |
| October 2000 | 94% | 88% | 82% | 33% | 100% | 74% |
| November 2000 | 94% | 85% | 92% | 78% | 91% | 55% |
| January 2001 | 89% | 100% | 82% | 100% | 88% | 94% |
| March 2001 | 83% | 79% | 75% | 78% | 96% | 90% |
| April 2001 | 100% | 97% | 80% | 83% | 94% | 87% |
| May 2001 | 89% | 88% | 92% | 100% | 100% | 97% |
| June 2001 | 67% | 94% | 100% | 94% | 97% | 94% |
| November 2001 | 94% | 79% | 92% | 61% | 100% | 81% |
| April 2002 | 94% | 100% | 85% | 89% | 96% | 90% |
| November 2002 | 94% | 97% | 88% | 78% | 96% | 90% |
| April 2003 | 89% | 100% | 100% | 94% | 98% | 68% |
| April 2003 (WB PM Only) | -- | -- | -- | -- | -- | 100% |
| October 2003 | 94% | 88% | 85% | 100% | 97% | 94% |
| Average | 90% | 91% | 88% | 82% | 96% | 86% |

Note: Construction activities do not allow for additional studies after October 2003.

Similar studies have been completed on I-45 North (Table 4) and on the SH 225 LaPorte Freeway. As presented in Table 7, the compliance rates for the 18-wheelers as monitored west of Richey on SH 225 are relatively high. The exception is for the morning peak for the westbound direction. This is most likely due to the roadway geometrics in that the three inside lanes are a connector to the southbound direction of the I-610 East Loop Freeway. It is likely that because of high traffic demands and congestion approaching the interchange, some of the trucks are moving to the inside lane while still within the limits of the restriction. The compliance for the eastbound direction exceeds 90 percent for all time periods.

**Table 7. SH 225 Compliance Rates for 18-Wheelers Observed West of Richey.**

| Month of Study | Eastbound/Outbound | | | Westbound/Inbound | | |
|---|---|---|---|---|---|---|
| | AM Peak | Mid-Day | PM Peak | AM Peak | Mid-Day | PM Peak |
| May 2003 | 87% | 91% | 95% | 0% | 63% | 64% |
| October 2003 | 88% | 97% | 94% | 0% | 29% | 77% |
| January 2004 | 93% | 97% | 100% | 93% | 94% | 95% |
| July 2004 | 100% | 97% | 96% | 38% | 94% | 97% |
| Average | 92% | 96% | 96% | 33% | 70% | 83% |

The enforcement of the truck lane restriction has typically concentrated on 18-wheeler tractor-trailer vehicles. In fact, most signing deployed in the field specify "trucks" as the type of vehicles for which the restriction is targeted. The specific law for applying the truck restrictions in Texas (Figure 1) allows for application "by class of vehicle." Restrictions implemented to date in Texas have specified vehicles with three or more axles. However, the enforcement has concentrated on the 18-wheelers (three axle single unit trucks, passenger/commercial vehicles towing a trailer). As there is less enforcement of the left-lane restriction for these classes of vehicles, any compliance could be termed as "voluntary" or more likely just a shift in those classes of vehicles to other lanes. Table 8 presents a comparison of the shift for the single-unit truck and vehicles towing trailers for the studies completed on the I-10 East, SH 225 LaPorte, and I-45 North Freeways in Houston. For the majority of the study periods, there has been a significant shift of these classes of vehicles to other lanes. If greater enforcement was also applied to these classes of vehicles, it is anticipated that more vehicles would vacate the restricted lane.

