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Case Studies and Annotated Bibliography of Truck Accident Countermeasures on Urban Freeways

U.S. Department of Transportation
Federal Highway Administration

Research and Development
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FOREWORD

Non-recurring congestion resulting from incidents is a substantial part of congestion on high volume urban freeways. When a large truck is one of the vehicles involved, an entire freeway can be closed for substantial periods of time. This report documents a number of countermeasures, in the form of case studies, that operating agencies are using to reduce the frequency and severity of non-recurring congestion resulting from incidents involving large trucks.

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Lyle Saxton

Lyle Saxton, Director
Office of Safety and Traffic
Operations Research and Development

NOTICE

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16. Abstract

To address the growing problem of congestion caused by incidents, especially truck-involved incidents, this study was undertaken to identify truck accident countermeasures which have been used nationwide. Desired conditions surrounding implemented countermeasures in this study included urban freeway volumes of 95,000 vehicles per day or higher, a significant number of trucks in the traffic stream (typically 5 percent or more), and countermeasures involving road design. The study omitted countermeasures directly related to the vehicle and the driver. This project included the following steps: literature search, telephone survey, and field visits to selected sites.

The information collected by this project is intended to assist agencies in identifying, selecting, and implementing truck accident countermeasures. Information was gathered on the following truck accident countermeasures: lane restrictions, separate truck roadways, urban inspection stations, ramp treatments, major incident response and clearance, and truck bans/diversion and time restrictions. The detailed information found in this document is summarized in the final report, FHWA-RD-92-059.

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Unclassified	Unclassified	250	

Form DOT F 1700.7 (8-69)

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: Volumes greater than 1000 l shall be shown in m^3.				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised September 1993)

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CHAPTER 1

INTRODUCTION

BACKGROUND

When a large truck is involved in a freeway incident, the consequences can be monumental, depending on the number of vehicles directly involved, the characteristics of the incident, the nature of the load being transported, the traffic demand at the site, the number of lanes blocked, and responsiveness of incident management techniques. The excessive costs and delays due to truck accidents and incidents on urban freeways have prompted several operating agencies to consider strategies to mitigate the impacts of these events.

The number of trucks on the Nation's freeways is rising every year and trucks must maneuver in denser traffic in urban environments. The Michigan Department of Transportation reports that more than 13 percent of all accidents throughout the State on freeways involved trucks. Freeway truck accidents in California have increased by 10 percent per year since 1985 when they totalled 12,000 accidents. Accidents involving trucks sometimes block entire freeways and create massive traffic congestion as heavy-duty tow equipment slowly moves the wreckage from the travel lanes and a spilled load is cleared. Delays averaging 2,500 vehicle-hours have been noted for each accident in California. Hazardous materials spills bring their own additional delays as other agencies get involved to assess environment and health implications.[1]

In an earlier study of truck accidents on urban freeways, it was estimated that the total annual cost of high volume urban freeway truck accidents was $634,000 per freeway mile. This total consisted of the following per-mile costs: $182,000 in accident costs, $440,000 in delay costs, $3,000 in clean-up costs, and $9,000 in operating costs. This study evaluated accidents occurring from January 1985 through September 1988 on 74.9 km (46.5 mi) of urban freeway which had experienced 2,221 accidents involving trucks over 4 540 kg (10,000 lb) gross vehicle weight.[2]

Numerous other studies have also shown the serious effects of freeway incidents on congestion. A study in California showed that for each additional minute of freeway blockage during off-peak periods, 4 to 5 minutes were added to the duration of congestion. Stated another way, for each minute that the time to clear blocked lanes is reduced, at least 4 or 5 minutes of delay reduction will result.[3] A study in Houston showed that 80 percent of all incidents reduced capacity by at least one-third, regardless of whether a lane was blocked. On a three-lane freeway, the capacity was reduced by one-half when one lane was blocked.[4] In Seattle, motorists experienced an estimated 18.4 million hours of delay in 1984. Fifty-eight percent of that delay was the result of freeway incidents.[5]

Even though non-recurrent congestion resulting from incidents is a substantial part of overall congestion, it is only in the recent past that operating agencies began to deal with the problem in an organized, comprehensive manner, and even then only a few did so. Others are participating, however, as the problem grows. Nationally, travel has grown at an annual rate of almost 5 percent, and is expected to double in metropolitan areas by the turn of the century.[6] One of the recently developed publications which addresses this growing problem, titled "Freeway Incident Management Handbook," was sponsored by the Federal Highway Administration.[7]

To address the growing problem of congestion caused by incidents, and especially truck-involved incidents, this study was undertaken to identify truck accident countermeasures which have been used throughout this country and abroad. Desired conditions surrounding implemented countermeasures in this study included urban freeway volumes of 95,000 vehicles per day (vpd) or higher, a significant number of trucks in the traffic stream (typically 5 percent or more), and countermeasures involving road design. The study omitted countermeasures directly related to the vehicle and the driver. Target trucks, in this study, are defined as those over 4.5 Mg (9,920 lb). There is some inconsistency in the information gathered concerning vehicle type because the various State agencies have defined trucks differently. There were no "new" data collection activities involved in the study, so evaluations of existing accident data for the "before" and "after" periods and other discussions in the text reflect data that agencies had available. The scope of this study included freeway truck accident countermeasures implemented on mainlanes and also on ramps.

The information collected by this project is intended to assist agencies in selecting and implementing truck accident countermeasures. The strategies might be classified into three categories: traffic management, incident management, and prevention. Traffic management is a combined activity, including both traffic engineering and public information. It includes activities aimed at maximizing the utilization of existing highway facilities. Its objective is to decrease the frequency of incidents, but it does little to reduce the impact of incidents after they occur. The objective of incident management is to reduce the impact of incidents, once they occur. An example is contractual arrangements to reduce response times of heavy-duty tow trucks. Prevention includes various countermeasures to reduce both the frequency and severity of truck accidents. Examples include: urban inspection stations, ramp and mainlane treatments, and separate truck facilities.

PROJECT SCOPE

This project included the following tasks:

- Conduct a literature search to determine the countermeasures which have been documented nationally and internationally.
- Conduct a telephone survey of State agencies to identify implemented truck accident countermeasures.
- Conduct field visits to selected sites to gather existing information from responsible agencies and at the site.

REPORT CONTENTS

This report contains a series of case studies followed by an annotated bibliography. Case studies were developed for the following urban areas: Atlanta, Chicago, Detroit, Fort Worth, Hagerstown, Los Angeles, Portland, Seattle, and Tampa; and on the following specific freeways: the Capital Beltway (Washington DC area), the New Jersey Turnpike, and the Pennsylvania Turnpike. Case studies include information gathered from site visits and information not previously identified in the initial literature search. The annotated bibliography follows the case studies; its purpose is to report on truck accident countermeasures described in the literature.

CHAPTER 2

ATLANTA, GEORGIA CASE STUDY

OVERVIEW

Description of Area

Atlanta, with a metropolitan area containing 2.8 million people, has 1.4 million wage earners that use the transportation systems each day. Early in 1977, the Georgia Department of Transportation (GA DOT) decided that worsening traffic congestion in Atlanta was "not inevitable" and developed a plan to improve congestion. With the introduction of Atlanta's rapid rail transit system (MARTA), GA DOT began a "Freeing the Freeways" program to improve the safety, capacity, and operation of the city's major freeway arteries. In 1975, 1,648 freeway lane-km (748 lane-mi) were in use in the Atlanta area; by 1990, 2,981 lane-km (1,851 lane-mi) were in use. These modern freeways carry one-third of all the region's auto travel and a much higher percentage of its truck travel with dramatically lower congestion. The level of service at six critical locations was improved by an average of 1.5 grades while serving 44 percent more traffic.[8]

Atlanta's freeway system is shown in figure 1. Interstate 75 and Interstate 85 have north-south orientations, and Interstate 20 serves east-west traffic inside the Interstate 285 loop. The two north-south freeways merge near downtown and split again a short distance from the central business district. Interchanges between I-285 and other freeways are typical locations where large numbers of trucks enter and exit because of a ban on through trucks using the interior freeways.

GA DOT's office of Planning Data Services provided average daily traffic (ADT) and percent tractor-trailer traffic for Atlanta (see figure 1). For all Interstate highways in Atlanta, tractor trailers represented 4.1 percent of total travel in 1986 and 1987, increasing to 5.7 percent in 1988 and 1989. It should be noted that the percent truck traffic on figure 1 includes other trucks as well as tractor trailers thereby causing the percent trucks on figure 1 to be considerably higher than 5.7 percent. However, GA DOT personnel cautioned that the estimates of tractor trailer travel percentages, while being the best practically available, are based on limited truck sampling counting procedures which could produce varying results and questionable reliability. These estimates should not be considered to be statistically reliable.

Countermeasures Implemented

Four countermeasures for heavy truck accidents implemented in Atlanta, Georgia were investigated. Brief introductions to these countermeasures follow:

- **Lane Restrictions**--Beginning in September 1986, trucks were restricted to the right lane(s) except to pass or to make a left-hand exit on all State and federally funded highways in the State of Georgia.

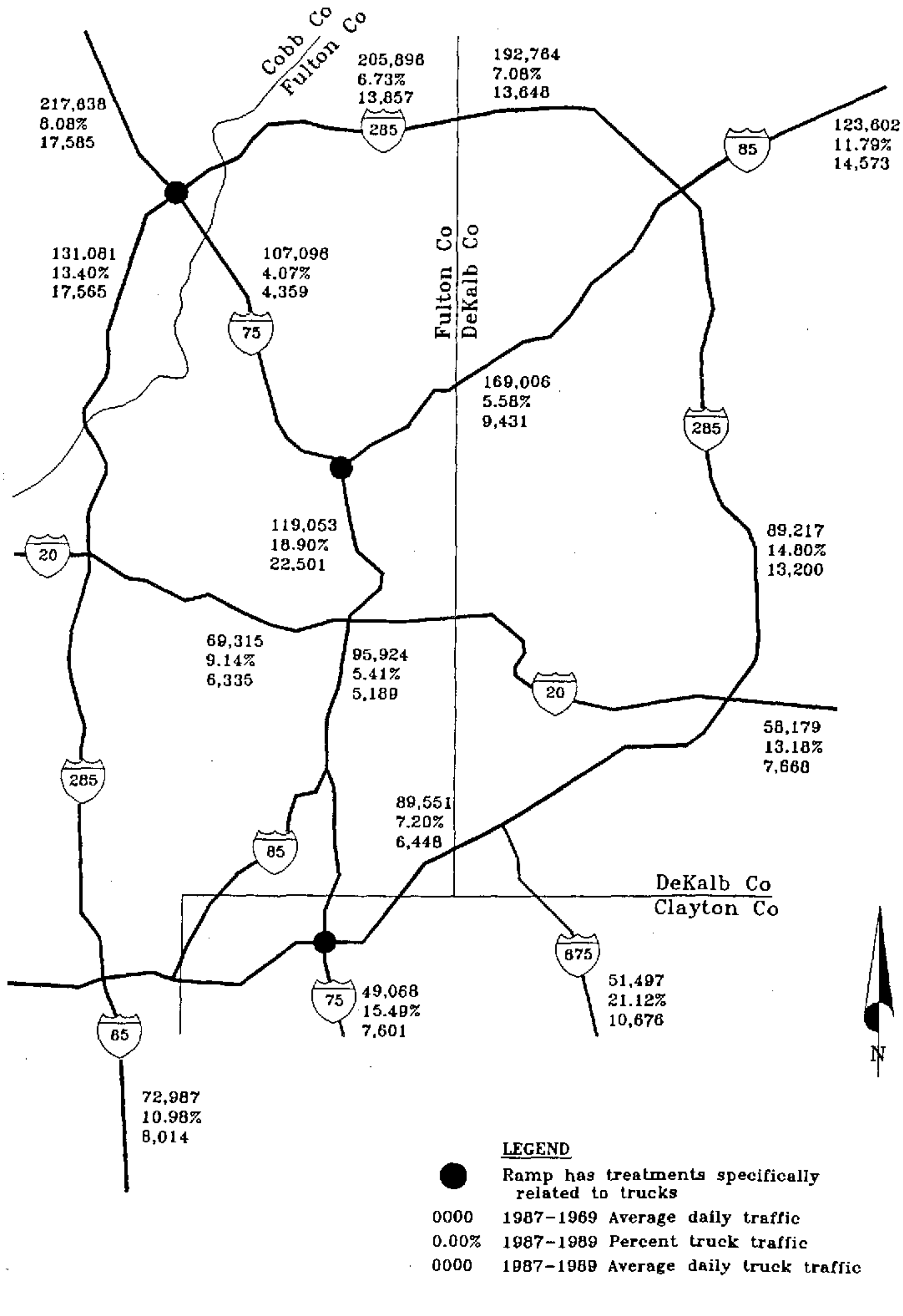


Figure 1. Atlanta, Georgia freeway system.

- **Truck Ban**--In December 1978, the Georgia DOT exercised their right to enact an Order to require through trucks approaching Atlanta to use I-285 instead of using the freeways within the I-285 loop.

- **Freeway Ramp Improvement**--Two ramps were identified by a GA DOT District Traffic Engineer as having improvements specifically relevant to trucks.

- **Additional Enforcement**--For 90 days beginning January 15, 1987, the Georgia State Patrol assigned a special task force contingent of 18 officers to focus on large truck violations such as speeding, following too close, and improper lane changes.

In addition to these countermeasures, in December 1986, GA DOT and the Georgia Department of Public Safety decided to place special emphasis on finding solutions to problems created by or exacerbated by trucks on I-285. The two agencies hosted a forum and invited other agencies including: the Federal Highway Administration, National Transportation Safety Board, Georgia Public Service Commission, American Trucking Association, Georgia Motor Trucking Association, and all Atlanta Metro County Commissioners. In the 2-week period following the forum, GA DOT increased signing for trucks around the Atlanta area. On I-285, I-85, I-75, and I-20, they placed 90 1.2-m by 1.5-m (4-ft by 5-ft) ground-mounted signs and 33 2.1-m by 2.4-m (7-ft by 8-ft) overhead signs with the message "TRUCKS OVER 6 WHEELS MUST USE 2 RIGHT LANES." On Interstate routes entering the city, 2.1-m by 2.4-m (7-ft by 8-ft) overhead signs were also installed with the message "ALL THRU TRUCKS OVER 6 WHEELS MUST USE I-285" (see Lane Restriction and Truck Ban sections).

Accidents

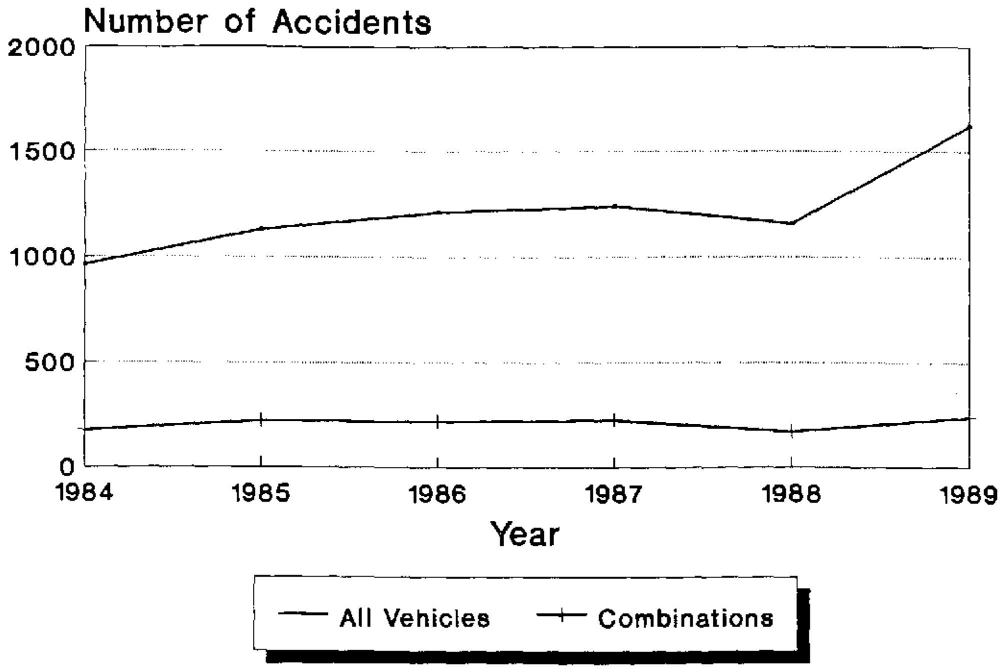
Georgia DOT provided accident data for I-285 and for all Interstates within the Atlanta metropolitan area. Table 1 summarizes the accident information; figures 2, 3, 4, and 5 are plots of the data. This time period was selected because of data availability. The information is provided not to attempt to prove the effect of any one particular countermeasure on accident rates, but rather to illustrate possible trends over the 6-year time span. Specific information regarding other variables which might have affected accident rates was not obtainable within the time and budget limitations of the project.

A factor which has influenced accident rates over the past several years is freeway reconstruction. Starting in the mid-1970's and continuing to the present, various segments of the freeway system have been under construction. Since 1977, more than 1 287 freeway lane-km (800 lane-mi) have been added, and a 51-km (32-mi) rapid rail system has started operations. According to Georgia Department of Transportation officials, segments under construction typically affect adjacent segments which are not under construction, thus truck accident countermeasures must be considered in light of this widespread freeway

Table 1. Number of accidents on Atlanta freeways.

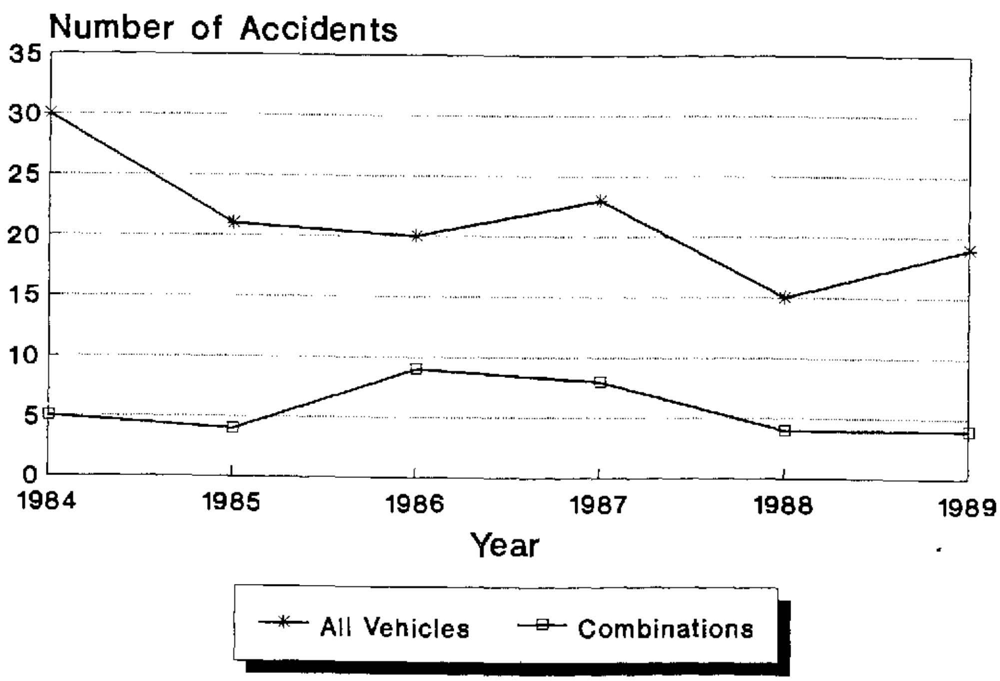
Year	Total Accidents		Injuries		Fatalities		Percent TT Fatalities (TT/AV)[1]
	All Vehicles	Tractor-Trailers	All Vehicles	Tractor-Trailers	All Vehicles	Tractor-Trailers	
Interstates -- Atlanta Metro							
1984	8777	1228	3463	388	75	18	24%
1985	9800	1367	3776	548	45	12	27%
1986	10473	1523	4146	532	69	17	25%
1987	10596	1487	4326	510	69	15	22%
1988	10689	1351	4254	458	58	16	28%
1989	12624	1420	5447	618	73	14	19%
I-285 Only							
1984	2475	475	961	176	30	5	17%
1985	2912	596	1129	222	21	4	19%
1986	3073	611	1213	220	20	9	45%
1987	3108	583	1238	224	23	8	35%
1988	3263	501	1156	169	15	4	27%
1989	3907	541	1621	242	19	4	21%

[1] TT = Tractor trailers, AV = All vehicles



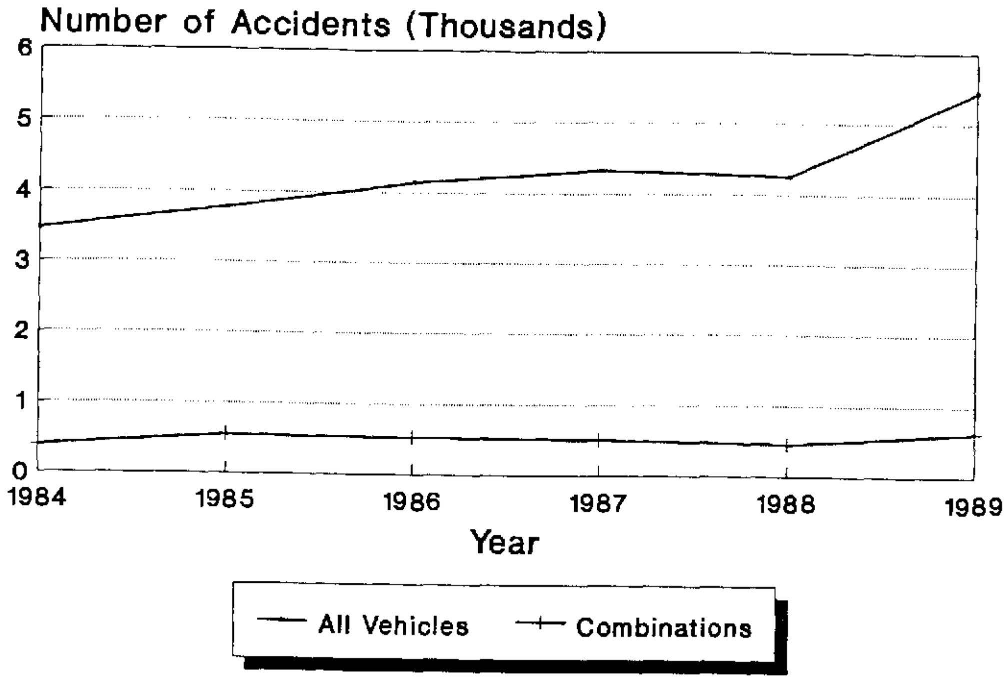
Source: Georgia DOT

Figure 2. Number of injuries on I-285.