**Table 8. Comparison of Vehicle Volumes by Class in Left Lane.**

| Freeway/Date | Percentage Change in Volume in Left Lane | | | |
|---|---|---|---|---|
| | Inbound | | Outbound | |
| | Single Units* | Vehicles/Trailer | Single Unit* | Vehicles/Trailer |
| I-10 East at Wayside | | | | |
| October 2000 | -58 | -51 | -37 | -42 |
| November 2000 | -32 | -35 | -49 | -31 |
| January 2001 | -48 | -69 | -69 | -25 |
| March 2001 | -78 | -40 | -76 | 100 |
| April 2001 | -69 | -44 | -83 | -61 |
| May 2001 | -59 | -31 | -87 | -22 |
| June 2001 | -68 | -45 | -72 | -50 |
| November 2001 | -65 | -58 | -82 | -31 |
| April 2002 | -61 | -44 | -72 | -67 |
| November 2002 | -72 | -60 | -83 | -64 |
| April 2003 | -80 | -73 | -85 | -75 |
| October 2003 | -70 | -29 | -66 | -42 |
| SH 225 at Richey | | | | |
| May 2003 | 16 | 15 | -3 | -44 |
| October 2003 | -20 | -4 | -49 | -79 |
| January 2004 | -76 | -85 | -68 | -68 |
| July 2004 | -76 | -67 | -65 | -71 |
| I-45 North at Little York | | | | |
| July 14, 2004 | -37 | 16 | -35 | -17 |
| July 15, 2004 | -39 | 0 | -51 | 1 |
| July 21, 2004 | -32 | 6 | -56 | -58 |
| July 22, 2004 | -25 | 18 | -59 | -24 |
| August 2004 | -24 | 33 | -61 | -14 |

*Single units may include two and three axle vehicles.

## CRASH DATA ANALYSIS

An additional measure of the success of the truck lane restrictions is any change in the crash rates along the freeways with the implemented restrictions. The challenge in completing any analyses of this information is obtaining crash data to do the comparisons. There is an approximate two-year lag in obtaining crash records from the Texas Department of Public Safety (DPS); this is currently being addressed such that the time lag will be significantly reduced through a cooperative project by TxDOT and the DPS. For the truck lane restriction projects in Texas, only the I-10 East Freeway project in Houston has been in effect long enough such that a "before and after" analysis of crash data can be evaluated.

A two-year time period (104 weeks) was assumed for the "before" time period, which translates to the September 25, 1998, to September 24, 2000, time period. The "after" time period used is approximately 15 months (66 weeks) in length, from September 25, 2000, to December 31, 2001–the last day for which crash data is currently available.

Table 9 presents the analysis of the crash data comparing the before and after time periods. Although the percentage decrease is different among the various sections studied, an overall 7 percent decrease in number of crashes has been realized. Comparing the section of freeway adjacent to the restricted limits, the number of crashes has increased by 3 percent over the same time period. Although the rate of decrease is not as high as was realized during the initial study period, and considering that there have been no changes in roadway geometry, it appears that the truck restriction has had a continued impact on safety by reducing the number of crashes along the I-10 East Freeway.

**Table 9. Crash Comparison for I-10 East Freeway.**

| Freeway Section | Length (mi) | Number of Crashes | | | | Percent Change |
|---|---|---|---|---|---|---|
| | | 09/25/1998 to 09/24/2000 | | 09/25/2000 to 12/31/2001 | | |
| | | Total | Per Week | Total | Per Week | |
| Waco to Lathrop | 1.5 | 147 | 1.42 | 74 | 1.12 | -21% |
| Lathrop to I-610 | 2.0 | 163 | 1.57 | 97 | 1.47 | -6% |
| I-610 to Uvalde | 4.5 | 410 | 3.94 | 255 | 3.86 | -2% |
| Total | 8.0 | 720 | 6.92 | 426 | 6.45 | -7% |
| Uvalde to Crosby-Lynchburg | 8.0 | 261 | 2.51 | 171 | 2.59 | +3% |

Notes:
1. 09/25/1998 to 09/24/2000 represents 104 weeks of crash data.
2. 09/25/2000 to 12/31/2001 represents 66 weeks of crash data.
3. Truck restriction not in effect for Uvalde to Crosby-Lynchburg and is evaluated for comparative purposes.
4. Percent change based upon crashes per week statistics.

# 7.0 STUDY RESULTS AND GUIDELINES

The goal of this project was to develop guidelines for implementation of truck lane restrictions in Texas. Researchers completed a literature review, gathered information and experiences from other states, and monitored the truck restriction projects that are already implemented in the state. Specific findings of the research are as follows:

- The implementation of truck lane restrictions during peak traffic periods have had a long-term impact on reducing crashes on the I-10 East Freeway in Houston.
- Based upon the study of enforcement levels and crashes, it is not conclusive if increased enforcement activities have direct impacts to improved safety to freeway operations.
- The truck restrictions in Houston have not had a detrimental impact on freeway speeds or operations.
- Based upon recent surveys of opinions on the I-10 East restriction, the general public continues to see a need for and benefit of the truck restrictions on freeways in Texas.

Preliminary guidelines for implementation of truck lane restrictions in Texas were developed in 2000 and were used to deploy the restriction on the I-10 East Freeway in Houston. Based upon the results of this research, very few changes are needed to the original implementation guidelines. However, researchers point out that the truck restrictions might not be warranted for implementation on all freeways throughout the state. The restrictions should only be implemented if the guidelines as shown below are met, if it is the opinion of the local traffic engineers that crashes may be reduced, and if there are no adverse impacts to truck movement and commerce in terms of goods movement. There must also be a commitment for continued operational impact monitoring of the restriction, especially in areas where truck volumes are increasing at a rate faster than that of the total traffic. It is also recommended that urban areas in Texas complete an overview study of their jurisdiction to determine that for each freeway system such that a plan for implementing (or not implementing) the restrictions in their area can be formulated. An example of a brief overview that was completed for Houston is presented in the Appendix.

In order to not reduce the effectiveness of truck lane restrictions, it is recommended that the following guidelines be used to determine if a truck restriction is warranted on a section of freeway:

- Meet the requirements of Texas Transportation Code Section 545.0651 or 545.0652 as needed.
- Have a minimum of 4 percent total trucks in the traffic stream over a consecutive 24-hour period.
- Approximately 10 percent of the total number of trucks are currently using the lane (most likely left or inside) to be restricted.
- The section of freeway to be restricted should be spaced approximately 1 mi from any entry and/or exit ramps to allow sufficient distance for traffic to access or vacate the lane as needed.
- A minimum continuous length of 6 mi is recommended.

- Completion of a brief overview of the local freeway system to develop an overall plan for implementation if warranted. (See Appendix for example)
- After implementation, monitor truck volumes and operations such that the guidelines continue to be met. This also serves as a means to be aware of increasing truck and general traffic volumes, which may also cause concern that the restriction may need to be modified to accommodate higher traffic volumes.
- Routine enforcement of either regular traffic patrols and/or specialized dedicated Truck Enforcement Units should be available to assure compliance.
- Signs should be provided at 1-mile intervals throughout the restricted area to notify trucks entering the freeway of this restriction. In addition to placing signs along the right side of the freeway as per normal practice, supplemental signs should be placed overhead and along the left side to increase awareness of the restriction. The sign message should specify the class of vehicles to which the restriction applies (i.e., "vehicles with three or more axles" instead of "trucks"). These sign placements will provide for sufficient information to motorists of the restrictions, which may have a positive impact on compliance rates. Pavement marking should also be considered for additional notification.
- A good public information campaign should be undertaken to inform the public of the implementation of the restriction. Special emphasis on getting the word out to truck drivers who frequent the corridor is important to assure success of the project.