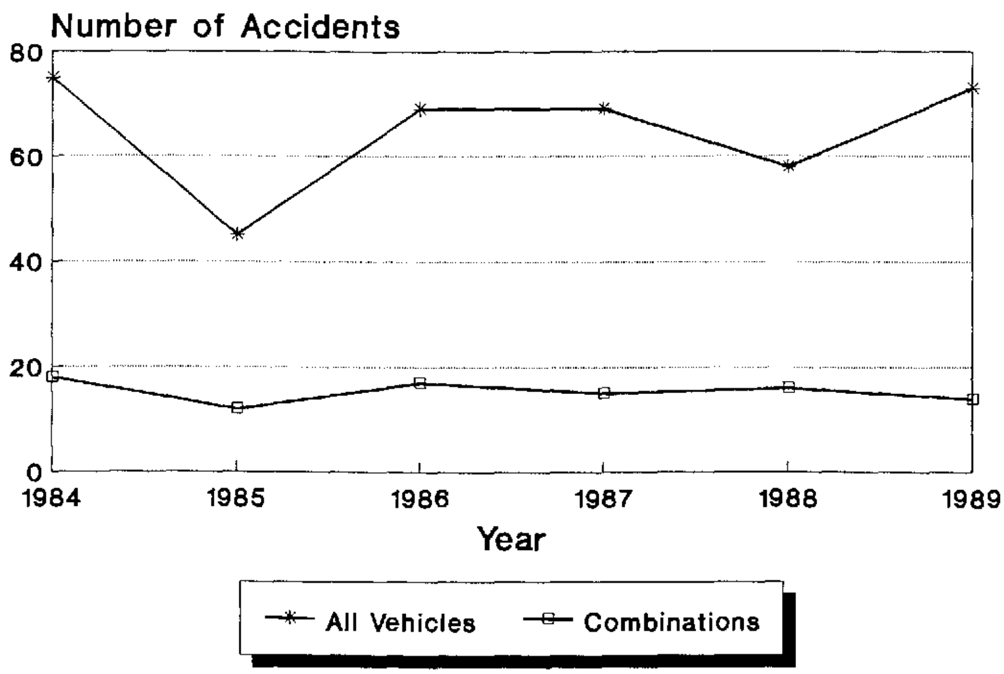
Source: Georgia DOT

Figure 3. Number of fatalities on I-285.



Source: Georgia DOT

Figure 4. Number of injuries for Atlanta Interstates.



Source: Georgia DOT

Figure 5. Number of fatalities for Atlanta Interstates.

reconstruction. GA DOT officials estimate an overall accident reduction of approximately 20 percent (or 2,700 accidents) following freeway reconstruction.

Accident costs, positive for accident increases or negative for accident reductions, are estimated by GA DOT personnel. For years, GA DOT used National Safety Council figures -- about $5,000 per accident. More recently, the Federal Highway Administration (FHWA) found that motorists were willing to pay more than this amount to reduce accidents. Georgia now uses a figure of $14,000 per accident.

Truck Industry Views

Six truck drivers, who are currently based and/or operate within the Atlanta metropolitan area, provided their perspective on three truck accident countermeasures implemented in Atlanta. Contacts with these individuals were made by telephone. Most of these individuals have driven trucks in the past and/or currently drive them on at least a part-time basis. This "behind the wheel" experience factor is important in interpreting their comments.

The first truck driver is an administrator for a less-than-truckload (LTL) hauler with a terminal in the Atlanta area. He was a truck driver from 1967 to 1971 and has driven sporadically since then. He is still qualified to drive. The second interviewee was a driver (former truck driver) for 13 years, but now holds an administrative position. The third interviewee in Atlanta is a safety director for an auto transporter. The fourth truck driver works in an administrative position with a national less-than-truckload carrier (national carrier driver/administrator). The fifth person interviewed was a driver for a petroleum distributor (petroleum tanker driver) in Atlanta. The sixth person is a concrete redi-mix administrator, but was formerly with an over-the-road, less-than-truckload hauler.

LANE RESTRICTIONS

Background

Lane restrictions are currently in effect on all State and federally funded highways in the State of Georgia. Beginning September 1986, trucks (defined as vehicles with more than 6 wheels) were restricted to the right lane(s) except to pass or to make a left-hand exit. On roadways with three or more lanes in each direction, trucks are restricted to the right two lanes. This legislation was passed with the intent to prevent trucks from impeding other traffic desiring to pass. On urban freeways, trucks were often observed travelling abreast across several lanes, thus denying passing opportunities for other vehicles.

Another reason cited by Georgia officials for initiating lane restrictions for trucks was their over involvement in weaving and lane changing accidents. In a review of accidents by GA DOT officials, 53 percent of truck accidents on I-285 were found to be "sideswipes same direction." By comparison, this category is only 24 percent for all vehicles on I-285. A closer analysis of the "sideswipe same direction" truck accidents revealed that "changing lanes improperly" was cited as a contributing factor in 50 percent of these accidents. The truck driver was determined to be at fault in 72 percent of the "changing lanes improperly" violations. GA DOT concluded that restrictions to the right lane(s) would reduce the occurrence of lane changing problems with large trucks.

Implementation

The lane restrictions were implemented in stages. The Atlanta metropolitan area was the first stage of implementation (within Atlanta, I-285 was the first roadway). According to GA DOT officials, the lane restrictions signs cost $88 per sign, which includes the cost of two 4-m (14-ft) sign posts. As of the summer of 1991, 280 ground-mounted signs were installed on the right side, and another 101 were scheduled to be installed on the left side of the freeway. This is a total of 381 signs at a total cost of $33,528. GA DOT uses one sign truck and one two-person crew; however, the cost above does not include labor and equipment costs.

Effectiveness

GA DOT officials commented that they currently do not have the necessary support of local law enforcement officials to heavily enforce lane restrictions (and other truck restrictions). Efforts are underway that would allow Georgia DOT Weight Enforcement personnel to enforce lane restrictions.

Truck Industry Views

Georgia DOT officials cite the following complaints regarding the truck lane restrictions: (1) autos attempting to exit sometimes cut in on trucks, causing the truck driver to brake quickly; (2) trucks must contend with slower moving on-ramp traffic which must weave across truck traffic; and (3) lane restrictions sometimes "trap" the truck driver thereby forcing the driver onto an unwanted Collector-Distributor split. DOT officials personally feel this countermeasure works and that trucks do not need additional lanes. Comments from the six interviewed truck industry representatives follow.

The administrator stated that lane restrictions are beneficial because they reduce lane changing. However, problems occur when a truck approaches left-hand exits because there is no attempt to inform truck drivers when they can begin changing lanes to the left for the exit. Currently, the law enforcement officer decides the appropriate distance. The use of signs with the message," END LANE RESTRICTIONS," would solve this problem.

The former truck driver stated that the restriction increases accident exposure for trucks due to entrance and exit ramp traffic, and that accident rates have increased rather than decreased. He also stated that trucks are often forced onto exit ramps when other vehicles do not allow them into a through lane, and that if trucks approaching a left-hand exit merge too quickly, they risk receiving a citation. When asked which lanes would be appropriate for truck restrictions, he stated that there should be no (lane) restrictions.

The safety director stated that the Atlanta lane restrictions are acceptable because multiple lanes are used, and the petroleum tanker driver stated that truck drivers have been able to tolerate the lane restriction, and did not give specific objections or alternatives.

The national carrier driver/administrator responded that although this restriction is often inconvenient, in most cases the restriction to the right two lanes is acceptable. In terms of speed differentials, however, slower moving trucks are safer in the right lanes. Yet, at times, the safest lane may not be one of the allowed lanes, and the law does not allow truck drivers the option to choose. Recently, enforcement personnel have been more tolerant with truck drivers. In the past, citations would be issued to a driver who moved left too soon when approaching a left-hand exit.

The concrete redi-mix administrator voiced an objection dealing with left-hand exits. He commented that in the past police were too strict when trucks needed to move left for a left-hand exit. He also stated that enforcement recently has not been as strict as it should be regarding lane restrictions, and that more trucks are violating the restriction. This individual likes this law because it separates faster moving cars from his company's concrete trucks which travel at relatively slow speeds.

TRUCK BAN

Background

In December 1978, the Georgia DOT exercised their right to restrict trucks by enacting an order which required through trucks approaching Atlanta to use I-285 (see figure 1) instead of using the freeways within the I-285 loop. Signs were placed on the freeways approaching I-285 to inform truck drivers of the ban. In the December 1986 forum (see Section 1.2), several potential solutions were identified including installing additional overhead signs to inform truck drivers of the ban.

Implementation

An attempt was made at the outset of this ban (December 1978) by GA DOT to control the use of interior freeways by issuing a decal to truck drivers who qualified. When officials realized, based on the number of requests received from all over the United States, that this would be an overwhelming task, decal issuance was discontinued. Because of the intense labor needs and lack of space available for inspecting the truck's bill of lading, enforcement personnel typically do not check a truck's destination unless the truck is involved in an accident. Truck drivers in violation of the truck ban are cited.

In the 2-week period following the forum, GA DOT increased signing for trucks around the Atlanta area. On Interstate routes entering the city, just prior to their junction with I-285, additional 2.1-m by 2.4-m (7-ft by 8-ft) overhead signs with the message "ALL THRU TRUCKS OVER 6 WHEELS MUST USE I-285" were installed. According to GA DOT personnel, six of the "ALL THRU TRUCKS OVER 6 WHEELS MUST USE I-285" signs have been installed at a cost of $500 each, exclusive of labor and equipment.

Effectiveness

No attempt has been made by GA DOT to quantify the benefits of the truck ban countermeasure or to assign cost savings to it. However, they did estimate that combination truck travel on interior freeways was reduced from 6 to 2 percent, or approximately 6,000 trucks per day. No detailed accident information exists for the period before December 1978 when this ban was initiated. For the "after" period of 1984 through 1989, figures 2 and 3 show the injury and fatality accidents which occurred on I-285 involving all vehicles and combination-only vehicles. Figures 4 and 5 show the injury and fatality accidents which occurred on all freeways (including I-285) from 1984 through 1989. Because the reliability of truck counts was uncertain, no attempt was made to plot accident *rates*. Available data were insufficient to account for other variables which might affect accidents. These figures are included for the purpose of showing general accident trends over the period of time represented.

To evaluate truck driver compliance with this ban, a study was performed by the Georgia Department of Transportation on March 25, 1980. The study involved a 24-hour count period, and established count stations at each interchange with I-285. In this 24-hour period, a total of 18,996 trucks approached Atlanta on the major freeways. Of this total, 14,555 (76.7 percent) exited onto I-285 leaving 4,411 (23.3 percent) trucks remaining on the approach freeway and proceeded toward downtown Atlanta. Twelve observation vehicles followed random samples of trucks that continued past I-285 and onto interior freeways to determine if they continued through Atlanta without stopping to load or unload. Study personnel followed a total of 650 trucks in the 24-hour period. Results showed that 5.4 percent of those followed passed through Atlanta, violating the truck ban. Approximately the same number of violations occurred at night as in the daytime. GA DOT officials suspect that the compliance rate is lower now, due to the lack of support by local law enforcement.

Truck Industry Views

The administrator stated that the truck ban affects company operations by adding 9 km (5.7 mi) each direction on a trip to Nashville, Tennessee. He was initially in favor of the ban because of congestion on the interior freeways. In the past he used I-285 when he travelled in his own automobile, however, I-285 is no longer the best route. Today, he says, the downtown freeways are less congested than I-285, and trucks should be allowed to use them.

The former truck driver stated that the travel distance is only one negative factor, and that there is less "accident exposure" when a truck goes through the city as opposed to using the I-285 bypass. The safety director stated that his company has no problem with the ban because his company's terminal is near I-285 and that the distance added to some trips is not "unbearable." When asked, he stated that the ban is not very strictly enforced and that truck drivers suffer as a result. (He did not elaborate.)

The national carrier driver/administrator, whose firm has a terminal located inside I-285, said that the firm's drivers do not have a problem with the ban. Although travel distances are increased by the ban, the main objection to it is that pavements on downtown freeways are now better than on I-285. When asked about enforcement, he stated that it is not strict enough, and that trucks can not be stopped on interior freeways without creating a hazardous situation.

The petroleum tanker driver stated that daily deliveries are made inside the loop, so the ban has no effect on the company. The concrete redi-mix administrator thinks the ban is a good idea and that many through-trucks want to avoid the downtown area anyway. According to him, they know that if there is an accident, they will get stuck in traffic.

RAMP IMPROVEMENTS

Background

Two ramp locations were identified by the District Traffic Engineer of the GA DOT as having improvements specifically relevant to trucks (see figure 1). These were located at interchanges of radial freeways with the by-pass freeway, I-285. Each of these interchanges uses collector-distributor (C-D) roads. Their descriptions are as follows:

- I-285 eastbound to I-75 northbound in Cobb County: GA DOT made several improvements to this ramp at different times. These included: static warning signs, an active warning device, improving the inside (left) shoulder, and improved superelevation (see figure 6).

- I-285 eastbound to I-75 southbound in Clayton County: GA DOT added superelevation, an active message device, a truck tipping sign, and chevrons (see figure 7).

Implementation

According to GA DOT officials, the ramp at I-285 and I-75 in Cobb County (see figure 8) was at one time the ramp location with the highest number of truck accidents in metro Atlanta. Traffic desiring to go northbound toward Chattanooga, Tennessee from eastbound I-285 used this ramp. From the freeway, motorists make a right-hand exit onto a collector-distributor roadway, pass under I-75, then make a left-hand exit onto the ramp which crosses under the mainlanes of I-285 (see figure 6). GA DOT officials stated that accidents usually occurred directly under the I-285 eastbound bridge. Two separate construction projects made improvements to the ramp.

One construction project improved the inside shoulder cross slope to match the cross slope of the main ramp lanes and added a concrete safety barrier. These improvements were prompted by truck accidents involving rollovers to the inside of the curve. The previous inside shoulder and ditch profile was more severe than that on the main lanes of the ramp which could have contributed to truck problems. Georgia DOT officials could not state conclusively why trucks were overturning to the inside but they thought truck drivers probably had to make a steering correction to the right within the curve.

A second project increased the superelevation on the ramp. Georgia DOT officials stated that increasing the superelevation on the main lanes of the ramp helped more than anything else to reduce accidents. No as-built construction plans were available to determine the exact final superelevation rate, but one GA DOT official stated that the maximum superelevation rate was increased to 0.08 m./m.

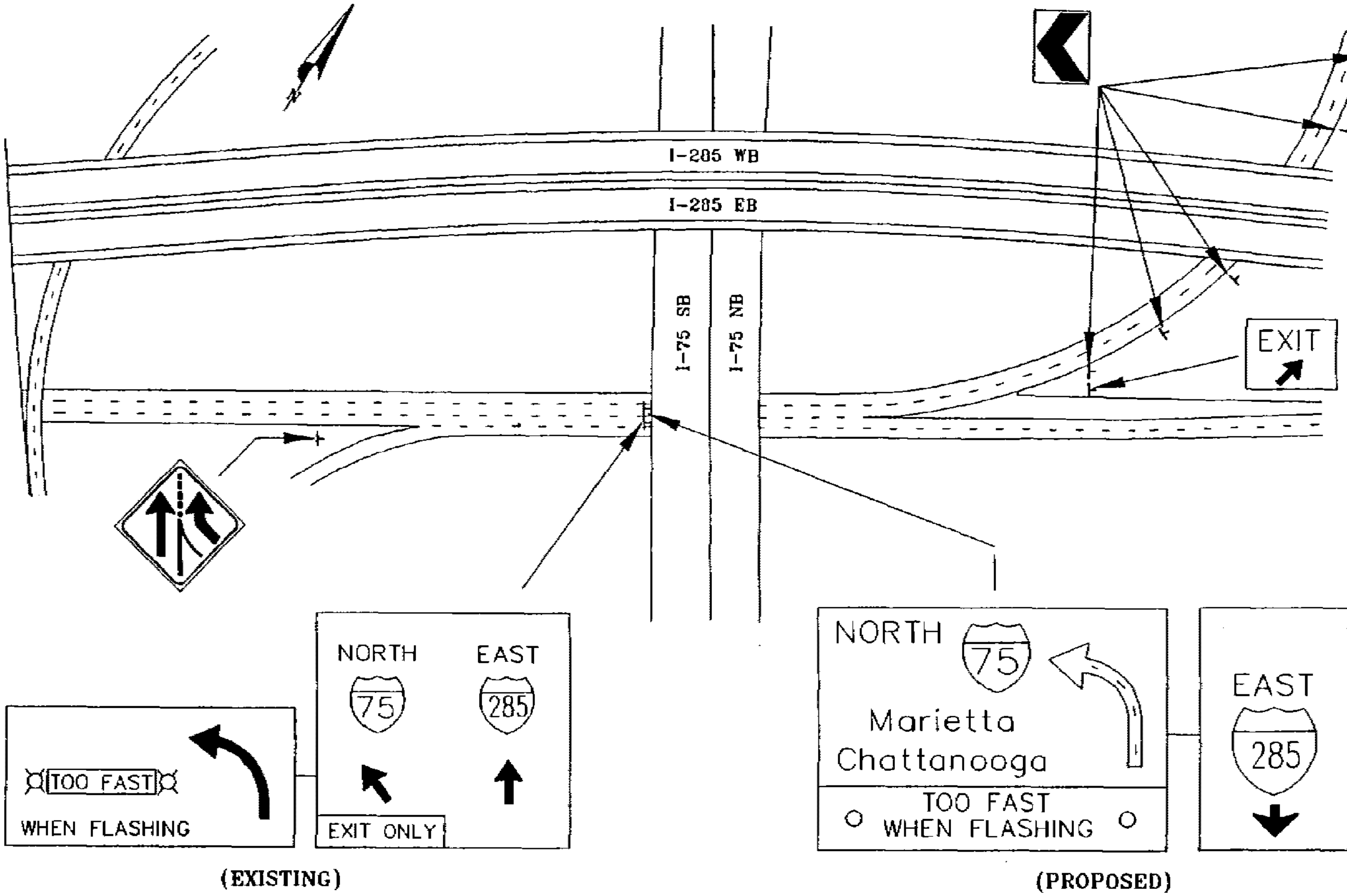


Figure 6. Ramp treatments at I-285 eastbound to I-75 northbound in Cobb County.

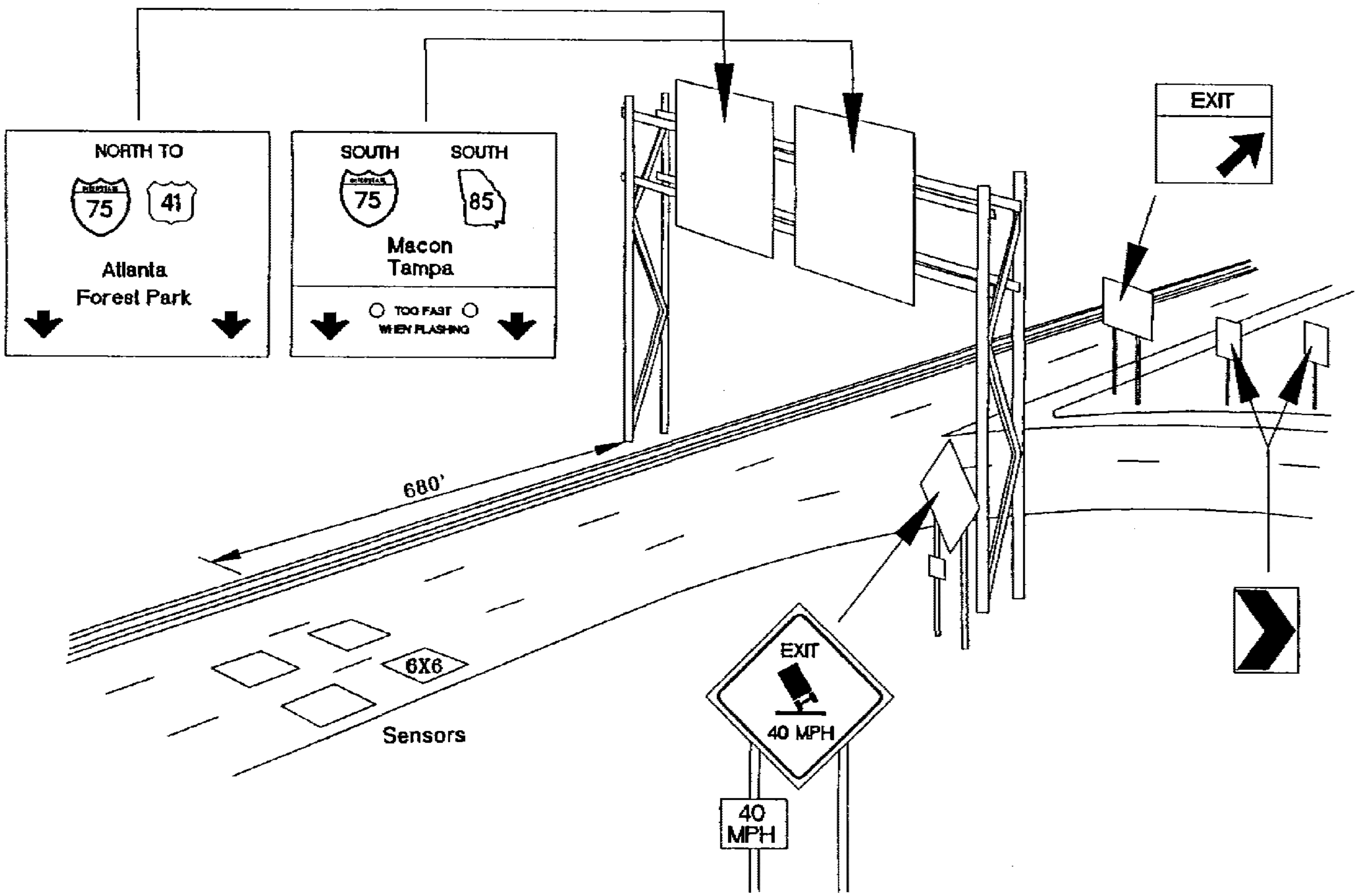
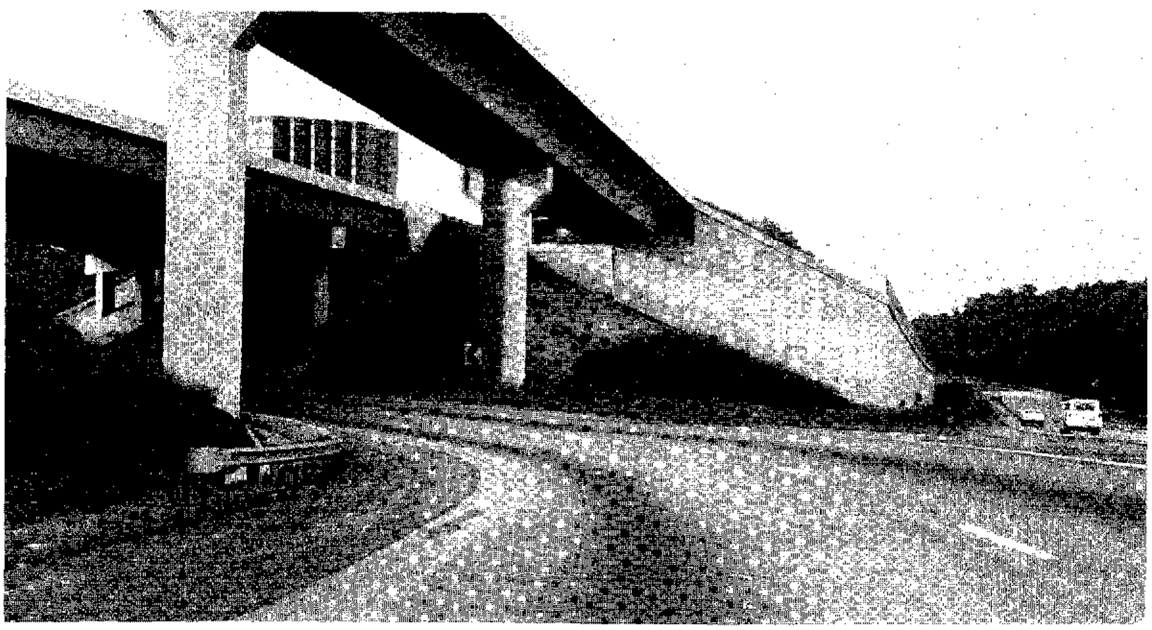


Figure 7. Ramp treatments at I-285 eastbound to I-75 southbound in Clayton County.