# 8.0 REFERENCES


1. D.A. Dagang and L.R. Grenzeback. "Methods for Reducing the Impact of Large Trucks on Urban Peak Period Freeway Congestion." *1989 Compendium of Technical Papers,* pp.1-5. Institute of Transportation Engineers, 1989.
2. Federal Highway Administration, *Effects of Lane Restrictions for Trucks*, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 1986.
3. F.L. Mannering, J.L. Koehne, and J. Araucto, *Truck Restriction Evaluation: The Puget Sound Experience*, WA-RD 307.1, Washington State Transportation Center, University of Washington, Seattle, WA, August 1993.
4. J.M. Mason, D.R. Middleton, and H.C. Peterson, *Operational and Geometric Evaluation of Exclusive Truck Lanes,* Research Report 331-3F, Texas Transportation Institute, Texas A&M University System, College Station, TX, 1985.
5. B.N. Janson and A. Rathi, *Feasibility of Exclusive Facilities for Cars and Trucks*, Final Report, Contract No. DTFH61-89-Y-00018, Center for Transportation Analysis, Oak Ridge National Laboratory, Oak Ridge, TN, April 1990.
6. J.E. Vidunas and L.A. Hoel, *Exclusive Lanes for Trucks and Cars on Interstate Highways,* Final Report, Report No. UVA/52924/CE96/103, Department of Civil Engineering, University of Virginia, Charlottesville, VA, May 1996.
7. H.L. Wishart and L.A. Hoel, *Analysis and Evaluation of Truck Traffic Restrictions and Separation Methods on Interstate Highways,* Final Report, Report No. UVA/529242/CE96/104, Department of Civil Engineering, University of Virginia, Charlottesville, VA, June 1996.
8. L.A. Hoel and J.E. Vidunas, *Exclusive Lanes for Trucks and Passenger Vehicles in Interstate Highways in Virginia: An Economic Evaluation,* Final Report, Report No. FHWA/VTRC 97-R16, Virginia Transportation Research Council, Charlottesville, VA, June 1997.
9. A. Trowbridge, D. Nam, F.L. Mannering, and J. Carson, *The Potential for Freight Productivity Improvements along Urban Corridors,* Final Report, Report No. WA-RD 415.1, Washington State Transportation Center, University of Washington, Seattle, WA, December 1996.
10. BST Associates, *1991 Washington Ports and Transportation Systems Study,* Washington Public Ports Association and Washington State Department of Transportation, Seattle, WA, 1991.
11. Civic Society, County Surveyors' Society and Department of Transport, *Lorries in the Community*, HMSO, London, England, 1990.
12. OECD Scientific Expert Group, *Cargo Routes: Truck Roads and Networks*, Road Transport Research, Organisation for Economic Co-operation and Development, Paris, France, 1992.
13. Planning and Transport Research and Computational International Association, *Financing Transport Infrastructure*, Proceedings of Seminar L, The 23rd European Transport Forum, 11-15 September 1995, University of Warwick, England, PTRC Education and Research Services Ltd., London, England, 1995.
14. D. Jasek and D. Middleton, *Literature Review for the S.R. 60 Truck Lane Feasibility Study*. Sponsored by Southern California Association of Governments, June 1999.
15. K. O'Brien and S. O'Brien, Information about Busways, Busways.org website, http://www.busways.org, June 2001.