Note: The inside left shoulder and superelevation of the curve have been improved.

Figure 8. Entering the I-75 northbound exit from the I-285 eastbound collector-distributor road.



Note: The warning sign with flashing lights is used as an active warning device.

Figure 9. Approach to I-75 northbound exit from the I-285 eastbound collector-distributor road.

Even with recent improvements, GA DOT is currently planning additional traffic control devices including a new active message sign (see proposed sign on figure 6). The current active device uses wig-wags attached to a static warning sign (see figure 9). The device is activated by any vehicle that approaches the ramp faster than the preset speed. The threshold speed is set based on the American Association of State Highway and Transportation Officials (AASHTO) design speed which does not necessarily consider high center of gravity vehicles. These active devices are installed on several ramps in the Atlanta area. Casual observations indicate they flash continuously, thus losing their effectiveness as active devices.

The ramp from I-285 eastbound to I-75 southbound in Clayton County near the airport was retrofitted with an active warning sign and chevrons, and the superelevation on the ramp was increased from 8 percent to 10 percent. The increased superelevation improvement was accomplished by contract and not by State personnel and the construction plans were signed in January 1987. A truck tipping sign with a 65 km/h (40 mi/h) speed advisory plate is also used near the start of the ramp (see figure 7).

Effectiveness

Georgia DOT officials observed the following pattern of effectiveness for the active devices using wig-wags. When first installed, speeds of most vehicles are reduced. After an initial familiarization period, motorists become accustomed to their presence, and with their own perceived safe speed on the roadway, their speeds once again increases. With commuters, the time period is less than for unfamiliar motorists, but within a month or so familiarity tends to reduce the active device's effectiveness.

Georgia DOT, like many other agencies, has difficulties assigning accidents to a specific ramp. Accident reports sometimes only indicate the interchange involved rather than the specific ramp. When accident reports are submitted to Georgia DOT coders, other differences may enter into the process due to the interpretation required. The travel direction, along with the type of accident and the vehicle type are included on accident reports. The two latter items would be important information in an effectiveness analysis of a ramp improvement. The accident reduction analysis would include "overturn" and "struck object" categories of accidents, and the "tractor-trailer" vehicle category. Currently there is no information related to jackknifing provided on accident reports, however, the object struck (e.g. guardrail) is normally coded. The type of trailer and a description of the load are not included on accident reports; however, this information may be provided in the text description of the accident. Accident data are not immediately available for the current time period; they lag behind the end of each calendar year by approximately 4 months.

The District Traffic and Safety Engineer does not believe signs (active or passive) are effective in reducing vehicular speeds, and that the presence of law enforcement officers is necessary to slow motorists. Georgia DOT, however, does not place regulatory speed signs on ramps due to a perceived liability problem. One problem with the "truck tipping" sign noted by this engineer is recognition. GA DOT has received numerous phone calls requesting an interpretation of the sign's meaning. To improve driver understanding, DOT personnel added a supplemental TRUCKS plate underneath the truck tipping sign.

Georgia DOT does not have an official sequence of improvements for ramp curves, however, one set of ramp improvements occurred as follows. First, the number of chevrons was increased, then the size of chevrons was increased, then truck tipping signs (static) were added, then finally, the over-speed warning device (wig-wag) was installed. If all of these actions remain insufficient, then the ramp is reconstructed (for example, add superelevation).

Truck Industry Views

GA DOT officials interviewed have had no feedback from truck drivers regarding ramp improvements. Results of direct communication with truck industry representatives is provided below.

The national carrier administrator stated that static signs, in general, help truck drivers. The truck tipping sign and "over speed warning device" are useful to truck drivers unfamiliar with the roadway, but for those familiar with the roadway it becomes "part of the environment."

When asked how truck drivers generally react to advisory speed warning devices, he responded that truck drivers know that they can safely exceed posted speeds by 16 to 24 km/h (10 to 15 mi/h). He emphasized that truck drivers base their driving decisions on the feel of the rig. He added that drivers who are unfamiliar with the roadway tend to travel closer to the posted speeds, and that trucks pulling a less stable load (i.e., tankers or swinging beef) will proceed more cautiously. Drivers pulling twin trailers must know whether there is a significant difference in the weights of the two trailers, as the heavier trailer must always be in front. If there is a minor weight difference there might not be a problem, however, if the front trailer is empty and the rear trailer is heavy, there is a risk of jackknifing upon rapid deceleration. According to this administrator, there is no Federal regulation which requires the heavier trailer to be in front.

The former truck driver feels that the "wig-wags" are effective, especially for truck drivers who are unfamiliar with the area. This driver states that the worst ramp in Atlanta is the ramp for traffic westbound on I-20 turning to go southbound on I-285. He says a tanker cannot negotiate this ramp at 24 km/h (15 mi/h) without rolling over and that three to four accidents per month occur there. This truck driver also notes that tanker trailers are much more hazardous than a dry cargo van, and that a bulk hauler is also more hazardous than a dry cargo van. He remarked that the rear trailer of a double is more likely to roll due to the rearward amplification phenomenon when a driver makes a steering adjustment. This can happen on a ramp when a driver does not anticipate the sharpness of the curve and is forced to correct quickly. Trucks must often travel slower than other traffic in order to negotiate ramps and other elements. He summarized his comments by favoring anything that will make a driver pay attention to the road and will warn of approaching hazards. He thought that truck tipping signs were helpful where ramps have no superelevation.

The safety director said some truck drivers are starting to pay attention to the over-speed warning devices on three ramps in Atlanta. He believes the device would be more effective if it was set-up specifically for trucks.

The national carrier driver/administrator knows about the over speed warning devices at I-285 eastbound to I-75 northbound in Cobb County. He stated that the device is always on, but it is still a good thing. Because of their high center of gravity, he thinks trucks should always be traveling slower than other traffic. One driver overturned a truck on the loop ramp at I-20/I-285 and insists that his speed was only 24 km/h (15 mi/h). Exceeding the speed limit is a problem almost everywhere, and some people will exceed the safe speed no matter how well the road is designed. He advocates installing a governor on all vehicles so they cannot exceed 104 km/h (65 mi/h).

The petroleum tanker driver mentioned the westbound I-20 to southbound I-285 ramp as being the worst ramp in Atlanta. He said most drivers approach an unfamiliar ramp by "going with the flow of other traffic." He also believes the over-speed warning device would help truck drivers in some situations. When asked how much "slosh" is involved in tanker trailers, he responded that all of their company's trailers have baffles which remove the problem, and he delivers only full loads. He did state, however, that trailers which haul chemicals do not have baffles and partial loads are much more hazardous.

The concrete redi-mix administrator stated that the only over-speed warning device he was aware of was I-285 to I-75 in Cobb County. He has not noticed a lot of accidents there, but thinks the situation is dangerous. He thinks the speed is set too low on the device, so it might as well be continuously flashing. He admits that it might be helpful for out-of-town truck drivers. His drivers are already cautious because of the type of load they haul.

ADDITIONAL ENFORCEMENT

Background

Georgia DOT officials believe additional enforcement has been instrumental in reducing accidents involving large trucks. In 1986, trucks were involved in 45 percent of the accidents resulting in fatalities in Georgia. Beginning January 15, 1987, traffic law enforcement activity was increased substantially on I-285.

Implementation

The Georgia State Patrol assigned a special task force contingent of 18 officers to patrol I-285 7 days a week for 90 days beginning January 15, 1987. Special emphasis was placed on truck violations such as speeding, following too close, and improper lane changes.

The additional enforcement was conducted by diverting existing manpower to focus on large trucks. No known additional costs were incurred in this effort. Obviously, benefits from this effort must be weighed against possible losses in other areas that were not enforced as heavily due to this concentrated effort.

Effectiveness

After the first 45 days of this additional enforcement, Georgia DOT reported the following generally positive results:

- Speeds in the right lanes on I-285 decreased 9 percent even though speeds in other lanes increased.
- A reduction for all accidents (decreased by 18 percent) and for trucks (33 percent) as compared to projections for this same (short) time period.
- A reduction by 85 percent occurred for tractor-trailer overturn accidents or others resulting in considerable traffic impacts.
- Georgia State Patrol issued 572 citations involving trucks on I-285 during the first 45 days.

The additional enforcement of truck driver violations on I-285 was a short-term countermeasure lasting for 3 months. Georgia DOT conducted a comparison on the change in the number of accidents for several 2-month periods: 2 months during the additional enforcement (January-February, 1987), 2 months of the preceding year (January-February, 1986), and the 2 months preceding the enforcement period (November-December, 1986). Table 2 lists the comparison. Comparisons indicate a reduction in the number of truck-involved accidents for the test period compared to the other two periods. No specific information was provided on traffic volumes to allow an accident rate analysis, however, the average volume on Georgia Interstate highways increased by approximately 5 percent from 1986 to 1987. The reduction in accidents during this time period of increased enforcement is inconclusive because the effects of other factors, such as the freeway reconstruction program, which was not controlled or accounted for in the calculations.

Table 2. I-285 accident comparisons.

Vehicle Type	Period 1 Jan-Feb 1986	Period 2 Nov-Dec 1986	Test Period Jan-Feb 1987	Difference from Period 1[1]	Difference from Period 2[1]
All Vehicles	388	475	415	+ 7%	-10%
Combinations	80	82	69	-14%	-13%

[1] Corrected for number of days.

Truck Industry Views

Beyond the immediate impact of the fine that was assessed, truck drivers consider moving violations a serious matter because they are allowed only a limited number of these citations. General comments from truck drivers indicate that enforcement has been too strict at times, especially in regard to approaching left-hand exits. Truck drivers believe there is a lack of understanding on the part of enforcement personnel concerning the distance required for trucks to move across traffic lanes in heavy traffic, and that there should be a traffic sign indicating to truck drivers exactly where they can legally occupy other lanes.

CHAPTER 3

CAPITAL BELTWAY CASE STUDY

OVERVIEW

Description of Area

Several truck accident countermeasures have been implemented in the Washington, DC area. The Capital Beltway (I-95 and I-495) and its ramps are the primary focus of these actions. Within the area, two key jurisdictions are involved: the Maryland State Highway Administration (MSHA) and the Virginia Department of Transportation (VaDOT). Figure 10 shows the Washington, DC/Maryland/Virginia area boundaries and the location of several of the countermeasures near the Capital Beltway.

Limited classification counts based on vehicle lengths were conducted by MSHA on the Beltway in November 1991. The first location on I-495 west of Route 236 had a total daily volume of 169,344 vehicles with 4.7 percent vehicles over 6.4 m (21 ft) in length. The second site, which was on I-95 south of Md Route 214, had a total daily volume of 136,630 vehicles with 10.4 percent vehicles over 6.4 m (21 ft) in length. Other vehicle classification counts conducted by Virginia DOT are provided in table 3.

Countermeasures Implemented

The following are among the major truck accident countermeasures implemented in the Washington, DC area:

- **Urban Inspection Stations**--Virginia has constructed an urban inspection station; Maryland uses an underutilized park and ride facility for truck inspections.

- **Ramp Treatments**--Static signs have been used to warn truck drivers.

- **Incident Management**--Maryland is evaluating the purchase of a heavy-duty tow truck and contractual arrangements with private tow truck operators.

- **Lane Restrictions**--Maryland and Virginia restrict trucks from the extreme left lane on the Capital Beltway.

- **Reduced Shoulder Parking**--Maryland allows truck parking at night in park-n-ride lots.

In addition to those listed above, other truck accident countermeasures are being investigated by the responsible agencies. There is very little in-depth information to report on these countermeasures, but they include: voluntary bans on trucks during peak traffic periods, fixed radar, and a public information campaign on trucks.

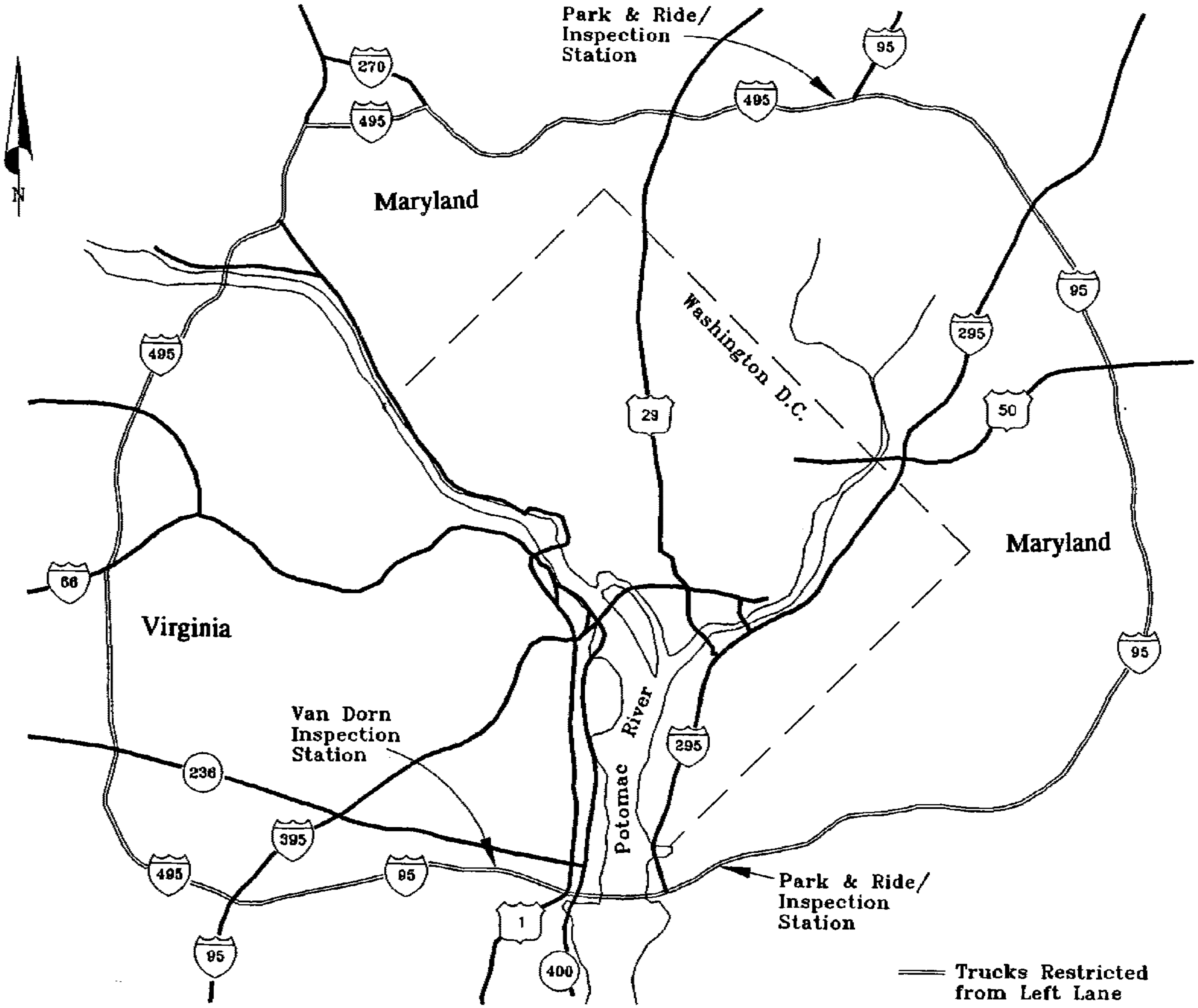


Figure 10. Washington, DC freeway system.

Table 3. Traffic volumes for selected sections of the Capital Beltway.

ROUTE / SECTION	I-495 from Rt 620 to Rt 236	I-495 from Rt 236 to Rt 620	I-95 from Rt 241 to Rt 1	I-95 from Rt 1 to MD State Line
PASSENGER CARS	159,000	169,000	121,100	130,700
SINGLE UNIT TRUCKS	6,390	6,670	13,000	7,700
TRACTOR TRAILERS	3,795	3,995	9,150	9,360
TWIN TRUCKS	55	55	250	240
TOTAL VEHICLES	169,240	180,760	143,500	148,000

Source: Virginia DOT

Maryland. MSHA evaluated the possibility of regulatory time restrictions on the Capital Beltway for all trucks. They found that the Interstate Commerce Act precludes this restriction on freeways (also determined separately in Los Angeles and New York City). Therefore, MSHA is now approaching the problem with voluntary restrictions as the twin cities of Minneapolis/St. Paul have done. The initial feedback indicates little or no success, but MSHA sources admit that quantifying success in this program is difficult.

Virginia. Virginia is also asking truck drivers to voluntarily limit their operations during peak periods. Companies are asked to receive deliveries after 5 p.m. in order to reduce congestion. One group being targeted for peak period avoidance is trash haulers. Virginia has instituted an Informational Bureau as part of a massive campaign to educate the public about trucks. The public information firm hired for the campaign collaborated with the American Automobile Association (AAA), the American Trucking Association (ATA), and others to develop and disseminate the information. Driver/vehicle elements were included such as "blind spots" and following trucks too closely. One resulting action was restricting hazardous materials trucks to only the right two lanes because many of the sideswipe accidents were being caused from trucks changing lanes.

Virginia has tried including meetings in which independent truck drivers, the ATA, and carriers discuss problems associated with truck operations in large urban areas. Also, Virginia uses a differential speed limit in rural areas. The speed limit for cars is 104 km/h

(65 mi/h), but trucks are limited to 88 km/h (55 mi/h). In urban areas, the speed limit is 88 km/h (55 mi/h) for both cars and trucks.

Accidents

Maryland and Virginia sources stated that, on the average, 24 percent of the accidents on the Beltway involve trucks. Several autos are typically involved in each truck accident, however, and the severity is typically greater where trucks are involved.

Truck Industry Views

Four truck drivers, who are currently based and/or operate around the Capital Beltway area, were interviewed for their perspective on implemented countermeasures on this roadway. Contacts with these individuals were made by telephone. Most of them have driven trucks in the past and/or are currently driving them on a part-time basis.

The first interviewee is currently a safety director who has limited truck-driving experience. He oversees driving safety for a company that specializes in transporting bituminous products. The second person interviewed is a concrete redi-mix president of a firm operating out of Virginia. He has limited driving experience as well. The third interviewee is a safety officer/assistant manager for a private carrier. He was a driver for 5 years, and participated in local and regional driving. The carrier operates vans and petroleum product tankers. The fourth contact is currently employed with a moving company that operates throughout the continental U.S. He was a driver only briefly, and now is an administrator.

URBAN INSPECTION STATIONS

Background

Three inspection stations are located near the Capital beltway: at the I-95/I-495 interchange in Maryland, at the Maryland Route 210/I-95 interchange in Maryland, and the Van Dorn Street inspection facility in Virginia (see figure 10).

Maryland. Originally, I-95 was designed to go directly through the District of Columbia. This plan was abandoned, however, leaving some of the right-of-way and paved areas within the I-95/I-495 interchange north of downtown underutilized. A park-and-ride lot was developed for commuters in this area, but only a small percentage of its capacity was being used. As part of a more aggressive campaign to reduce truck accidents on the Capital Beltway, MSHA began using a portion of this paved lot for truck inspections, and occasionally for weight enforcement.

Maryland State Highway Administration officials stated that due to an increase in truck incidents on the Beltway, safety measures were implemented at the I-95/I-495 location beginning in 1988. The Maryland State Police developed a two-pronged approach which is still in use to apprehend safety violators at this location. First they use a roving cruiser to pull trucks to the shoulder, then require violators to follow the patrol car to the park-n-ride lot. This approach is somewhat ineffective since it limits the number of vehicles that can be inspected. The MSHA wanted to build an inspection facility similar to Virginia's Van Dorn facility (see discussion below), but they could not find a suitable site. The State Police also conduct inspections at two rest areas near Laurel, Maryland, situated between Washington, DC and Baltimore.

Maryland spent $200,000 on a study to evaluate privatization of rest areas. One proposal included a very large truck stop facility adjacent to a rest stop. As part of the package, the State would have built a truck inspection station. The proposal progressed to the point of advertisement, but the governor stopped it because of enormous public opposition. MSHA officials believe "it will be next to impossible" to build inspection stations in urban areas in the future and have, in fact, seen similar opposition in rural areas. If another inspection station is ever built in an urban area, they quickly point out that the public will demand everything possible to make it environmentally acceptable (e.g. sound walls).

Because of difficulties in building additional inspection stations, some agencies are adding personnel to existing sites. For example, Maryland's truck inspection forces have increased dramatically in the past several years with the increased emphasis on truck inspections. Several agencies are involved, including local and State police. Local police have sites where they can stop trucks and get them out of the traffic stream. Their focus is on intra-city delivery trucks, because over-the-road trucks are inspected elsewhere.

Virginia. Virginia DOT personnel estimate that they weigh about 12 million trucks a year. Many of the weighing operations coincide with truck inspections; however, the Van Dorn Street inspection facility only accommodates inspections. Figure 11 shows a schematic and dimensions of the station. According to VaDOT officials, the inspection station at the Van Dorn Street exit resulted from conversations with State police at Federal Highway Administration engineering and enforcement conferences for city and State personnel, enforcement agencies, fire departments, and engineers. Subsequently, Virginia hosted the first southeast regional conference. State police identified the Capital Beltway as a facility that needed one or more Bureau of Motor Carrier Safety (BMCS) inspection facilities. Several VaDOT representatives from the office of Location and Design evaluated the entire Beltway in Virginia to identify appropriate sites.

Implementation

Maryland. For Maryland, implementing inspection programs was relatively easy and inexpensive because facilities already existed. A paved area within the I-95/I-495 interchange on the north side of the Washington, DC area was initially built as a park-n-ride lot. Its under utilization led to an alternative use for truck inspections. MHSA installed a concrete barrier between the area to be used for park-n-ride vehicles and the area to be used by State police for inspections. They also installed guide signs within the inspection area to provide directional information to users.

Along with the I-95/I-495 inspection station, another inspection location is at the interchange of the beltway with Maryland Route 210. Both locations require an officer to pull the truck over and escort it into the station, which means that only a fairly small sample can be inspected. In the past, Maryland used construction funds to build new inspection facilities, and maintenance funds if minor maintenance of the facilities was needed, although major maintenance projects may require construction monies.

Virginia. In 1983 when the Dumfries, Virginia weigh station was built on I-95, 20 miles south of the Beltway, VaDOT built a truck rest area. In the rest area, they built pits and a Bureau of Motor Carrier (BMC) building, which has rest rooms and desks for officers. During the 1990 calendar year, Virginia State Police inspected 3,400 trucks and took 1,400 or 40 percent of them out of service. Virginia is now building more segregated rest area facilities, separating cars from trucks. Rest areas are added or changed to accomplish the separation on sections of freeways being reconstructed. According to Virginia representatives, two or three facilities have been built or reconstructed and the State intends to inspect trucks at each of them. Because truck drivers are required by law to sleep a certain number of hours, the State wants to provide locations for this requirement. When these rest areas reach capacity, drivers resort to parking on ramps and shoulders.

Through legislative action in Virginia, most urbanized counties have police who perform inspections in addition to other enforcement activities. Some examples are: Fairfax, Prince William, and Loudon Counties. Truck operators are concerned because they

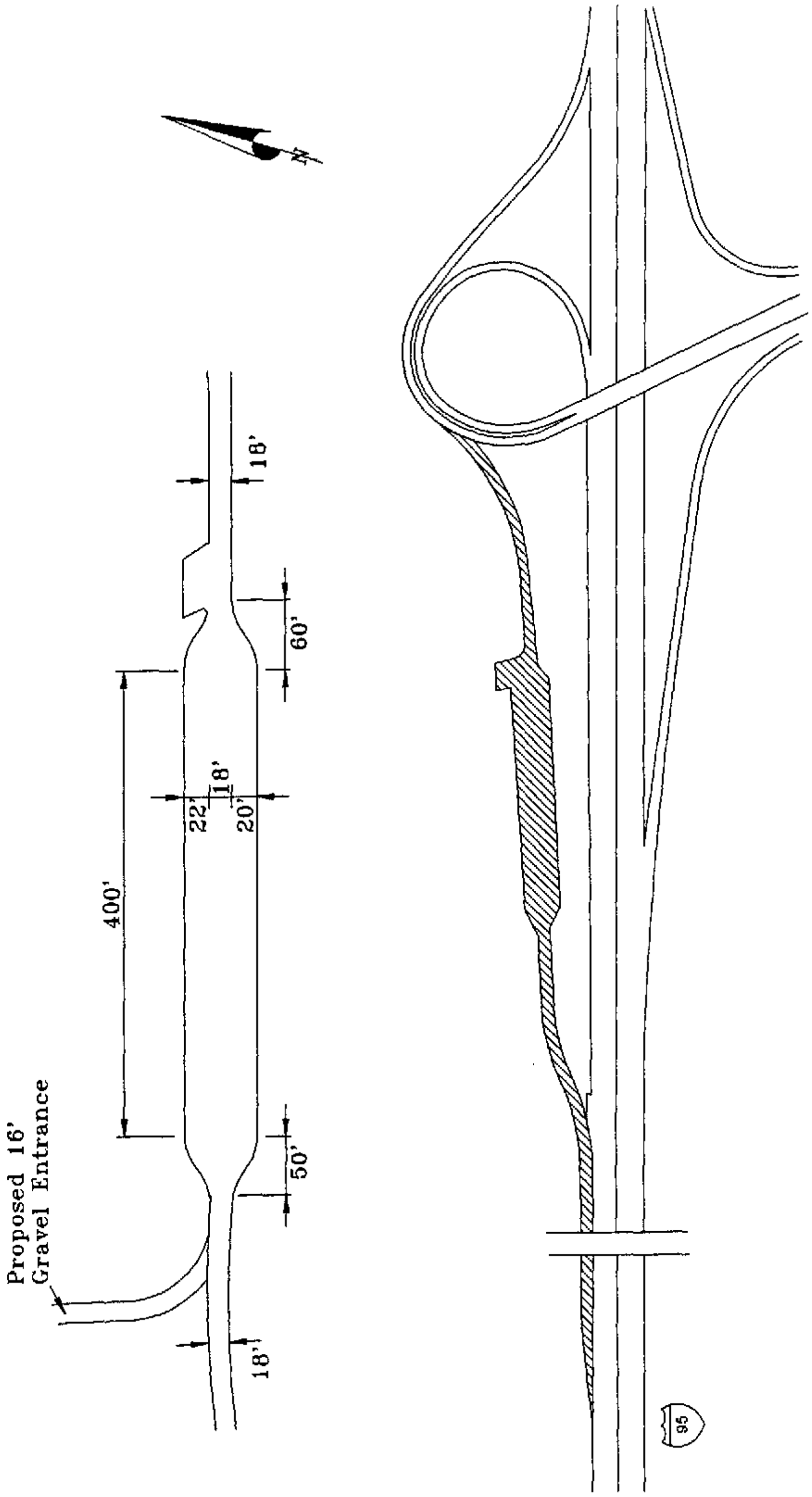


Figure 11. Van Dorn Street inspection station.

may be subject to several inspection stops while travelling through one urban area. To overcome this problem, the various enforcement agencies have developed a decal for display.

The inspection facility built by Virginia at Van Dorn Street used construction monies, while maintenance costs for the facility were from the maintenance budget. As a general rule, if a facility already exists, maintenance funding is used. Virginia uses its maintenance budget for any new (unexpected) regulations which must be met as well. The total construction cost of the Van Dorn Inspection Station in 1987 was $962,000. This facility has led to excellent public relations, so VaDOT officials maintain that the return is well worth the investment. One inspection facility being considered is near I-66, close to the American Legion Bridge (see figure 10). Traffic volumes are very high near this location at over 200,000 vehicles per day, but the total current cost would be $3.5 million, not counting sound walls that are now required. The State DOT admits that it just does not have the resources to accomplish this. As part of a second enforcement/engineering conference, VaDOT and the State police identified and established implementation priorities for 50 to 60 sites statewide that could be used for weighing and inspecting vehicles.

Effectiveness

Maryland. Maryland maintains an inspection database. It currently inspects 55,000 vehicles annually and expect this number to increase. It also has conducted special operations in Baltimore at tunnels and bridges. For full inspection of the vehicle and driver (MCSAP Level 1), it is currently (1991) taking 42 percent of vehicles inspected out of service. This percentage has decreased from approximately 3 years ago when the State was finding 53 percent of the trucks which had defects serious enough to take them out of service.

Maryland officials claim they do not get noticeable bypassing activity due to weigh-in-motion (WIM) activities because their WIM is attached to a bridge structure. They believe truck drivers do not know they are being studied. Maryland State Highway Administration personnel admitted they do not know what diversion, if any, occurs with inspections only. Because inspection stations close at 5:00 p.m. and inspection staff leave the site, truck drivers are able to leave without actually having made the required safety improvements. For safety equipment defects, Maryland requires reinspection within 15 days, but this applies only to vehicles registered in Maryland. State congressional staff made a follow-up (effectiveness) study to determine if repairs are made once a vehicle is taken out of service by State police.

Virginia. Virginia DOT personnel have received very positive feedback from the Van Dorn street inspection station. The Van Dorn inspection station was built at an existing highway facility where right-of-way already existed and a portion of an existing ramp could be used. A measure of effectiveness of this program would be whether the number of vehicles taken out of service due to mechanical defects is changing. Comments regarding this were inconsistent. Some of the VaDOT personnel contend that because the percentage taken out of service used to be 60 percent and is now 40 percent, the situation must be improving. State police officers who expressed opinions disagreed with each other on whether the number of vehicles taken out of service is decreasing. One pertinent factor to consider is the selection of vehicles to be inspected at the Van Dorn Street site is not random. For example, they do not inspect carriers with known effective safety programs because their resources are better spent elsewhere. Virginia State Police usually stop vehicles based on "probable cause." If they do not observe trucks with suspected or obvious violations, they stop vehicles at random (e.g. stop the tenth truck to pass their location). Because not all apprehensions are random, the percentage taken out of service cannot be applied to the entire truck population. The out-of-service proportion would be somewhat less for all trucks.

The trucking lobby in Virginia is very powerful according to VaDOT spokesmen. The chair of the House of Representatives Roads Committee is a trucker, whereas the comparable Senate committee is composed mostly of persons from northern Virginia who balance the situation in the other direction. In general, trucking interests in Virginia are supportive of inspections, probably because independents are thought to be heavy violators. Virginia sources predict that improvements in their inspection program will involve increasing the number of officers rather than the number of inspection stations. Virginia has fewer than 30 troopers statewide specifically assigned to Motor Carrier Enforcement, according to VaDOT personnel. State officials have identified this area of enforcement as one which needs to be expanded. One Virginia legislative committee believes this activity to be very cost beneficial and intends to approve additional funding to increase the activity level. Virginia uses Motor Carrier Safety Assistance Program (MCSAP) funds as seed money, but it is limited.

Another measure of effectiveness of Virginia's countermeasure is the diversion of trucks to alternate routes in order to avoid the inspection (and/or weighing) site. The VaDOT does a bypass study every year by using a motor home to study the effects of enforcement. However, these studies are inconclusive in determining the amount of diversion. VaDOT arrives at some of their conclusions through monitoring Citizens Band (CB) radio and through conversations at truck stops. Virginia also has its own vehicle inspection program in addition to MCSAP. The motoring public is very supportive of this countermeasure because they feel safer if large vehicles are required to pass a safety inspection. As elsewhere, they are supportive as long as the inspection station is not near their homes.

Truck Industry Views

The safety director thought that many agencies--city, county, State, Federal--have the authority to stop trucks and inspect them. He further stated that inspections are not conducted at safe locations. He would like to see appropriate areas designated for this purpose. Also, there should be adequate "runways" to decelerate and accelerate to achieve the speed of through traffic, and queues should not extend onto shoulders adjacent to through lanes.

The concrete redi-mix president found the Van Dorn urban inspection station to be a problem because concrete has a short life-span, and waiting for an inspection can ruin the product. Otherwise, he favors inspections.

The safety officer/assistant manager agreed that urban inspection stations were well-intended countermeasures, but create tie-ups. He stated that almost every truck entering the beltway has already been through a scale. He wasn't sure if the personnel at the Fairfax County Van Dorn Inspection Station were properly qualified or trained to run inspections.

The administrator stated that the Virginia inspection stations run by VaDOT or the State police were fair and consistent, however, those beltway stations run by Fairfax and Prince William counties were less consistent in their inspections. He remarked that the inspectors at these particular stations were not as well-trained as the State inspectors.

RAMP TREATMENTS

Background

According to MSHA personnel, truck drivers in their State favor more signing specifically intended for them. They perceive that roadways are designed mainly for cars, so additional warning for trucks is needed. Vehicles have changed significantly over the years. The cornering abilities of automobiles has improved, while trucks have gotten larger and the loading trend is toward a "cube-out" condition. This increases the center-of-gravity height. While vehicles are changing, designers continue to use the same procedure for establishing advisory speed signing on curves. One MSHA engineer believes their agency has created a very large credibility gap because the speed is set much slower than most drivers can comfortably drive, although on rural roadways, this may not be the case. Truck drivers feel that they depend more on these signs because their vehicles have greater rollover potential than cars. Truck drivers in Maryland have expressed some interest in having a dual advisory system -- one for trucks and one for cars.

Maryland. The overhead truck tipping sign near the I-95 southbound to the eastbound Capital Beltway connector was installed in January or February 1990. The cost of this sign was not provided by MSHA. Installation of the sign was prompted by trucks overturning on this ramp. Figure 12 shows this sign.

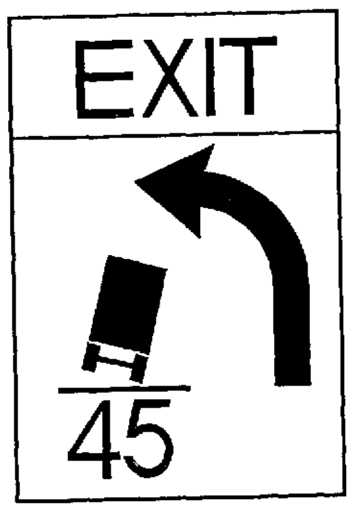


Figure 12. Truck tipping sign installed on I-95 southbound.

Virginia. Virginia DOT installed truck tipping signs at the following ramps on the Capital Beltway: 1) I-95 northbound to US 1 northbound ramp in Alexandria, 2) Route 236 eastbound to I-495 northbound, and 3) I-495 northbound to Route 236 westbound. All three of these ramps are loop ramps with 32 km/h (20 mi/h) advisory speed plates used in conjunction with the truck tipping signs. The cost of these 1.2 m by 1.2 m (48 in by 48 in) diamond-shaped signs plus 0.6 m by 0.6 m (24 in by 24 in) advisory speed plate and post was $282 each. Virginia DOT sources did not think these signs were installed as a result of accidents, but were a proactive measure to prevent tanker truck overturning accidents. Figure 13 shows the use of the (tanker) truck tipping signs.

Implementation

When comparing the implementation of ramp countermeasures to prevent truck accidents and incidents, it appears that both Maryland and Virginia have adopted roughly similar approaches. Each State used a ball bank indicator on their ramps, reviewed accident reports, and then installed warning signs.

Figure 13. Tanker truck tipping sign used by Virginia DOT.

Maryland. Maryland State Highway Administration personnel first used a ball bank indicator to check all ramps on the Beltway within their jurisdiction, using both a car and a truck in their testing. They found that some ramps had posted advisory speeds which were too high according to this traditional method. MSHA personnel felt that using this method alone is inadequate.

After checking ramp speeds and accident histories of ramps within its jurisdiction, Maryland then installed "truck tipping" signs on ramps that appeared to be problematic (higher than the statewide average accident rate). These signs used the new diamond grade reflective sheeting that is superior to lower grades of reflectivity. The signs employ an arrow (diagrammatic), an advisory speed, and the truck pictograph. The ramp noted above at I-95 southbound requires a left-hand exit for southbound traffic desiring to go eastbound on the Capital Beltway. The posted speed limit is 88 km/h (55 mi/h), and the tipping sign uses an advisory speed of 72 km/h (45 mi/h). The sign is located approximately 1.7 km (1 mi) upstream from the ramp gore on an overhead structure. Closer structures were not sufficient to support the large sign. The sign measures 1.8 m by 2.1 m (6 ft by 7 ft) and includes a diagrammatic (arrow) depicting the alignment of the ramp.

Virginia. In Virginia, the countermeasure implemented on several ramps on the Capital Beltway was speed reduction. Like Maryland, Virginia personnel also used a ball-bank indicator, mounted in a car on all ramps within its jurisdiction on the Beltway. They found that speeds needed to be adjusted on 44 ramps. They also tested the ramps using a ball-bank indicator inside a truck. The results were not significantly different from the auto readings, unless the truck-plus load had a high center-of-gravity and the load was subject to shifting while the vehicle was turning. A Virginia DOT design engineer agreed with personnel from Maryland that two different advisory speeds should be posted -- one for automobiles and one for trucks. The biggest truck operating on roadways when the Beltway was built was 16.8 m long (55 ft) and weighed 61,676 kg (68,000 lb), according to VaDOT personnel.

Sign placement is also important in warning drivers of hazards on ramps. A Virginia design engineer believes that some of the advisory panels are placed so close to the ramp that they do not allow truck drivers enough reaction time. Sometimes a truck driver is able to negotiate the ramp, only to roll over after entering the main lanes. This might indicate a load shift. Virginia DOT evaluated the accident history on ramps along the Beltway to determine which ramps had three or more accidents involving truck rollovers. While they did not find any ramps that had three accidents, they did install some warning signs as a proactive measure. An example is a truck tipping sign installed on Virginia's portion of the Beltway near the Fairfax County tank farm at the Route 236 interchange (see figure 13). VaDOT personnel placed the tipping signs using a tanker silhouette on the northbound I-495 to westbound Route 236 ramp and the eastbound Route 236 to northbound I-495 ramps (see figure 14). This was also a proactive measure rather than being based on accident history.

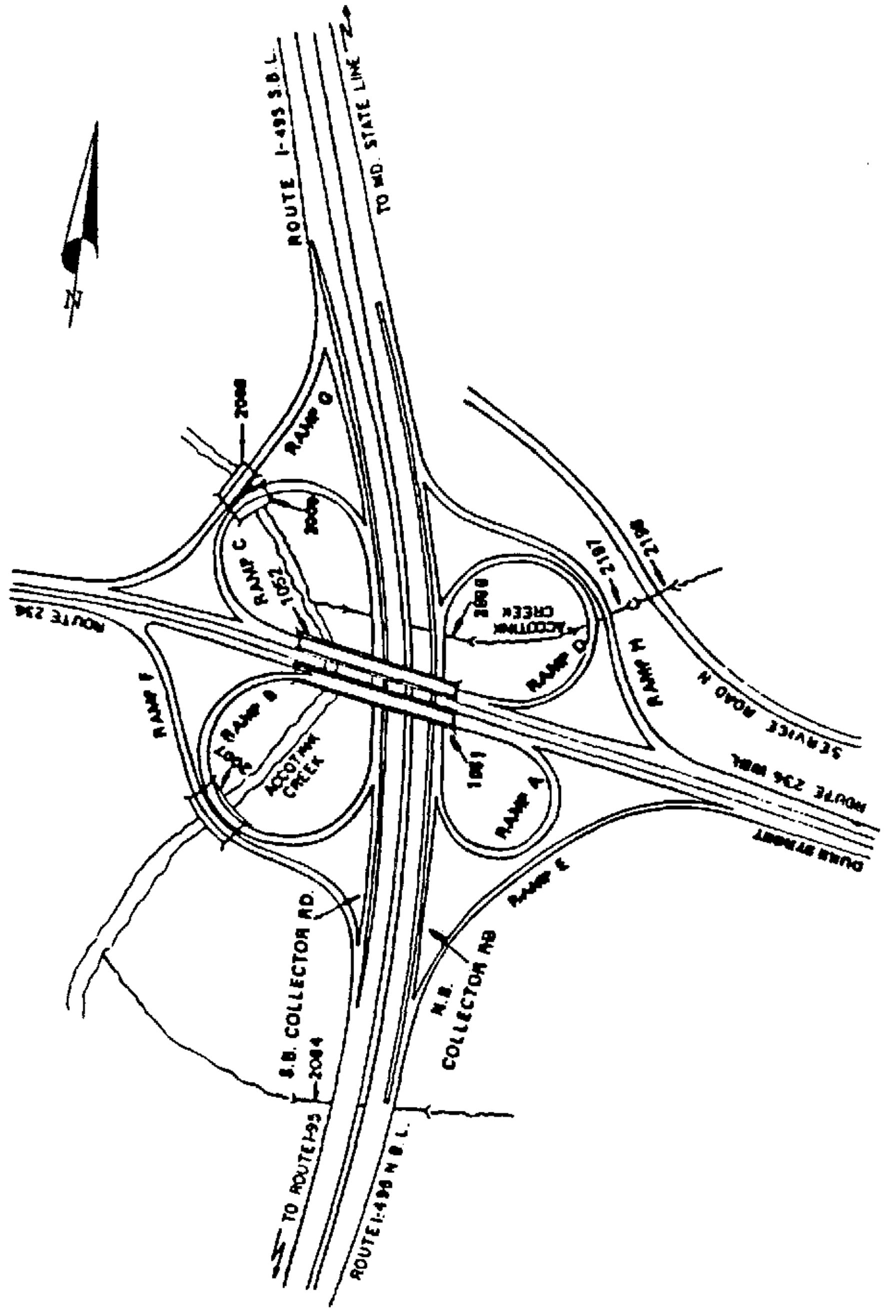


Figure 14. I-495/Route 236 interchange.

Older tanker trailers are especially problematic because they do not have baffles to reduce slosh. According to one VaDOT source, drivers are not necessarily familiar with the roadways and need special warning devices. Another truck tipping sign was installed on the Route 1 Alexandria exit for eastbound traffic on the Capital Beltway (see figure 15).

Effectiveness

Maryland. Truck drivers in Maryland prefer the truck tipping signs to signs used for all traffic, according to MSHA sources. In fact, truck drivers sent a list of sites to MSHA indicating where they thought the signs should be installed. Both motor carriers and independents would like to see them installed on a more widespread basis. A MSHA engineer warned about using them too often, because he believes overuse would reduce the sign's effectiveness. Enforcement is not an issue with this sign because advisory speeds and not regulatory speed restrictions are used. Maryland also attempted speed control using stationary radar to simulate the presence of enforcement. No indication of its effectiveness was provided.

Virginia. Virginia's procedures for sign implementation usually begin with an engineering study for placement, but sometimes the process starts with recommendations from the State police. Virginia personnel stated they are using the same truck tipping sign first used by Maryland, however, at the two interchanges of I-95/US-1 and I-495/Md 236 they installed signs that depicted a *tanker* silhouette. MSHA is using the same sign as CALTRANS. See figures 12 and 13 for a comparison of the two silhouettes. The current ramp signing study sponsored by the FHWA identifies several variations of this same sign from several States that are employing this countermeasure. The MSHA source indicated there is some confusion as to the meaning of the arrow (diagrammatic) on this sign. Some motorists seem to think the arrow is going the wrong way.

Truck Industry Views

The safety director stated that passive signs (intended for all traffic) pose a problem for truck drivers. If they are not familiar with a posted speed on a ramp, they *must* proceed more slowly than the speed posted for the ramp. He says these speeds are set for cars and not for trucks, therefore, they are not safe. He also thinks ramp design is not safe for trucks. For liquid loads, at least 3 percent of the volume is always left unfilled to permit expansion. This allows the load to move when it is accelerated side to side and also front to back.

The safety officer/assistant manager was unaware of any ramp countermeasures, and hadn't noticed any signs. He remarked that none of his drivers had commented on them either.

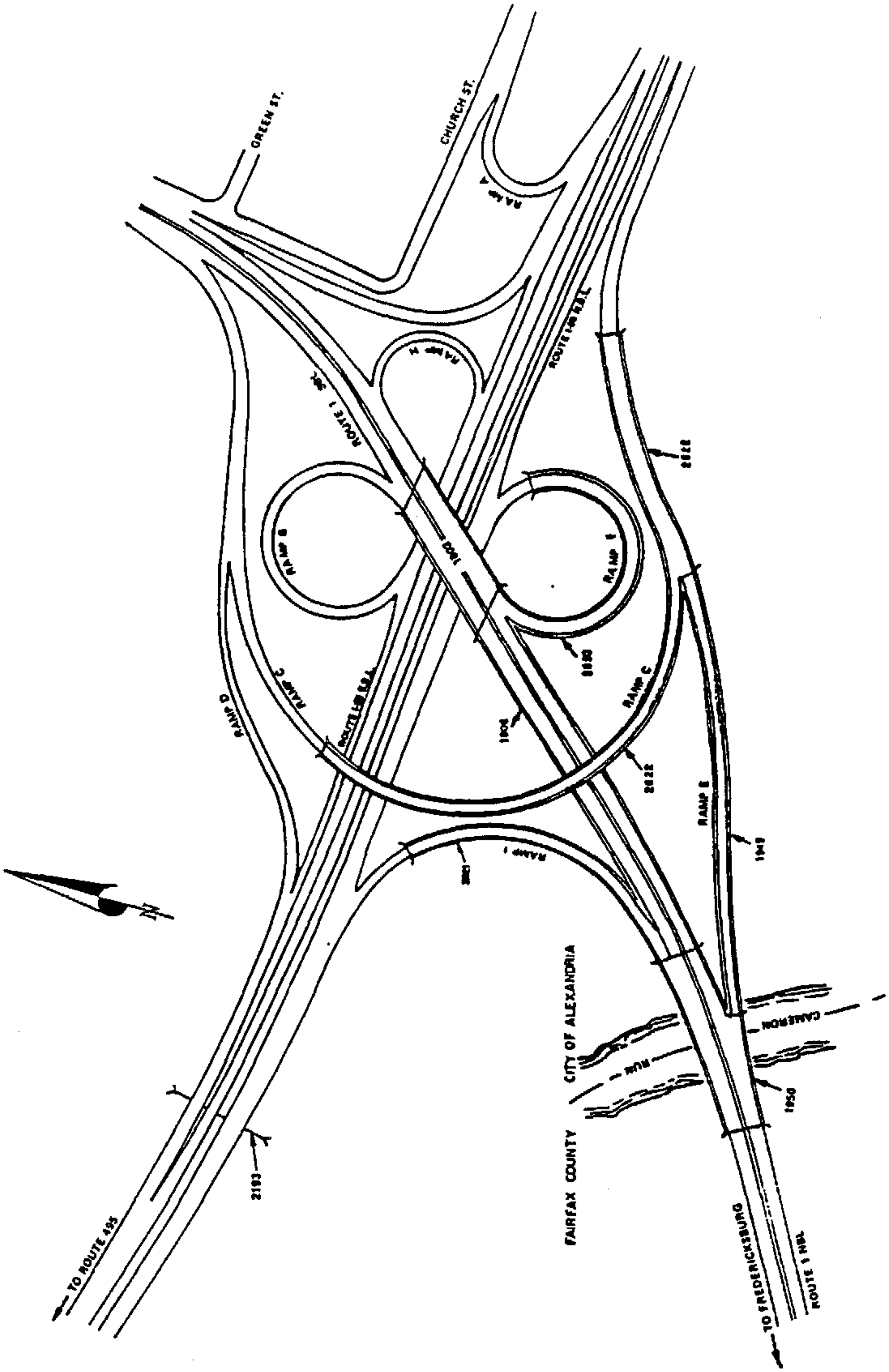


Figure 15. I-95/US 1 interchange.