16. R.W. Stokes and S. Albert, *Preliminary Assessment of the Feasibility of an Exclusive Truck Facility for Beaumont-Houston Corridor*, Research Report 393-2, Texas Transportation Institute, Texas A&M University System, College Station, TX, 1986.
17. J.T. Lamkin and W.R. McCasland, *The Feasibility of Exclusive Truck Lanes for the Houston-Beaumont Corridor*, Research Report 393-3F, Texas Transportation Institute, Texas A&M University System, College Station, TX, 1986.
18. A. Ranzo and F.P. Bocchetto, *New Freeways Reserved to Trucks, An Italian Project (in Progress),* Symposium on Geometric Design for Large Trucks, Denver (U.S.A.), August 5-7-1985, Transportation Research Board, Washington, D.C., 1985.
19. S. Sirisoponsilp and P. Schonfeld, *State-of-the-Art Studies/Preliminary Work Scopes: Impacts and Effectiveness of Freeway Truck Lane Restrictions*, Transportation Studies Center, Maryland State Highway Administration, Baltimore, MD, 1988.
20. W.R. McCasland and R.W. Stokes, *Truck Operations and Regulations on Urban Freeways*, Research Report FHWA/TX-85/28+1F, Texas Transportation Institute, Texas A&M University System, College Station, TX, 1984.
21. D. Middleton, K. Fitzpatrick, D. Jasek, and D. Woods, *Truck Accident Countermeasures on Urban Freeways*, Final Report, Texas Transportation Institute, Texas A&M University System, College Station, TX, 1992.
22. P. Samuel, *How to "Build Our Way Out of Congestion" Innovative Approaches to Expanding Urban Highway Capacity,* RPPI Policy Study 250, Reason Public Policy Institute, Los Angeles, CA, January 1999.
23. Cofiroute, *The A86 Underground Link-up West of Paris*, http://www.cofiroute.fr, 1999.
24. B.I. Kenyani and E.S. Putnam, *Transportation System Management: State of the Art*, Office of Policy and Program Development, Urban Mass Transportation Administration, U. S. Department of Transportation, Washington, D.C., 1977.
25. N.J. Garber and R. Gadiraju, *The Effect of Truck Strategies on Traffic Flow and Safety on Multilane Highways*, Presented at the 69th Annual Meeting, Paper 890117, Transportation Research Board, Washington, D.C., 1990.
26. D. Jasek, M.A. Shafer, D.L. Picha, and T. Urbanik II, *Guidelines for Truck Lane Restrictions in Texas*, Research Report 1726-S, Texas Transportation Institute, Texas A&M University System, College Station, TX, 1997.
27. M.C. Zavoina, T. Urbanik II, and W. Hinshaw, *An Operational Evaluation of Truck Restrictions on Six-Lane Rural Interstates in Texas,* Research Report 1152-1F, Texas Transportation Institute, Texas A&M University System, College Station, TX, 1990.
28. Rijkswaterstaat, *Segregation of Freight Traffic and Car Traffic: Reasons and Measures*, Transportation and Traffic Research Division, Rijkswaterstaat, Rotterdam, The Netherlands, 1990.
29. D. Borchardt, *Evaluation of the I-10 East Freeway Truck Lane Demonstration Project*, Texas Transportation Institute, Texas A&M University System, September 2001.
30. W.R. McCasland and R.W. Stokes, *Truck Operations and Regulations on Urban Freeways*, Research Report FHWA/TX-85/28-1F, Texas Transportation Institute, Texas A&M University System, College Station, TX, 1984.
31. Highway and Traffic Safety Division, *Capital Beltway Truck Trailer Restriction Study Final Report,* Virginia Department of Highways and Transportation, Richmond, VA, 1985.
32. Traffic Engineering Division, *Capital Beltway Truck/Tractor Trailer Restriction Study,* Virginia Department of Transportation, Richmond, VA, 1987.

33. Traffic Engineering Division, *Capital Beltway Safety Study with Truck Accident Update for 1988*, Virginia Department of Transportation, Richmond, VA, June 1989.
34. F.R. Hanscom, "Operational Effectiveness of Three Truck Lane Restrictions." Presented at the 69th Annual Meeting of the Transportation Research Board, Washington, D.C., 1990.
35. N.J. Garber and R. Gadiraju, *The Effect of Truck Traffic Control Strategies on Traffic Flow and Safety on Multilane Highways*, Report No. UVA/537363/CE90/101, School of Engineering and Applied Sciences, Department of Civil Engineering, University of Virginia, Charlottesville, VA, 1989.
36. N.J. Garber and S. Joshua, "Characteristics of Large Truck Crashes in Virginia," *Transportation Quarterly*, Volume 43, Number 1, pp. 123-138, Eno Foundation for Transportation, Inc., Westport, CT, 1989.
37. Cambridge Systematics, Inc., JHK & Associates, Roberts Associates, Inc., and Sydec, Inc., *Urban Freeway Gridlock Study: Technical Report*, California Department of Transportation, 1988.
38. D. Jasek, *Truck Restrictions and Legal Issues Concerning the Evaluation of the Feasibility of Dedicated Truck Lanes in Texas*, Unpublished Technical Memorandum prepared for the Texas Transportation Department, Texas Transportation Institute, Texas A&M University System, College Station, TX, December 1996.
39. B. Kuhn and D. Jasek, *State and Federal Legislative Issues for Managed Lanes*, Report No. FHWA/TX-02/4160-8, Texas Transportation Institute, Texas A&M University System, College Station, TX, January 2003.
40. Senate Bill 514, 78th Legislature of the State of Texas, Austin, TX, May 2003.
41. House Bill 1208, 78th Legislature of the State of Texas, Austin, TX, May 2003.
42. House Bill 3588, 78th Legislature of the State of Texas, Austin, TX, May 2003.
43. European Conference of Ministers of Transport, *Freight Transport and the Environment,* Organisation for Economic Co-operation and Development, Paris, France, 1989.
44. New Jersey Turnpike Authority, *Welcome to the New Jersey Turnpike, A Brief Tour,* New Jersey Turnpike Authority Interesting Facts, http://www.state.nj.us/turnpike.
45. Autostrade, S.p.A., *Autostrade Web Pages,* http://www.autostrade.it.
46. G. & C. Merriam Company, *Webster's New Collegiate Dictionary*, G. & C. Merriam Company, Springfield, MA, 1977.
47. S.M. Turner, *Video Enforcement for HOV Lanes: Field Test Results for the I-30 HOV Lane in Dallas,* Research Report 2901-S, Texas Transportation Institute, Texas A&M University System, College Station, TX, July 1998.
48. State of Texas, http://www.capitol.state.tx.us/statutes/tn.toc.htm. Accessed August 30, 2004.
49. D. Jasek, M.A. Shafer, D.L. Picha, and T. Urbanik II, Guidelines for Truck Lane Restrictions in Texas, Research Report 1726-S, Texas Transportation Institute, Texas A&M University System, College Station, TX, 1997.
50. P. Beckman, "Klausner delivers truckload of safety to Houston streets," Extra Milers. http://www.ci.houston.tx.us/pnl/empages/emwin03/emwin03_spotlight.htm. Accessed August 27, 2004.
51. Houston Police Online. http://www.ci.houtson.tx.us/department/police/teu_2.htm. Accessed September 28, 2004.