The concrete redi-mix president stated that any information on ramps is helpful. His drivers know they are especially unstable in right turns. As the truck turns, the concrete naturally shifts in the direction the drum is turning. This interviewee was once driving in Arlington County where an active traffic device was employed, and felt that it was effective because he reduced his speed. He said that sign placement is a problem because often signs are too close to the hazard to allow for sufficient reaction time. He mentioned one ramp at I-95/I-495 that was known for many truck rollovers because of insufficient warning.

The administrator also didn't notice signs, although some of his drivers have commented on them. For example, some of his drivers think that the signs are a good idea, but often they are placed too close to the ramp to provide adequate warning.

INCIDENT RESPONSE MANAGEMENT

Background

Several different incident management programs exist in the Washington, DC area. Table 4 lists the type of equipment and program components for programs in Fairfax County, Virginia, in Maryland suburbs, and in Northern Virginia suburbs.

Maryland. Maryland has incident management teams for all Interstate highways. Each of the 23 counties has a resident maintenance engineer who is responsible for the incident management plan. This individual is responsible for alternate route plans, signs, and other emergency equipment.

The State has a program called "CHART" which will eventually be capable of monitoring freeways through surveillance, communication, and control hardware. Maryland also has a State Police Liaison Officer who is responsible for incident management. MSHA has taken an aggressive posture regarding clearing a roadway, except when hazardous materials or pending injuries are involved.

Virginia. Virginia State Police operate courtesy patrols that respond to minor incidents. A proposed action to facilitate quicker response time to incidents would include wreckers to respond to incidents as part of a major construction contract. Whether the road can legally be cleared immediately of spilled loads, regardless of further damage to the load, is also being investigated. At present, the normal procedure is to wait for law enforcement to arrive on the scene.

Washington, DC Area. A consultant developed a regional incident management plan for the Washington, DC urban and suburban areas, including parts of Virginia and Maryland. Measures suggested to reduce response time and to keep traffic moving include stockpiling signs to prepare for incidents and developing alternate routing plans. There are many jurisdictional problems in the Washington, DC area that must be resolved to provide for efficient management of incidents.

Implementation

Maryland. The Maryland State Highway Administration developed a Maintenance Policy (71.01-05.1--Revised, April 1990, see figure 16) that calls for the prompt reopening of the roadway to traffic. The policy states that "the [Resident Maintenance Engineer] RME in cooperation with the police officer in charge should reopen the roadway as soon as possible on an urgent basis." The policy also "recognizes that public safety is the highest priority and must be secured, especially if injuries or hazardous materials are involved. It is understood that damage to vehicle or cargo may occur as a result of clearing the roadway on an urgent basis. While reasonable attempts to avoid such damage should be taken, the highest priority is public safety." The MSHA and the State police promptly clear the roadway if no hazardous materials are involved and there are no pending injuries.

Table 4. Incident management programs in the Washington, DC area.

Location	Fairfax Co., VA	Maryland Suburbs	Northern VA Suburbs
DETECTION AND VERIFICATION			
Traffic Operations Center	●	●	●
Service Patrols		●	●
Electronic Surveillance			●
Closed-Circuit TV			●
Citizen Call	●	●	●
Call Boxes			●
Other	●	●	●
RESPONSE			
Incident Management Teams	●	●	●
Wrecker Agreements	●	●	●
Agency Equipment		●	
Other		●	
MOTORIST INFORMATION			
Alternative Routes	○	●	●
Highway Advisory Radio		●	
Media Partnership	●	●	●
Variable Message Signs		●	●
GENERAL COMMENTS			
Comment	Non-freeway, county police program	Initial phase of state-wide CHART program	Major expansion underway

● = In place
○ = Planned or proposed

Source: Cambridge Systematics, Inc., JHK & Associates, Transmode Consultants, Inc. and Sydec, Inc. *Incident Management*. Trucking Research Institute, ATA Foundation, Inc. October 1990.

Maryland does not currently have special contracts with cranes or large tow trucks. The State police maintain a list of available cranes and locations, and also use a rotation list to determine who is next contacted. The MSHA would like to purchase at least one heavy-duty tow truck similar to the trucks used in Chicago, but currently do not have the resources for this relatively large investment of approximately $250,000. Yet, in evaluating Chicago's delay curves for very congested freeways, Maryland concluded that the heavy-duty response equipment would be worth the expense.

Maryland is currently evaluating several types of towing contracts. Reducing response time is one of the primary objectives in the evaluation of the new contracts. Developing a system of zones and hiring more than one towing contractor within each zone are being considered. The first contractor to arrive at the scene would be the one who is awarded the job. Also being considered is to have the contract include penalties if the tow rig does not arrive within a certain period of time.

A primary goal for Maryland is to inform the motoring public in real time about incidents so that the motorist can reroute their travel to avoid the incident. Maryland is now involved in a project that is combining video imaging, variable message signs, and Highway Advisory Radio (HAR). Maryland is planning to test some light emitting diode (LED) changeable message signs soon, along with highway advisory radio. Also being examined is the INFORM model used on the Long Island Expressway in New York. This system has cameras monitoring the freeways to quickly identify incidents. The INFORM system also has incentives built in so that operators can be paid a bonus if they arrive more quickly than a pre-defined limit.

Virginia. Removal and clearance of the roadway following an incident is the responsibility of the State police. They use push bumpers to move smaller vehicles from the roadway. Virginia, like Maryland, has also been studying the availability of heavy-duty tow trucks in the Washington DC area; they conclude that the private sector should provide the equipment. A task force of the Virginia Secretary of Transportation is also investigating ways to reduce the impact of incidents. The State police have a list of private tow truck operators who are contacted on a rotational basis. Virginia has also initiated service patrols so that minor mechanical problems can be corrected. These vehicles are currently being equipped with push bumpers to expedite the removal of smaller vehicles from the roadway. Virginia DOT personnel, through a cooperative effort with State police, are being trained to safely and effectively use these devices. Virginia's General Assembly passed an agreement in 1991 that will soon permit response to incidents that happen on the Woodrow Wilson Bridge. This allows the incident to be handled by the agency that first arrives.

The various agencies involved at a crash scene have different goals. By law, the Virginia State Fire Official is in charge at an incident. The Fire Official's primary goal is to prevent the situation from deteriorating, while the goal of the police is to maintain traffic movement. The Virginia DOT provides support as needed, such as hauling sand to the site. In summary, the State police are in charge of traffic control, but the fire chief is in charge of the incident in general.

MARYLAND STATE HIGHWAY ADMINISTRATION

MAINTENANCE POLICY 71.01-05.1 -- Revised | April 23, 1990

SUBJECT: PROMPTLY REOPENING ROADWAY TO TRAFFIC
Road/Lane Blocked/Closed by Accident or Loads Falling from Trucks.

PURPOSE: Whenever a roadway or travel lane is closed or partially blocked by an accident and traffic delays or safety problems may occur, the RME or his representative in cooperation with the police officer in charge should reopen the roadway as soon as possible **ON AN URGENT BASIS**. This policy recognizes that public safety is the highest priority and must be secured, especially if injuries or hazardous materials are involved. It is understood that damage to vehicles or cargo may occur as a result of clearing the roadway on an urgent basis. While reasonable attempts to avoid such damage should be taken, the highest priority is public safety.

PROCEDURE: Type of Occurrence

GENERAL

The RME or his representative is to assign the necessary equipment and manpower to reopen the road or lane as soon as possible.

If the incident involves any truck (other than a pick-up) or removal of debris (safe spilled cargo), a rubber-tired Front End Loader shall be dispatched to the scene as soon as possible in the event it could be needed to assist a tow truck in righting/relocating the vehicle(s) involved, or assisting in debris removal/relocation.

If commercial help does not arrive within a reasonable period of time, SHA forces shall begin the removal of vehicle(s)/spilled safe cargo.

If the commercial help is unable to correct the situation, the SHA shall assist by using the Front End Loader as needed.

If materials being transported are spilled, the SHA will make every effort to relocate the materials in the shortest possible time, using whatever equipment is necessary. All such materials shall be relocated as short a distance as possible, but not to be placed so as to present a traffic hazard.

The RME or his representative shall prepare a list of the personnel and equipment used and the work hours involved so that the owner of the vehicle and/or cargo can be billed for the cleanup. The SHA's towing response form shall also be completed for every incident involving the SHA.

Appropriate warning devices (signs, barricades, arrowboards, etc.) are to be placed on the scene should either the damaged vehicle(s) or cargo remain adjacent to the shoulder.

HAZARDOUS/FLAMMABLE/EXPLODING MATERIALS

No attempt is to be made by SHA personnel/equipment to remove any hazardous or flammable explosive material for any reason. If the SHA is first on the scene and the cargo content is not readily identifiable, the RME or his representative will contact the proper authorities to ascertain if special measures should be taken.

As soon as the public safety has been secured, then reopening the roadway is to proceed as described under "GENERAL" in this memorandum.

E. William Ensor, Jr.
Deputy Chief Engineer-Maintenance

Figure 16. Reprint of Maryland State Highway Administration quick removal policy.

Effectiveness

Neither Maryland nor Virginia have conducted site-specific delay estimates to determine the effectiveness of incident response and other specific countermeasures. Maryland State Highway Administration personnel stated they do not have the resources to conduct such studies. Also, this type of study requires making assumptions (e.g., on the value of time) that neither agency is comfortable making. They stated that some of the formulas yield up to a 100 to 200 percent difference in estimated delay.

Maryland. Maryland State Highway Administration personnel state that the changeable message signs are not always effective in warning motorists about traffic conditions. Therefore, traffic reporters in the Washington, DC area are considered a big asset. They do not overlap areas in which they fly and they readily communicate information to each other that provides motorists with details regarding road conditions.

Virginia. In examining the overall effectiveness of countermeasures, VaDOT sponsored a study of response times required by tow truck operators in their State and found that a 20-minute response time is usually required. They also evaluated the potential time-saving factor of adding call boxes and found it was insignificant. Virginia studies have also indicated that on a freeway with 1,500 to 2,000 vehicles per hour per lane (vphpl), 1 minute of congestion equals about 5 minutes of additional delay. So removing a blockage and clearing the freeway becomes extremely important. For every 5 minutes of congestion reduced, delay savings of 25 minutes plus reductions in secondary accidents could be realized. Virginia DOT sources agreed that technology providing real time information is vital in this regard. One example they cited was the Woodrow Wilson draw bridge incident where the bridge could not be lowered after being raised to allow the passage of ships. A message was provided to motorists at Woodbridge, south of the Beltway, informing motorists to use the west side of the Beltway.

Truck Industry Views

In response to incident management, the safety director is concerned about novice crane or tow truck operators who attempt to retrieve his trucks. If a State-owned crane comes out to an incident, he is wary of the operator's competence because the State does not provide economic incentives to attract the best operators. Also, they might send a 40 ton crane when a 60 ton crane is needed. One of his biggest worries is getting equipment to the scene with traffic blocking access.

The concrete redi-mix president said that he is not too concerned with crane or tow truck operator competence. He supports clearing the roadway as quickly as possible since delays are created when a truck rolls over or loses its load. As far as clearing the load immediately, his load is already lost if his trucks roll over.

The safety officer/assistant manager stated that incident response management is a good idea and the administrator commented that incident response is essentially great, but that it really aids motorists more than truck drivers.

LANE RESTRICTIONS

Background

Two lane restrictions that exist on the Capital Beltway (typically four lanes in each direction) are:

- All trucks are restricted from the left lane.
- Hazardous materials are restricted to the right two lanes.

In Maryland, evaluation of truck traffic on the Capital Beltway became crucial following a major truck accident. The Washington, DC news media emphasized the difference between the Capital Beltway and the Baltimore Beltway, which does not seem to have as many problems. The truck lane restrictions were initiated, not because of accidents, but because of political pressure. Overall, the lane restrictions did not seem to improve the situation, but auto drivers felt safer. A MSHA representative commented that there was no significant change in severity; accidents were simply moved from the fast lanes to the slower ones. Several studies were conducted on the effects of this restriction.

Implementation

Virginia DOT instituted a lane restriction for trucks on the I-95 section of the Washington, DC Capital Beltway between I-395 and west of the Woodrow Wilson Bridge (near the Virginia State line) on December 1, 1984 (see figure 10). A lane restriction was similarly imposed by Maryland on its portion of the Beltway in an attempt to reduce accidents.

Effectiveness

Maryland. In research sponsored by the MSHA, Sirisoponsilp and Schonfeld in 1988 reported on the strategies used by State highway agencies to restrict trucks from certain lanes and the impacts of the restrictions on traffic operations and safety.[9] State highway agency officials voiced mixed reactions on the effectiveness of lane restrictions on urban freeways. In those States where restrictions were used, reactions were positive. Yet, these reactions were based purely on judgements; no objective studies had been conducted to evaluate the impact of restrictions in those States. 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 their cost effectiveness is still doubtful.

Virginia. An analysis of the Virginia I-95 accident data for 1985, following the implementation of truck lane restrictions, showed a slight decline in the accident rate and in accident severity. The decrease in accident severity along with favorable public opinion led the authors to recommended retaining the restriction.[10]

A subsequent study evaluated accidents, speeds, and volumes along the Virginia I-95 section to determine the effects of the countermeasure.[11] The study included data collected during the 24-month period prior to implementation of the restriction and data collected periodically during the 24-month period following implementation. An analysis of the data showed that the accident rate increased 13.8 percent during the restriction, however, there was no change in the fatal and injury accident severity. The maintenance of severity level, plus favorable public opinion to Maryland's lane restriction, reinforced the authors' recommendation that the restriction be retained.

Further analysis of the Virginia I-95 data in 1988 showed that the accident rate increased for trucks on southbound I-95 during the truck lane restriction.[12] As a result of this increase and the increase discovered in the previous study, the authors recommended that the truck lane restriction be removed.

A subsequent evaluation indicated that the total number of accidents increased where restrictions had been enacted and that accident rates tended to be lower where less restrictions were present.[13] The authors found that there is some political and public perception that restriction of trucks to the right lanes makes the highways safer. Based on their study and others, however, they concluded that existing restrictions should be removed and additional restrictions not be considered. Lane restrictions are still in place.

Truck Industry Views

The safety director stated that trucks should not be restricted to the right lane only; instead a second lane should also be available. He stated that auto drivers complain about trucks occupying the right lane because it makes entry and exit difficult for them.

The concrete redi-mix president has no opinion on lane restrictions. He remarked that his trucks are geared for top speed of about 80 km/h (50 mi/h) so they do not need to travel in the "fast lane." He hears auto drivers complain about not being able to easily enter and exit from the right lane because of trucks.

In discussing lane restrictions, the safety officer/assistant manager said that his company does not like the drivers using the left-hand lane, although they should have that option if necessary. He commented that merging traffic is often responsible for problems on the roadway, particularly during heavy traffic. Under these conditions, he said that auto drivers cut truckers off because they can't move into the left-hand lane to get out of the way.

The administrator is familiar with lane restrictions, and stated that none of his drivers has any problem with them. In his company, there is emphasis on driving safety and courtesy as an integral part of the company's image.

REDUCED SHOULDER PARKING

Background

The Maryland DOT analyzed parked vehicle shoulder accidents on all major routes. They found that of the 746 parked vehicle shoulder accidents on Interstate routes, 31 (or 4 percent) were fatal accidents and that of the 11,082 parked vehicle shoulder accidents on all other routes 30 (or 0.3 percent) were fatal accidents. They also found that conditions involving parked vehicle shoulder accidents are considerably different from statewide vehicle accidents on Interstates. Some of the differences included:

- 0.8 percent of statewide accidents were fatal, compared to 4 percent of the parked vehicle shoulder accidents.
- 49 percent of statewide accidents involved injury, compared to 54 percent of the parked vehicle shoulder accidents.
- 34 percent of the statewide accidents occurred at night, compared to 54 percent of the parked vehicle shoulder accidents.
- 24 percent of the statewide accidents occurred when the pavement was wet, compared to 19 percent of parked vehicle shoulder accidents.
- 11 percent of statewide accidents involved alcohol, compared to 21 percent of parked vehicle shoulder accidents.

The analysis of accident data also showed that parked vehicle shoulder accidents on Interstate routes were most likely to occur on Saturday (19 percent of the total), and between the hours of 12 a.m. and 6 a.m. (40 percent of the total). Table 5 is a summary of parked vehicle shoulder accidents on Interstate routes in Maryland. The number of these which involved trucks parked on shoulders is not known.

Maryland's representatives stated that the issue of providing adequate rest area parking is very important. Currently, there is a shortage in parking at private truck stops. In the Laurel, Maryland area (northeast of Washington DC, near Baltimore), shoulder parking has been a significant problem. In many cases, these trucks are waiting until the port at Baltimore opens in the morning. According to MSHA sources, shoulder parking near Laurel is more of a problem in 88 km/h (55 mi/h) zones than in 104 km/h (65 mi/h) zones (possibly because these are urbanized areas). So, a traveling motorist is more likely to strike a parked truck in a 88 km/h (55 mi/h) zone. During a MSHA survey conducted at night, 50 to 60 tractor-trailers were parked along this particular length of freeway.

Table 5. Summary of parked vehicle shoulder accidents on Interstate routes in Maryland.

ACCIDENT SEVERITY	1985	1986	1987	1988	1989	TOTAL
Fatal Accidents	6	9	3	10	3	31
Number Killed	6	15	3	10	3	37
Injury Accidents	69	81	94	83	79	406
Number Injured	109	134	144	137	128	652
Property Damage Acc.	50	65	86	57	51	309
Total	**125**	**155**	**183**	**150**	**133**	**746**

Implementation

Because of the high numbers of trucks parking on shoulders and the under utilization of park-and-ride lots during nighttime hours, Maryland began allowing trucks to use park-and-ride facilities as an alternative to parking on the shoulders.

Effectiveness

MSHA conducted a simple survey to determine truck usage of park-n-ride lots. In general, MSHA believes, truck drivers do not use the lots because of low enforcement of shoulder parking. MSHA officials agreed with truck drivers that they need to improve the techniques used to provide information to truck drivers. Signs provide information on *when* restrictions are imposed and not when the lots are open to trucks. The message used on these regulatory signs within parking areas is NO TRUCKS 6 AM TO 10 PM.

Truck Industry Views

The safety director stated that it is unlawful to park anywhere on the Interstate. He agrees there is a shortage of parking areas. Truck stops that he has used have never charged for parking if no other services were required. The Michigan plan, where truck stops charge a fee for parking only, was news to him. In Virginia, rest areas are well-monitored. Some have time restrictions which do not allow parking longer than the posted time limit. If the truck driver parks elsewhere, a citation is given.

The concrete redi-mix president did not have a strong opinion on this concept except that truckers should be provided parking accommodations off the shoulder. The safety officer/assistant manager thought that shoulder parking was a good idea, and the administrator liked the idea of providing rest areas for truck drivers, especially when drivers are fatigued.

CHAPTER 4

CHICAGO, ILLINOIS CASE STUDY

OVERVIEW

Description of Area

Chicago is located near the southern tip of Lake Michigan. Its population, according to the 1980 census, was 3,005,072 (metropolitan area was 7,803,800). Several factors contribute to Chicago's heavy truck traffic. For example, Lake Michigan represents a natural barrier to expanding a roadway system. Also, northern Illinois and Indiana have a concentration of industries, such as steel, which generate heavy truck traffic. The established rail system in Chicago also results in several transfers of containerized freight between rail and truck. Because many of the arterial streets in Chicago have insufficient vertical clearance at overhead structures, trucks are using the freeways for short trips.

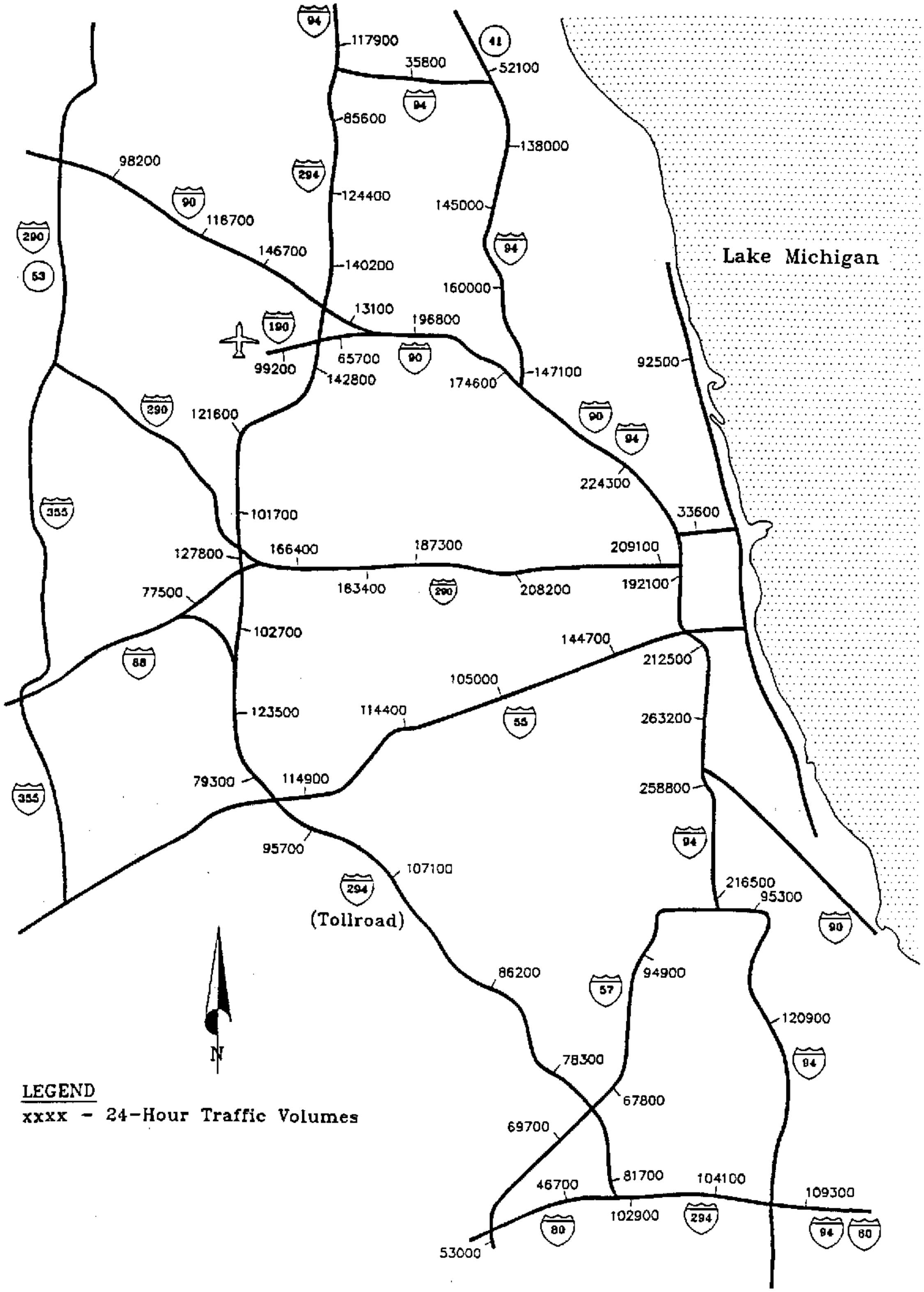
Prior to the reconstruction of a critical 4.8-km (3-mi) stretch of the Dan Ryan Expressway (I-90/I-94) in 1988-1989, between Thirty-first Street and the Eisenhower (I-290) Expressway, the Illinois Department of Transportation (IDOT) requested that truck traffic avoid the area near downtown, if possible. Rail interests discovered they could actually be more operationally efficient by removing their piggy-back operation from the freeway altogether.