# APPENDIX

## PRELIMINARY ASSESSMENT OF POSSIBLE TRUCK LANE RESTRICTIONS IN HARRIS COUNTY ON STATE ROADWAYS

Base Criteria:

1. Minimum of 4 percent trucks.
2. Minimum length available of 6 mi.
3. Local knowledge of the freeways such that specifics that may preclude implementing a truck lane restriction on that section of roadway.
4. About 10 percent trucks in using the inside lane.

| Freeway | Criteria #1 & #2 | Comments / Recommendations |
|---|---|---|
| I-10 Katy | Yes | Do not recommend due to construction activities west of I-610. Segment east of I-610 is of insufficient length to implement truck lane restriction prior to downtown ramps. |
| I-10 East | Yes | Extend current restriction to limits of 6-lane freeway to the east to approximately one mile east of Sjolander -- however will need to remove the restriction for about one mile through the Spur 330 interchange as only 2-lanes are available for through traffic for each direction.<br>The restriction should be suspended in the construction area between Gregg to Wayside until the roadwork has been completed. |
| I-45 North | Yes | Would recommend restriction from Crosstimbers to C/L, but cannot implement due to sections with no inside shoulders. |
| I-45 Gulf | No – Yes | Truck percentages are in the 3.8 to 4.3% range, so it is borderline in terms of truck percentages. Recommend to not deploy along I-45 Gulf until truck percentages increase. |
| US 59 Southwest | Yes | Would recommend restriction from Chimney Rock to C/L, but cannot implement due to sections with no inside shoulders. No restrictions should be considered east of I-610 until the Spur 527 construction project is completed. |
| US 59 Eastex | Yes | Recommend restriction from Liberty to Will Clayton. This stops south of the current construction projects. |
| SH 225 | Yes | No changes from current restriction. |
| SH 288 | Yes | Meets truck percentages south of I-610 only. Recommend restriction from Bellfort to C/L. |
| US 290 | Yes | Would recommend restriction from Antoine/W. 34th to Mueschke, but cannot implement due to sections with no inside shoulders. |
| I-610 Loop | Yes | Truck percentages vary from 2.6 to 13.6%. The heaviest concentrations are on the north and east sides. While the west side has low volumes of trucks, the restriction should not be implemented in the construction area. Recommend restrictions from Ella eastward to South Post Oak. |

Note: This preliminary review is based upon data available from TxDOT's RI2T database. Criteria #4 has yet to be evaluated.

Texas Transportation Institute – March 26, 2004