Figure 17 shows average daily traffic (ADT) on the major freeways in Chicago. Figure 18 shows the heavy commercial traffic volumes and the multiple-unit traffic volumes. The heavy commercial traffic volumes include 6-tire and 3-axle single unit trucks, buses, and all multiple-unit trucks. The multiple-unit traffic volumes include tractor-semitrailer combinations, large trucks and trailer combinations, and two-trailer combinations.

Currently, the selection of routes for trucks and other traffic is limited in the Chicago metropolitan area. The north-south I-90/I-94 corridor has only one major route alternative, the I-294 toll road, available to traffic bypassing the downtown area. According to IDOT officials, many trucks continue to use the I-90/I-94 facility to avoid paying the toll. A cross-town expressway was proposed in the late 1970's as a relief measure, but was never built. Another factor resulting in high truck percentages on these freeways is low viaduct clearances on alternative arterial streets.

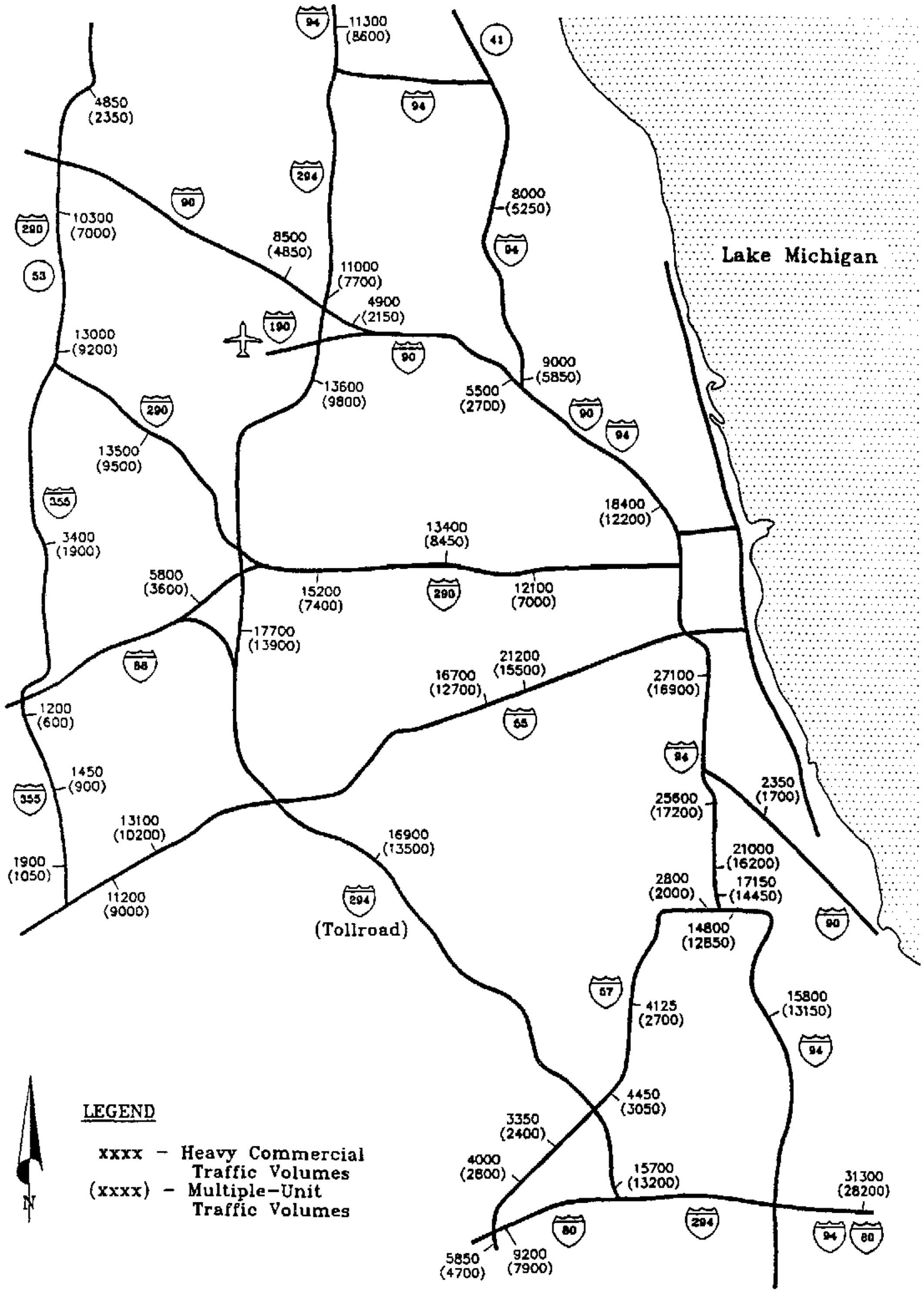
Countermeasures Implemented

The following countermeasures that have been implemented in the Chicago area were investigated. Brief introductions to these countermeasures follow:



Source: IDOT 1990 Traffic Map, Cook County

Figure 17. Chicago, Illinois freeway system and daily traffic counts.



Source: IDOT 1988 Average Daily Heavy Commercial Traffic Map, State Primary System and 1988 Average Daily Multiple-Unit Traffic Map, State Primary System

Figure 18. Chicago, Illinois average daily commercial traffic.

- **Incident Response Management**--In September 1961, a quick response unit was initiated to respond to traffic problems. A parallel effort began simultaneously in order to monitor freeway traffic conditions. These two efforts were the result of IDOT management's commitment to keep traffic moving on the freeways.

- **Lane Restrictions**--In 1964, trucks were restricted to the two right lanes on all freeways in Illinois, which have three or more lanes.

Accidents

IDOT provided accident information for the Chicago area. This is summarized in table 6.

Truck Industry Views

One interviewee is a safety director for a trucking company which hauls freight in the Chicago area. He has never been a driver.

Table 6. Chicago area expressway accident involvements by expressway and vehicle type during 1989.

TYPE OF VEHICLE	EXPRESSWAY											
	Calumet	Edens	Eisenhower	Inter. 80	Kennedy	Kingery	Dan Ryan	Stevenson	West Leg Dan Ryan	Eisenhower Extension	TOTAL	Percent
Passenger car	2193	2186	4915	70	8872	286	6078	2615	1181	3530	31926	74.2
Single unit truck or tractor	78	74	169	7	367	9	267	103	34	174	1282	3.0
Truck-trailer and semi-trailer	369	161	310	11	741	129	1091	384	65	331	3592	8.4
Pickups/vans	350	271	603	9	1180	57	793	340	152	606	4361	10.1
Bus	16	4	20	-	42	2	54	11	5	6	160	0.4
Motorcycle, scooter or bike	10	8	7	2	21	-	19	14	10	11	102	0.2
Other vehicle	3	1	10	-	10	2	5	3	1	9	44	0.1
Not stated	146	61	191	1	402	15	404	145	67	107	1539	3.6
TOTAL	3165	2766	6225	100	11,635	500	8711	3615	1515	4774	43006	100.0

Source: Illinois Department of Transportation

INCIDENT RESPONSE MANAGEMENT

Background

In September 1961, a quick response unit was initiated to respond to traffic problems, and a parallel effort began to attempt to monitor freeway traffic conditions. IDOT personnel did not know of any engineering study which was done prior to starting the freeway service patrol; IDOT simply made a commitment to keep traffic moving by whatever means were available. Initially, mobility on the Kennedy Expressway (I-90/94) was the problem area, but the service was soon expanded to other freeways. The use of service patrols began by obtaining any available vehicles such as old patrol squad cars and pick-up trucks with push bumpers. This group was soon given the name "Minutemen" because of their quick response. IDOT's Minuteman emergency response team is the only one of the 20 to 30 courtesy patrols throughout the country that owns a fleet of vehicles large enough to tow large combination vehicles.

Elements of freeway surveillance, communication, and control, which are currently in place on the Chicago freeways include: the Minutemen with their Emergency Patrol Vehicles (EPV's), the Traffic Systems Center, and the Communications Center. The Traffic Systems Center monitors input from an extensive pavement sensor system (2,000 inductive loops on 209 km (130 mi) of freeway and 95 ramp metering stations), controls messages displayed on the 13 changeable message signs and controls messages broadcast by the Highway Advisory Radio (HAR). HAR broadcasts messages on two frequencies; one frequency with messages regarding congestion is updated every 5 minutes and the other with messages regarding travel times is updated every minute. The Communications Center, located at the IDOT district office, receives cellular phone messages from the highly successful *999 program. This program allows cellular car phone users to call in free of charge and describe freeway "emergencies" they encounter. The *999 calls are received at a rate of 10,000 to 13,000 calls per month. According to IDOT, this program, in combination with the Minuteman program, help alleviate the need for surveillance and communication devices such as call boxes and closed circuit television (CCTV).

Implementation

Figure 19 shows the IDOT Minuteman coverage area, which represents a total of 160 km (100 freeway centerline mi) or 1290 lane km (718 lane-mi), including ramps. The Emergency Traffic Patrol currently has 58 Minutemen that are on duty 24 hours a day, 7 days a week. They also respond to major incidents upon request of the State police outside the area and to requests from suburban fire departments or other agencies. For example, when two tornadoes hit Chicago in 2 successive years, the Minutemen were some of the first emergency personnel on the scene. Their role was to clear the roadway for other emergency vehicles and personnel.

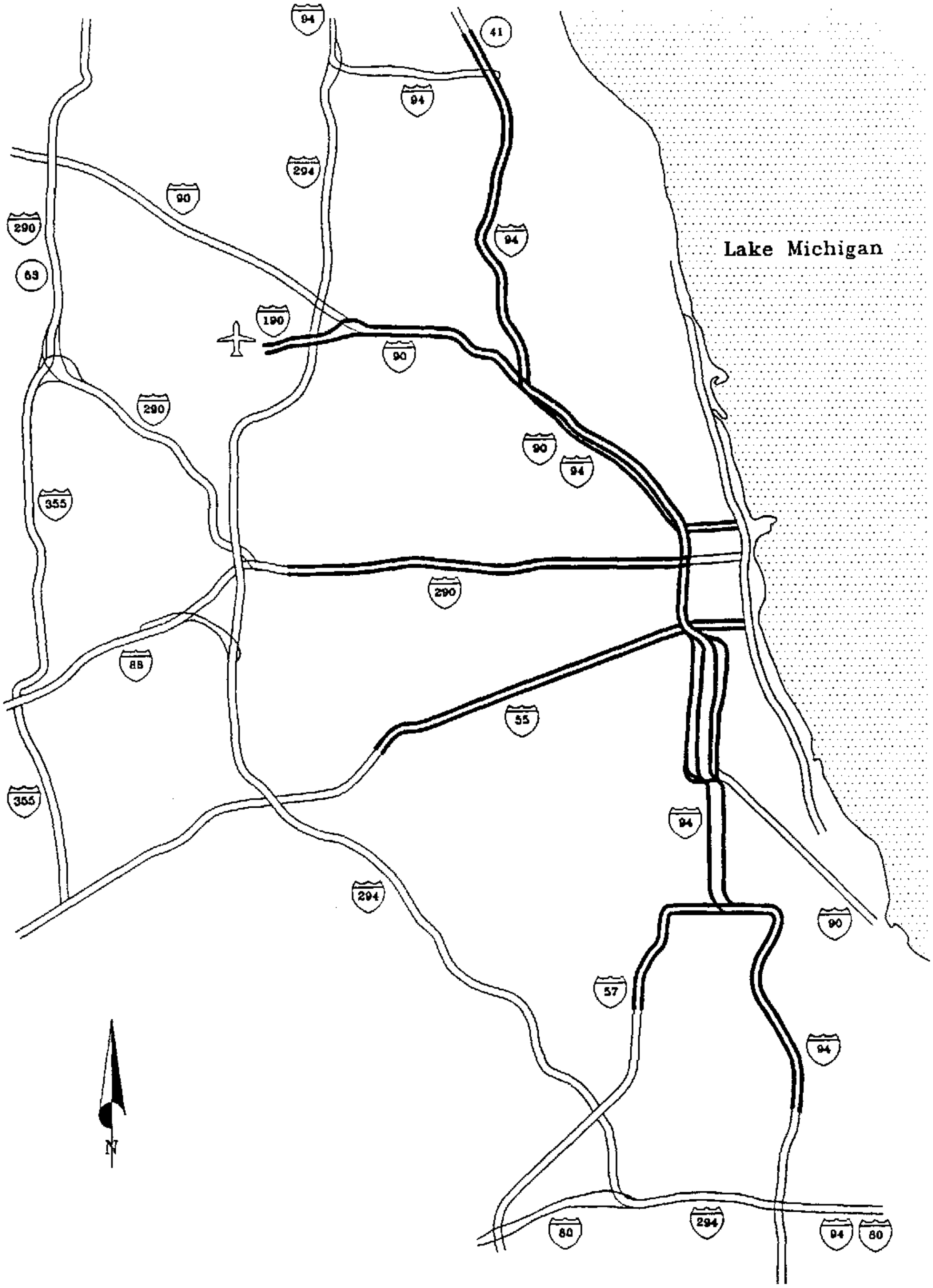


Figure 19. Minuteman coverage area.

The Minutemen, with their EPV's, are equipped and trained to handle most traffic incidents that are likely to occur on Chicago's freeway system. This service is called an "emergency" service because assistance is directed toward actual emergencies and hazardous situations. Minutemen are trained to administer first aid, put out a small car fire, and other minor actions. Towing is provided, but only to relocate vehicles to the nearest safe refuge off the freeway. The motorist or police are then to arrange for towing from that location.

Minutemen also provide assistance when motorists experience minor mechanical problems or when they run out of fuel or need coolant. All patrol services are free of charge except for the 2 gal of gasoline which is accompanied by an invoice to the motorist in the amount of $5.00 for payment to the State Treasurer. Minutemen are not allowed to accept money. The types of service rendered in 1990 is listed in table 7.

Table 7. Types of incidents Minutemen responded to in 1990.

TYPES OF INCIDENTS	NUMBER	PERCENT
Vehicle Disabilities	58,646	63.27
Abandoned Vehicles	14,515	15.66
Accidents	9,960	10.75
Debris	5,799	6.26
Non-Disabilities/Other	2,334	2.52
Pedestrians	990	1.07
Fires	443	0.48
TOTALS	92,687	100.00

Source: Illinois Department of Transportation

The emergency traffic patrol fleet includes 35 EPV's that are the backbone of the system. It also includes nine light 4 by 4's, three heavy-duty tow trucks, one crash crane, one tractor-retriever, a sand spreader, and a heavy rescue and extrication truck. An EPV and a heavy-duty tow truck are shown in figures 20 and 21. Among the traffic control devices the fleet uses at incident sites are four portable, changeable message signs.

The 35 EPV's are diesel-powered, two-axle vehicles on a short wheelbase chassis that have a multicompartment body, a 9 000 kg (20,000 lb) capacity hydraulic tow rig and a heavy steel push bumper. The drive line and frame are reinforced to allow an EPV to relocate a loaded combination vehicle off the freeway.

Figure 20. Emergency patrol vehicle.

Figure 21. Heavy-duty tow truck

The EPV is equipped with a public address system and multi-frequency radio for direct communication with IDOT and State police. Each EPV also has an engine-mounted compressor used for filling flat tires, releasing trailer air brakes, and for operating recovery lift air bags. These air bags when deflated are placed underneath an overturned truck so that when they are inflated the truck is raised to an upright position. They are typically used on trailers which would likely break apart if pulled or lifted with a tow hook.

The IDOT fleet also includes four heavy-duty tow trucks purchased at different times for handling specialized incidents, such as overturned combination vehicles. The IDOT fleet also has two specialized units that include an Emergency Sand Truck, used for fuel and engine oil spills, and a converted 1971 Kaiser Jeep military 6 by 6 truck tractor, used to tow abandoned trailers or to lift and tow semitrailers that have uncoupled from the tractor.

Personnel assigned to this unit receive special training in all phases of Freeway Incident Management and specific operational techniques. To complement these primary activities, they are trained in: advanced first aid, CPR, fire fighting, basic auto extrication, State and city police coordination, radio communications, work zone protection, traffic control, heavy equipment use, and heavy recovery procedures. Heavy recovery procedures cover tank truck emergencies, hazardous materials handling and using air cushions to right an overturned vehicle.

The annual budget of the Minuteman operation is approximately $3.5 million. The replacement cost for the EPV's are $31,000 for the chassis and $9,000 to change over the tow assembly. IDOT uses a rotating purchase scheme where all 35 of the units are replaced over a 4-year period. The newer heavy-duty tow trucks purchased by IDOT cost approximately $250,000 each. When IDOT purchases one of these heavy-duty rigs, they buy it in a 2-year budget cycle. The Minuteman operation has never used any Federal funds.

Effectiveness

The Minutemen have produced an effective incident management program. A study by IDOT using analytical calculations to determine the effects of freeway incident and freeway management programs found a reduction in secondary accidents of 18 percent and a 60 percent reduction in congestion. IDOT representatives state consistently that the Minutemen are the best public relations tools that they have, by providing approximately 100,000 expressway motorist assists each year. A study prepared for the Trucking Research Institute found that the program returns about $17 in benefits for each $1 invested in the program. [14]

While local private tow operators contend that Minutemen operations negatively affect their business, the Minuteman's main goal is to clear the roadway quickly, relocating an involved vehicle to a removal location less than 0.8 km (1/2 mi) away. The owner or the State police then contact a tow operator to move the disabled vehicle to a location for repairs. The Minutemen do not operate over the entire freeway system in Chicago, and only respond to areas outside their 160-km (100-mi) length of freeway if the situation is quite serious or if a public agency requests them to assist.

IDOT personnel are emphatic in stressing that conscientious, well-trained personnel are as important to getting the job done as having the right equipment. A new person hired as a Minuteman works approximately 2 months in on-the-job training supplemented with classroom training.

In 1985, enforcement of Chicago's freeways changed from the Chicago City Police to the Illinois State Police. Apparently, the transition was a cooperative effort assisted by the IDOT Minutemen.

Authority at an incident site within the Chicago city limits is conflicting. By Illinois statute, the State police are in charge at the site of an incident. By City Ordinance, the highest ranking fire official on the scene is in charge. According to IDOT officials who are present on-site at many incidents, the "hat" of control passes from one individual to another in an appropriate manner, depending on what the individual needs are at that site.

Truck Industry Views

The safety director stated that this program is great. One of his company trucks (a tractor pulling a tanker trailer) tipped over, requiring the Minutemen to respond and clear the roadway. He commented that they had the trailer pumped and righted in record time. He added that they are well trained, responsive, and do the needed job without a lot of hassles. The City of Chicago and Illinois DOT are to be commended for this program.

LANE RESTRICTIONS

Background

Lane restrictions are in effect on all freeways in Illinois which have three lanes or more in each direction. Trucks are restricted to the two right lanes. The sign used is a regulatory sign with the message "TRUCKS USE 2 RIGHT LANES." The signs, which have black letters on a white background, are posted both on overhead structures and along the roadside (see figure 22). On the Dan Ryan Expressway, (I-90 near downtown), trucks are only allowed in the outside lanes of the outer roadway (see figure 23). The inner roadway is meant to be used for long-distance express traffic, while the outer roadway is intended for local traffic and trucks. Trucks are not allowed on the Kennedy reversible express lanes (I-90/94 northwest from downtown). Regulatory signs are placed on this freeway to prohibit trucks from using the facility.

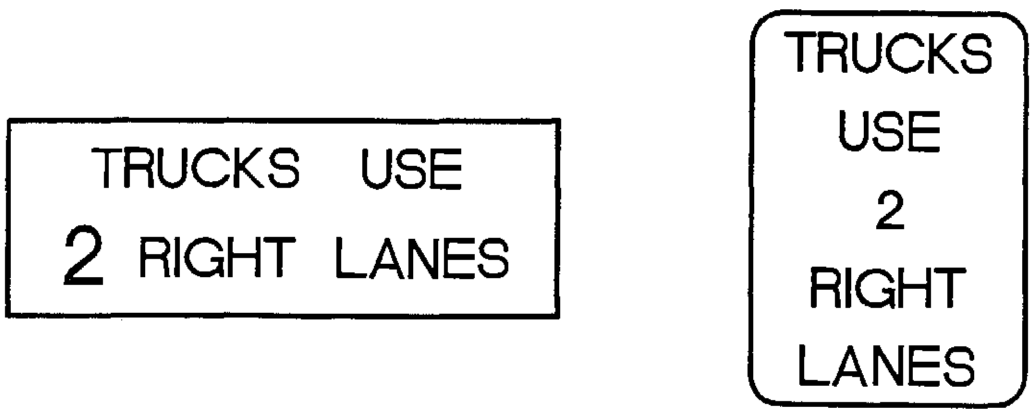


Figure 22. Lane restriction signs.

Implementation

Lane restrictions have been in place in Chicago since 1964. They were implemented because, in some situations, trucks were occupying all available lanes (for example, passing slower trucks in remaining lanes), forming a roadblock to other traffic. According to IDOT personnel, the restriction was initiated by the Chicago mayor. Through his contacts with several trucking concerns, he solicited their cooperation in accepting the lane restriction.

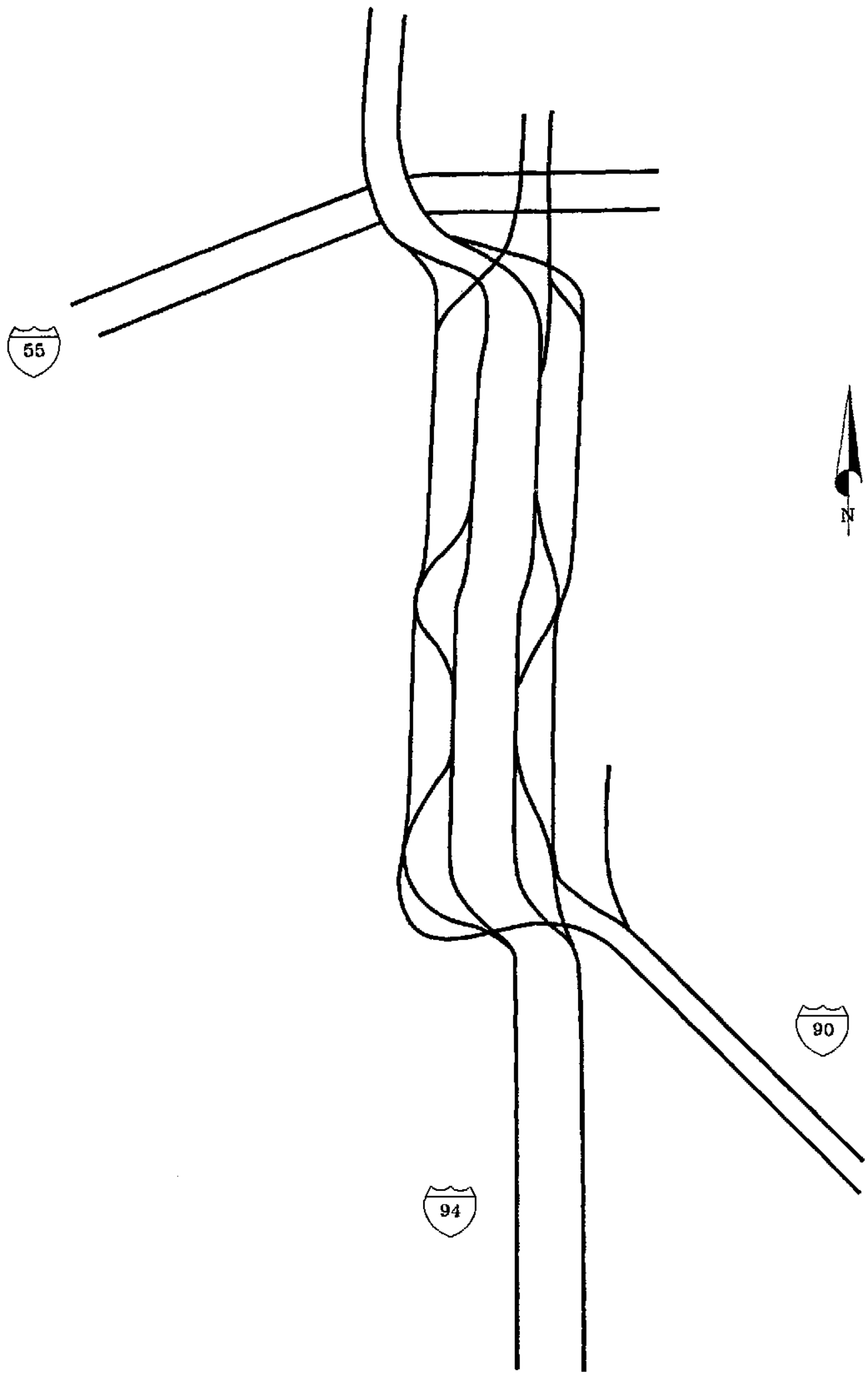


Figure 23. Schematic of Dan Ryan Expressway.

Effectiveness

IDOT officials commented that prior to 1985, State police were more inclined than the city police to enforce truck restrictions such as weight laws and safety measures. In 1985, freeway enforcement changed from city to State police. The incremental cost of enforcing truck regulations is difficult to assess because officers are also involved in many other elements of enforcement. An IDOT administrative engineer believes there would be significant objections from auto drivers if lane restrictions for trucks were relaxed now. Observations of truck traffic indicates that the majority of trucks stay in the second lane at interchanges, thus allowing entering and exiting motorists easier access to the outside lane at interchanges. The lane restrictions are typically relaxed in advance of major interchanges, so trucks can use other lanes or merge left if desired.

Truck Industry Views

The safety director stated that lane restrictions do not cause a lot of problems except near interchange ramps. He believes that the concept of separating cars from trucks is a good idea, however, the merging and exiting across the truck lanes cause problems.

CHAPTER 5

DETROIT, MICHIGAN CASE STUDY

OVERVIEW

Description of Area

Figure 24 shows the Detroit area including many of the suburbs within the urbanized area. Detroit has a population exceeding 1.2 million people and is located on the Detroit River which connects Lake St. Clair and Lake Erie. It is a major industrial center on the Canadian border and its port handles over 125 million tons of freight annually. Detroit is also located on the Canadian border. The Detroit Freeway system includes I-94 (also known as the Edsel-Ford Freeway) and I-96 (also known as the Jeff Ries Freeway), that are major east/west corridors, and I-75 (also known as the Chrysler Freeway) that is a major north/south corridor. Figure 25 shows 24-hour traffic volumes in the Detroit area.

Countermeasures Implemented

The following countermeasures that have been implemented in the Detroit area were investigated. Brief introductions to these countermeasures follow:

- **Ramp Treatments**--Two freeway ramps have been treated with countermeasures to mitigate accidents involving trucks. Improvements include construction of tall reinforced concrete barrier walls and improving superelevation on a ramp curve.

- **Reduced Shoulder Parking**--Efforts are underway by the Michigan Department of Transportation (Michigan DOT) to evaluate and take remedial action against truck drivers parking on shoulders and ramps, particularly when rest area capacities are exceeded.

Another countermeasure was being used, but information on its use and effectiveness was limited. Statewide lane restrictions require trucks to use the right two lanes on roadways that have three or more lanes. This law was passed in 1985 or 1986 because trucks often occupied all lanes for passing purposes, restricting passing opportunities for faster moving vehicles. The sign used in Michigan provides this message: "ALL TRUCKS USE 2 RIGHT LANES." The cost of each ground-mounted sign is estimated to be $250 to $300 each, but the total number of the signs installed is not known. Establishing lane restrictions was thought to be politically motivated; apparently no studies were conducted to evaluate this countermeasure before implementation.

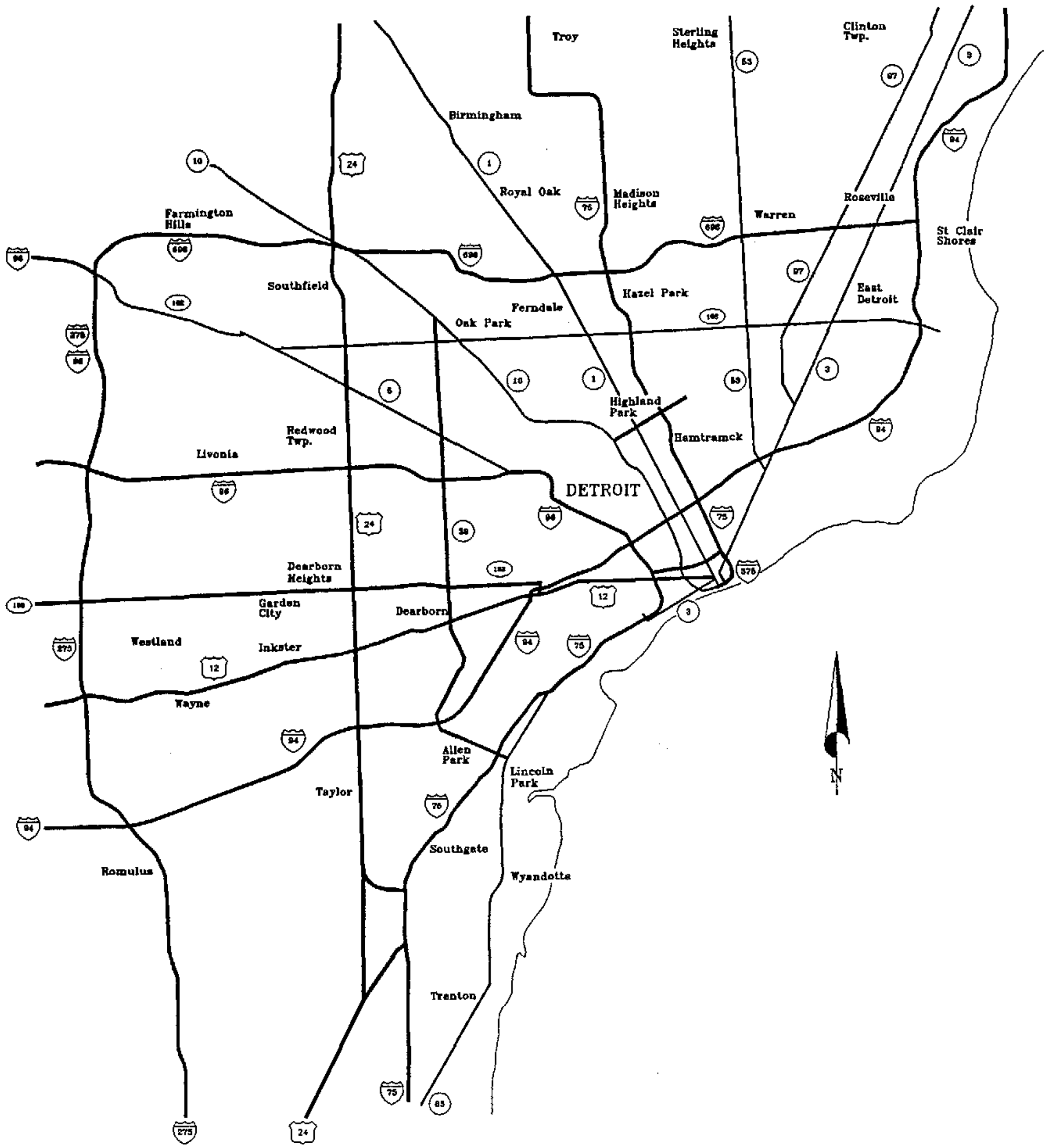


Figure 24. Detroit, Michigan roadway system.

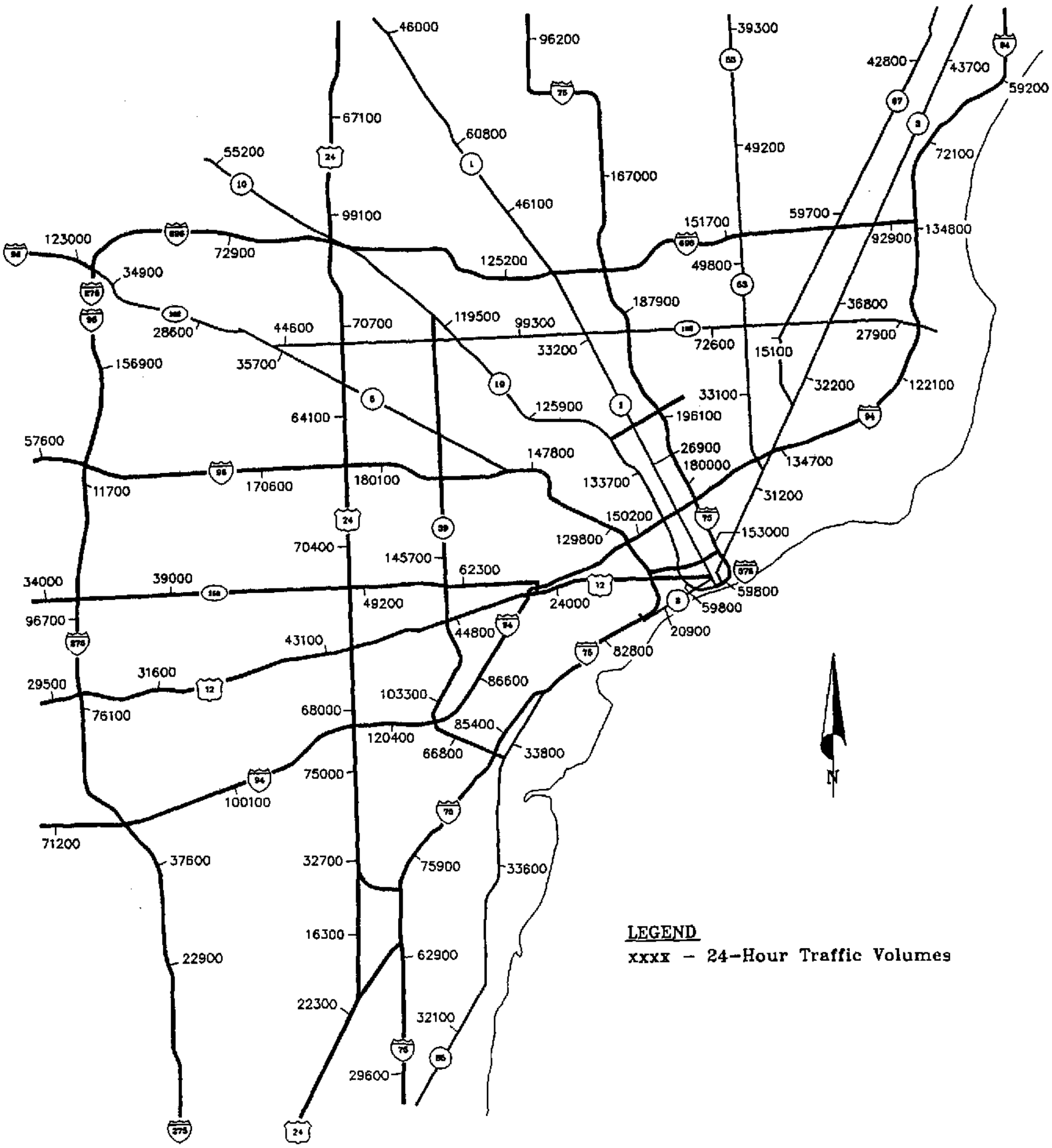


Figure 25. 24-hour traffic volumes in the Detroit area.

Accidents

Michigan DOT provided accident data for Detroit freeways within the three counties of Wayne, Oakland, and Macomb. From January 1988 through December 1990, large trucks were responsible for 3 fatalities, 329 injuries, and 1,153 property damage accidents on mainlanes of freeways. During the same time period, large trucks were responsible for no fatalities, 79 injuries, and 253 property damage accidents on non-mainlanes (e.g. ramps) of freeways. These accidents are only those in which large combination vehicles caused the accident; many other accidents occurred in which smaller trucks were *at fault* and where both larger and smaller trucks were *involved*.

Truck Industry Views

Attempts to contact truck drivers and/or administrators in the Detroit area have thus far been unsuccessful.

RAMP TREATMENTS

Background

The first of two ramps is a two-lane freeway-to-freeway connector located in downtown Detroit where I-75 (Chrysler Freeway) northbound traffic continuing on I-75 northbound must exit the freeway mainlanes onto this ramp. The directional orientation of traffic on I-75 northbound changes from an easterly direction to a northerly direction. Interstate 375 traffic must also interchange at this location as shown in figure 24. Figure 26 shows an enlargement of the interchange with the subject ramp shaded.

One improvement to this ramp included changing the cross-slope (superelevation) of the original design. Originally, the superelevation was less on the outside half than on the inside half. It originally included an outside barrier curb which could have "tripped" combination vehicles, leading to rollovers. The improvement removed the differing cross-slope rates and formed a constant superelevation rate of 7.4 percent over the full width of the ramp to the outside barrier as shown in figure 27. The new lift of pavement is shaded so the original surface shape can be identified. The other major improvement was construction of a tall barrier on the outside of the ramp curve to contain high center-of-gravity vehicles and loads that might be dumped on other ramps and the freeway below. The improvements on this ramp were completed in 1981.

The second ramp improvement was made on a two-lane ramp serving traffic that exits I-94 (Ford Freeway) in the westbound direction intending to go southbound on I-75 (Chrysler Freeway). The improvement at this ramp included the addition of a taller barrier similar to the ramp at I-75/I-375 for the purpose of containing trucks and their loads. Barriers at both ramps are 1.8 m (6 ft) high and their base thickness is 0.63 m (2 ft, 1 in).

The following two-way daily truck counts were provided by Michigan DOT on I-75: 7,000 trucks per day on the south side of the metro area, and 12,000 trucks per day in the center of the metro area. The number of trucks that actually use the subject ramps is unknown. Because the first I-75 to I-75 ramp is simply a continuation of I-75, the number of daily trucks is expected to be approximately half of 12,000 trucks per day.

Implementation

According to a Michigan DOT traffic engineer, the problem at both ramps was practically identical. Both ramps were built with tight geometrics; one was built next to a large building which limited available right-of-way. Michigan DOT had installed extensive signing first in an attempt to reduce accidents, but results were insufficient.

The barrier and superelevation improvements on these ramps were completed in approximately 1981. The cost of all elements of this improvement was difficult to determine because warning devices were probably installed in phases. One problem is in trying to

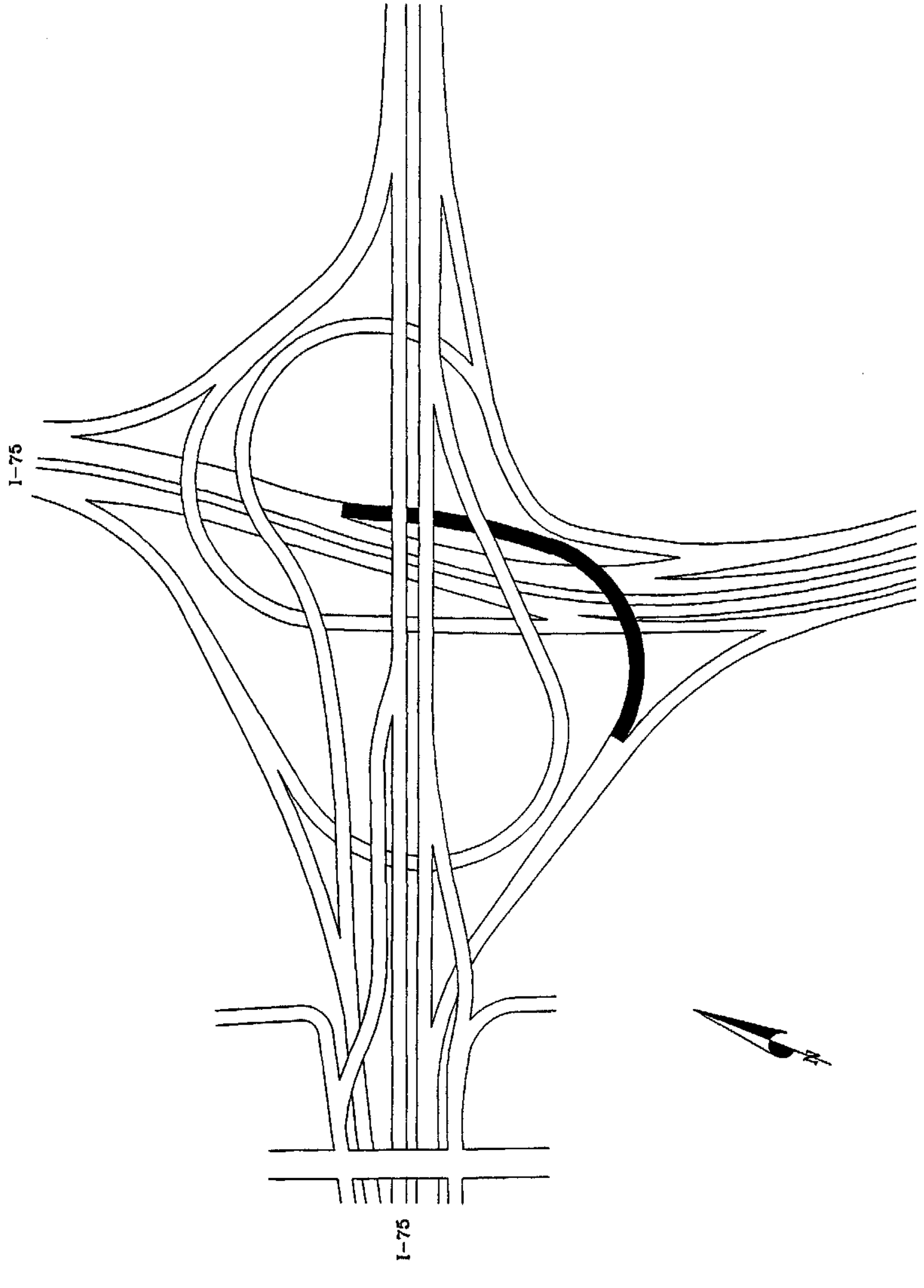


Figure 26. I-75/I-375 interchange layout.

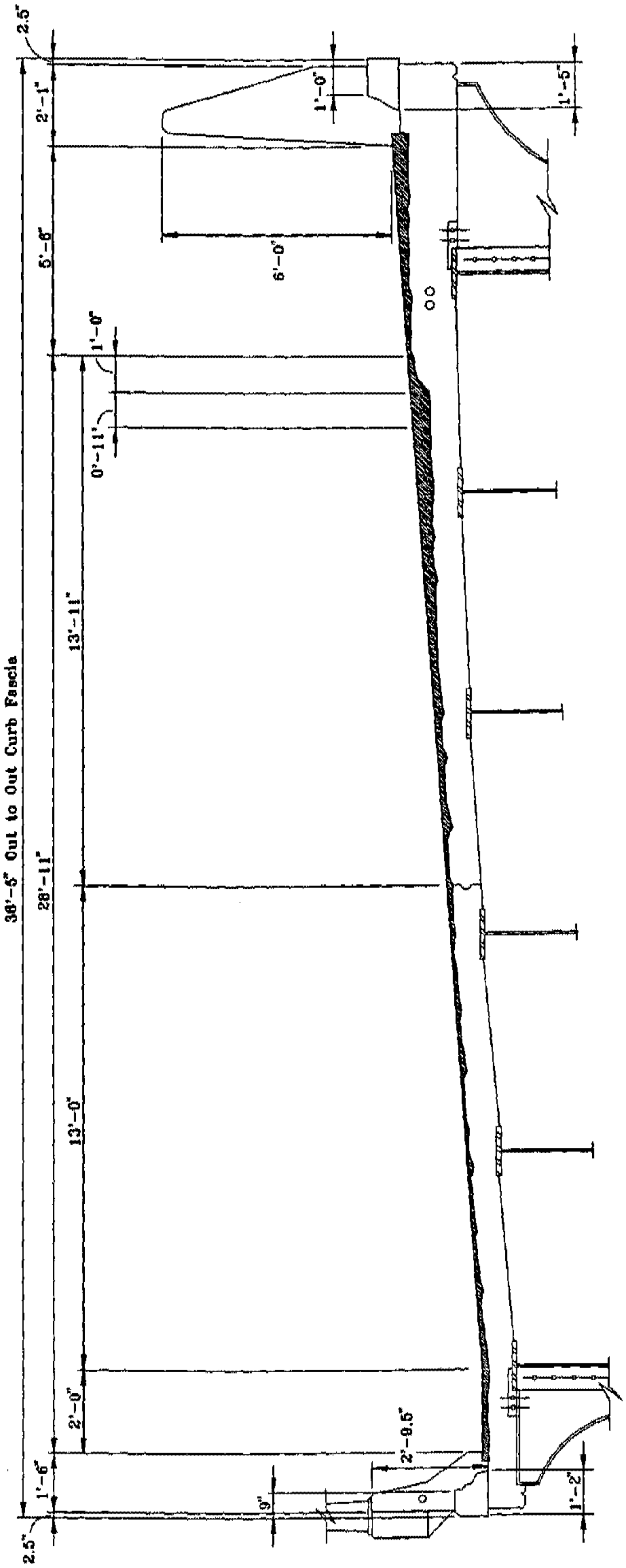


Figure 27. Cross section showing ramp improvement.

re-create documentation over this long (10-year) time period. A typical sequence of improvements used by Michigan DOT is to install signs, then flashers, then symbol signs. Their philosophy is not to spend more money than necessary if a less expensive solution will solve the problem. The truck tipping sign is not used in Detroit, although there was interest expressed in its use.

Effectiveness

Michigan DOT has used ground-mounted and overhead static warning devices, both with and without flashers. According to Michigan DOT sources, the typical truck incident involves rollover with a spilled cargo. These sources also remember only one truck which had ever penetrated the shorter barrier prior to the installation of the 1.8-m (6-ft) barrier. Figures 28 and 29 show the traffic control devices currently in place on the ramp as well as the tall barrier.

Michigan DOT provided accident information on the two ramps for the "after" period. For the I-94/I-75 ramp during the January 1985 through June 1991 time period, there were 16 accidents recorded involving trucks. Five of these resulted in truck rollover. On the I-75/I-375 interchange, 12 of the total 61 truck accidents recorded during this same time period were rollover accidents. These accidents resulted in 2 fatalities, 25 injuries, and 36 cases of property damage only. No accident data was available for the period before improvements were made; however, Michigan DOT sources believe that accidents are not as numerous now compared to the before period. Furthermore, they state that barriers are tall enough to contain loads to keep them from spilling onto the freeway below.

Truck Industry Views

Attempts to acquire information regarding the ramp improvements from truck drivers and/or administrators in the Detroit area were unsuccessful.

Figure 28. I-75 northbound ramp.

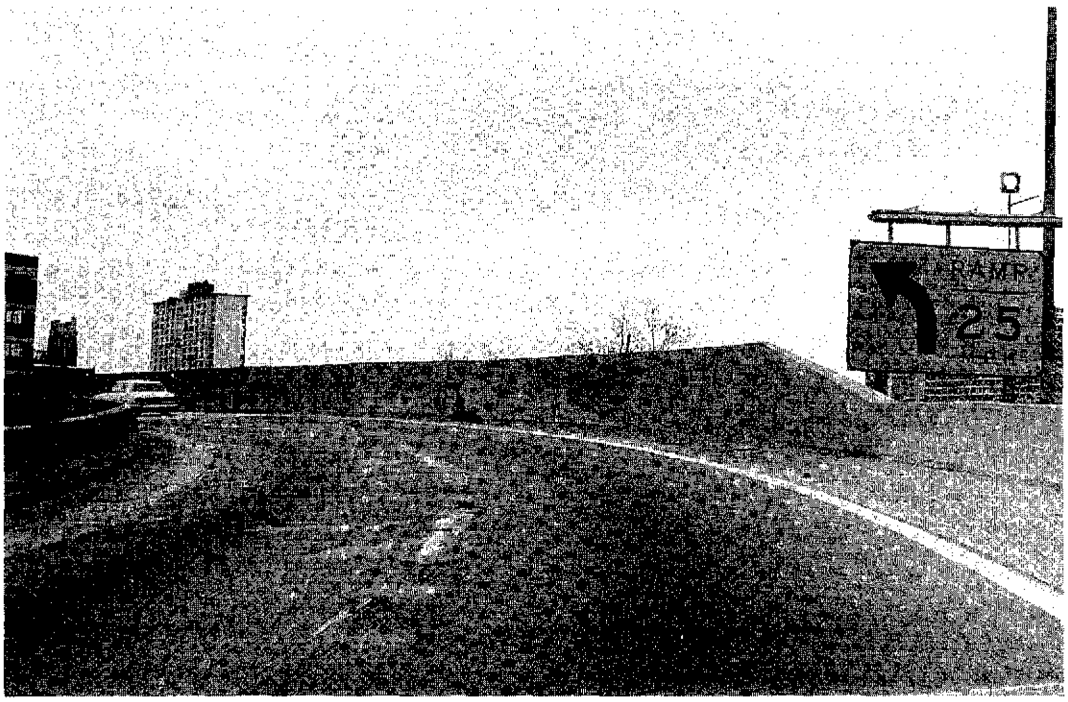


Figure 29. Close-up of barrier on I-75 northbound.

REDUCED SHOULDER PARKING

Background

Michigan DOT, State police, and the trucking industry are working together to reduce illegal truck parking on the shoulders of State highways. In the 4-year period from 1984 through 1988, 55 combination vehicles were hit by other vehicles while parked on freeway shoulders in Michigan. Much of the illegal parking is occurring in the vicinity of rest areas.

The Michigan DOT district responsible for 198 km (124 mi) of I-94, the major east-west truck corridor between Detroit and Chicago, discovered that 28 of the total 55 shoulder accidents had occurred in their district. These accidents included 1 fatality and 12 injuries.

Implementation

In January 1990, a task force was organized to address the problem of trucks parking on freeway shoulders and ramps, and parking too long at Michigan DOT Rest Areas. This task force consisted of representatives of the Michigan Truck Stop Owners Association, Michigan State Police (Motor Carrier Division), the Michigan Trucking Association, the Federal Highway Administration, and various Michigan DOT personnel.

One outcome of several meetings of the task force was a survey of truck parking activities along the I-94 corridor from the Indiana State line to Ann Arbor, Michigan. The survey, conducted by the Michigan DOT Bureau of Transportation and Planning, was intended to identify the locations and severity of the problems. Counts of parked trucks were conducted on 4 week nights at: 9 p.m., 12 midnight, 3 a.m., and 6 a.m. Observations included the truck parking demand in rest areas and truck stops, capacity of the rest areas and truck stops, and the length of stay of trucks in rest areas.

Interviews with 237 truck drivers provided additional information regarding the nature of stops. Fifty-two percent of drivers interviewed stated that they parked at rest areas for longer than 2 hours once or twice a week. Eleven stated they use rest areas for longer than 2 hours every night, while 92 drivers answered they never use the rest areas for longer than 2 hours. The most common reason for parking (68 percent) in rest areas was because the driver was fatigued. Only 8 percent stated that they stopped because of hours of service laws. Ten drivers stated they were waiting for an appointment to load or unload. Other answers included using the phone, using the bathroom, and checking their load. When asked for their first choice for long-term parking, 57 percent chose truck stops.

Results of the parking survey are informative in comparing parking demand and capacity. The total I-94 corridor demand exceeded its capacity every night of the survey at the 3 a.m. and 6 a.m. times. The highest capacity rating of 135 percent was achieved by trucks being parked on ramp shoulders and in the automobile section of the rest areas.

While rest areas were overcrowded, only two truck stops within the corridor exceeded their capacities.

Based on the survey results, the following recommendations were made: 1) stricter enforcement of shoulder parking restrictions, 2) limit the length of stay in freeway rest areas, and 3) Michigan DOT should provide information on appropriate overnight truck parking facilities at the rest areas and through press releases.

Effectiveness

The results of the above recommendations are as follows:

- State police increased enforcement of parking restrictions along shoulders (allowed emergencies only). Placing special emphasis on shoulder parking during the weeks of July 30, 1991 and August 22, 1990, State police issued a total of 589 citations, 108 for improper parking and another 171 in verbal warnings.
- A time length of 2 hours was placed on parking within rest areas. No information was available on the effectiveness of this restriction.
- A brochure was prepared for distribution to truckers and to be posted in rest areas. It was intended to provide locations of all private sector parking along the freeway system in southern Michigan.

Two types of signs were proposed for use also, one blue on white motorist service sign to be placed along the highway or a white on green sign to be used within rest areas. The first would be used upstream of an exit possibly attached to the bottom of an existing services sign. The message would use the words, TRUCK PARKING. The second (white on green) sign would list the exits where truck parking is normally available. Both of these signs are shown schematically in figure 30.

Truck Industry Views

Attempts to acquire information from truck drivers and/or administrators regarding attempts to reduce shoulder parking were unsuccessful.

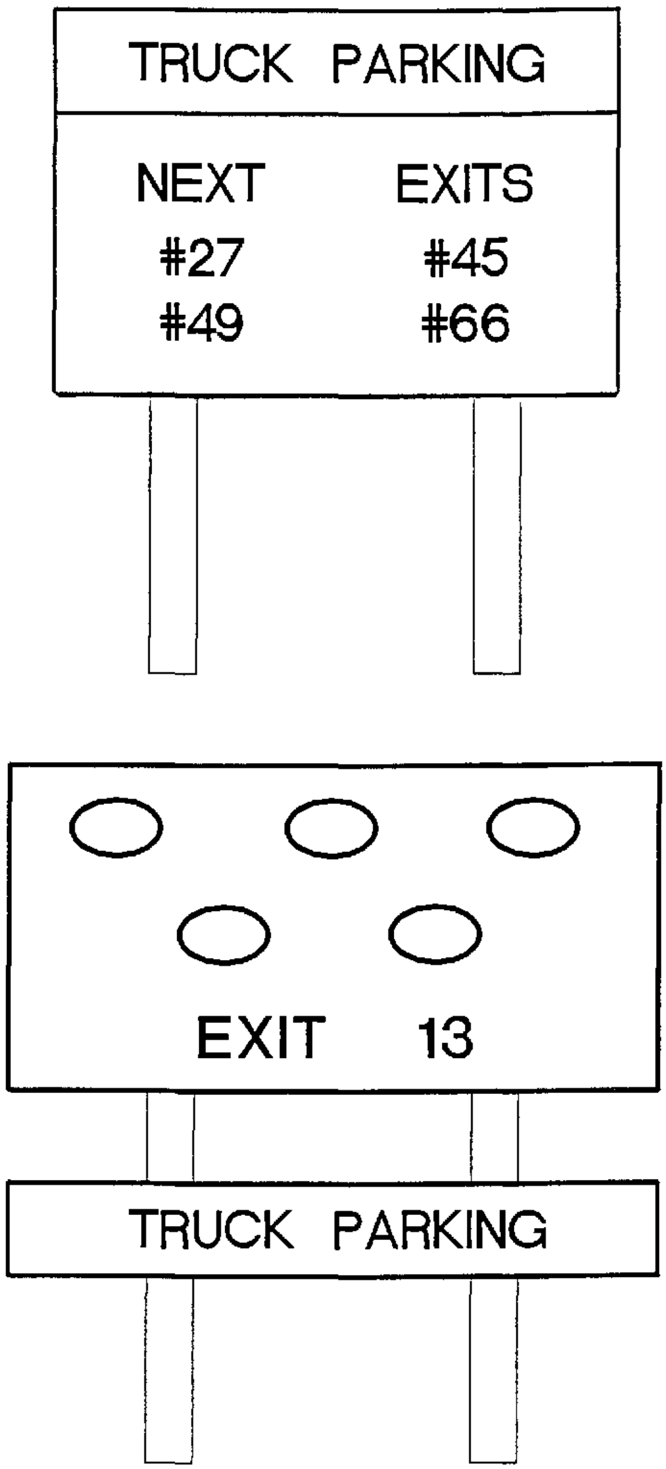


Figure 30. Proposed truck parking information signs.

CHAPTER 6

FT. WORTH, TEXAS CASE STUDY

OVERVIEW

Description of Area

Fort Worth makes up the western portion of the Dallas/Fort Worth urbanized area that is one of the fastest growing metropolitan regions in the nation. More than one-fifth of all Texans live in the region and one-sixth of all nonagricultural jobs are located in the area. The major employers in Fort Worth are the defense and electronics industries and 1,500 manufacturing firms are located within the city limits. Fort Worth is easily accessible with more than a dozen major highways leading into the city. Interstate 35W is the major north/south corridor and I-20 and I-30 are the major east/west corridors. Figure 31 shows the major freeways in Ft. Worth.

Countermeasures Implemented

Incident Response Management is the major truck accident countermeasure implemented in the Ft. Worth area. The Texas Department of Transportation (TxDOT) has taken an aggressive approach to clearing roadways following truck (and other) incidents.

A second countermeasure implemented in the Ft. Worth district by TxDOT was a ramp improvement in Decatur, Texas at the interchange of US 287 and US 380. Unfortunately the available information was not sufficient to create a case study. Traffic volume using the interchange is approximately 20,000 vehicles per day with as much as 60 percent trucks. Problem trucks include livestock haulers, tire trucks, brick haulers, and anything with a shifting load. The westbound US 380 ramp to northbound US 287 was built with a 45-m (150-ft) radius and a 2 percent cross-slope, i.e., no superelevation.

Basic improvements to the ramp included additions of oversize warning signs (primarily word message) on the approach, improving the gore, and providing additional sight distance for truck drivers approaching the ramp (westbound US 380 to northbound US 287). The additional sight distance was achieved by flattening a cut slope near the ramp to improve drivers' view of the curve. Sign installation and earthwork improvements were accomplished by July 1990. The signs on the westbound US 380 approach included the following messages: "US 287 NORTHBOUND TRAFFIC SLOW SHARP CURVE AHEAD" (435 m, 1,450 ft from gore), "SHARP CURVE SLOW TO 20 MPH" (300 m, 1,000 ft from gore),"EXIT 20 MPH" (195 m, 650 ft from gore), Reverse Curve (symbol) with "20 MPH" advisory and flashing wig-wag (60 m, 200 ft from gore), and "EXIT 20 MPH" (at the gore). All of these signs were black-on-yellow, with the exception of the sign at the gore. The cost of static signs came out of the TxDOT maintenance budget.

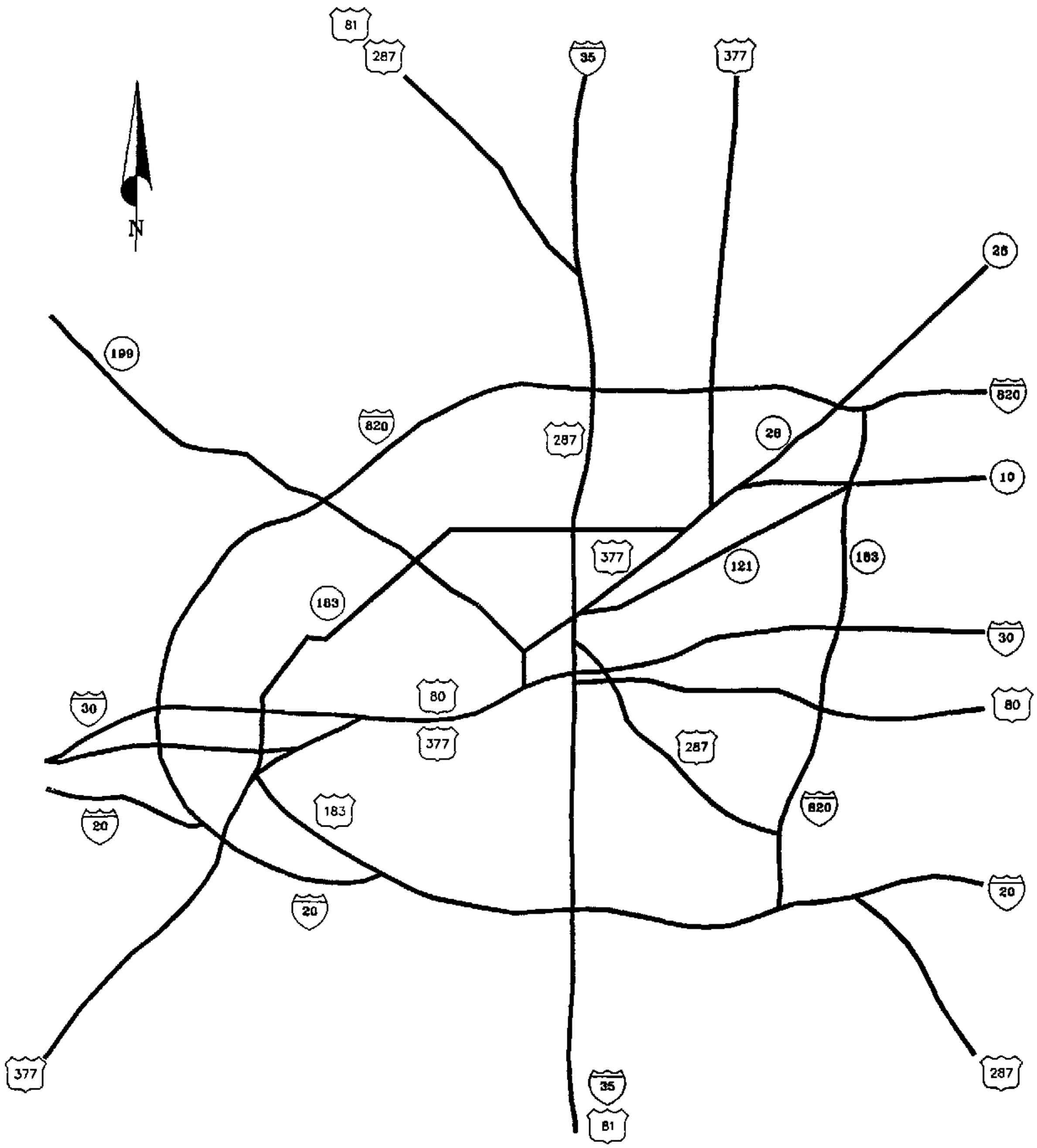


Figure 31. Ft. Worth, Texas freeway system.

Accidents

Accidents were not reviewed for the incident response countermeasure due to the difficulty in isolating its effects from all of the other factors which could have influenced accident rates.

Truck Industry Views

Comments from a truck driver who was involved in an incident are included. His comments pertaining to incident response management reflect his desire to protect his load.

INCIDENT RESPONSE MANAGEMENT

Background

The Texas Department of Transportation (TxDOT) and local governments decided that due to congestion and anticipated reconstruction projects on the Fort Worth freeway system, the development and implementation of a freeway traffic management system in the Fort Worth area would enhance current operations. The Fort Worth District prepared a comprehensive freeway traffic management plan that included staged implementation to coincide with reconstruction projects for the local freeways. This management plan incorporated the use of surveillance components to constantly monitor operational conditions on the freeway, an interactive control network with options to correct freeway conditions, a city-State command post, and an area-wide communications network.

An important portion of this plan is the traffic management team. The team consists of representatives from various transportation agencies whose goal is to meet on a regular basis to share ideas and seek ways to improve traffic conditions. All members of the team were selected for their ability to make binding decisions for the agencies they represent. The traffic management team is an important tool for reducing reaction time in emergencies and improving intergovernmental cooperation for special events.

Another element of freeway traffic control employed on a continuous basis is using Courtesy Patrols. These patrols began in the Ft. Worth district in 1972, and provide service at no charge to motorists in the form of minor repairs, engine coolant, a gallon of gasoline, or a tow to the nearest exit.

For almost 20 years, the Ft. Worth district of TxDOT has maintained an aggressive posture in clearing the roadway following an incident. For truck incidents, a concern of the driver and the owner of the truck is salvaging the load. Timely clearance of traffic lanes, however, means salvaging the load is of secondary importance to reducing motorist delay and secondary accidents which increase with increasing closure time. Historically, motorist delay costs plus costs of secondary accidents are significantly higher than any additional damage that might occur to the salvageable part of the load. Typically, the load is substantially damaged already and appropriate handling assures minimal additional damage. Once the damaged vehicle and its load are moved out of the traffic lanes, and preferably completely off the freeway, the truck driver will have time to inventory the load.

Implementation

By passing Senate Bill 312 in 1991, Texas took a proactive stance regarding the removal of obstructions from roadways and rights-of-way. This bill authorized the Texas Department of Transportation (then State Department of Highways and Public Transportation) to remove, without consent of the owner or carrier, spilled cargo and personal property from any portion of the State highway system or rights-of-way. It also relieved the Department from liability for any damage resulting from removal of the property unless the removal or disposal was carried out recklessly or in a grossly negligent manner. Furthermore, it required the property owner or carrier to reimburse the Department for the costs of removal and subsequent disposition of the property.

When incidents occur on Ft. Worth freeways, portable and permanent electronic message boards (EMB's) are often used to assist with traffic control. District maintenance sections deploy portable EMB's upstream of the accident. A pre-appointed TxDOT official is responsible for communicating traffic control needs at the site with other TxDOT personnel, and with law enforcement representatives. If a crane is needed to retrieve an overturned combination vehicle, the TxDOT District Safety Coordinator can request its use from the contractor, with an informal agreement to reimburse the contractor for costs involved.

The cost of permanent electronic message boards varies depending on the number purchased. On I-35W between I-30 and I-20, four EMB's were installed at a cost of $75,000 each. In another project, one EMB on US 360 cost $114,000, and multiple units on I-20 cost $70,000 each. There will be 45 of these throughout the metropolitan area when the entire system is installed. Command centers will be built at district headquarters and in downtown Ft. Worth.

Each maintenance section of the Ft. Worth district has portable electronic message boards that can be used for traffic control upstream of an incident. These were originally purchased with Federal money for freeway reconstruction. When these reconstruction projects are completed, the portable EMB's are available for other uses by TxDOT.

Effectiveness

TxDOT representatives can relate many success stories of clearing the roadway following an incident. In one incident, a tractor-semitrailer overturned with its load of liquor worth $250,000. About half of load was lost already by the time response personnel arrived. TxDOT personnel contacted the company and explained to them that the freeway had to be cleared immediately. Then, TxDOT moved the truck and contents off the freeway. Attorneys for the State argued successfully that TxDOT has the authority to clear a roadway of an overturned vehicle and spilled load (if any) in order to make the roadway safe for other motorists. TxDOT was reimbursed for the damage the truck caused. According to TxDOT sources, they are recovering approximately 75 to 80 percent of the costs they incur from incidents. This includes damage to their infrastructure such as guardrail damage.

Secondary accidents happen if road closures remain for very long. The Courtesy Patrol, operating 7 days a week, 365 days a year, is the best public relations tool TxDOT has, according to TxDOT representatives who receive comments by mail from those who have been assisted. The few negative comments they recall pertain to not having the proper parts to make a repair, or in reducing the amount of gasoline from 7.6 l (2 gal) to 3.8 l (1 gal). The cost of this program, which comes from the maintenance budget, is approximately $500,000 per year. TxDOT also has a sand truck loaded and ready to respond to oil spills; this reduces the cleanup time from 2 to 4 hours to less than 1 hour.

Truck Industry Views

In the late 1970's, a tractor-semitrailer load of computers overturned on the eastbound mainlanes of I-30 within the I-30/I-35 interchange in Ft. Worth. The incident caused total traffic stoppage on the entire interchange, according to TxDOT sources. The driver was not willing to allow the truck or contents to be moved until a company representative arrived from out of State. This would have closed the freeway for too long a time period, so the load was moved against the driver's wishes. This is not a very common occurrence; drivers are typically willing for emergency personnel to do what is best for all concerned and clear the roadway quickly because they understand that quick removal of accidents is best for the motoring public.

CHAPTER 7

HAGERSTOWN, MARYLAND CASE STUDY

OVERVIEW

Description of Area

Hagerstown is a small city in western Maryland near the interchange of I-70, a major east-west freeway, and I-81, a north-south freeway. I-70 provides connections from Baltimore and Washington, D.C. (via I-270) to Pittsburgh, St. Louis, and other mid-western and western cities. I-81 provides connections to Harrisburg to the immediate north and cities in Virginia and West Virginia to the south. The interchange of I-70 and I-81, shown in figure 32, is a full cloverleaf with collector-distributor roads. The northwest and southeast loop ramps are the locations where truck accident countermeasures have been installed.

Countermeasures Implemented

The countermeasure implemented at the I-70/I-81 interchange is ramp treatment. Truck tipping signs have been installed on both the eastbound and westbound exit ramps on I-70. Another improvement implemented on the westbound exit ramp was increasing the cross-slope of the shoulder to match the superelevation of the ramp mainlane.

Accidents

No accident information was provided except on the interchange ramps being discussed in this study. The two truck tipping signs were installed as a result of a greater number of accidents on these two ramps. Both of the higher accident ramps were downhill or descending ramps. Trucks could exit the freeway at relatively high speeds on all four ramps, but the two uphill or ascending ramps had fewer accidents.

Truck Industry Views

One local trucker provided his opinion of ramp signing for trucks. He is a safety manager for a national trucking firm, that has a regional distribution center in Hagerstown. He was not a truck driver, but rather a Virginia State Police Truck Inspector for over 20 years before assuming his present position.

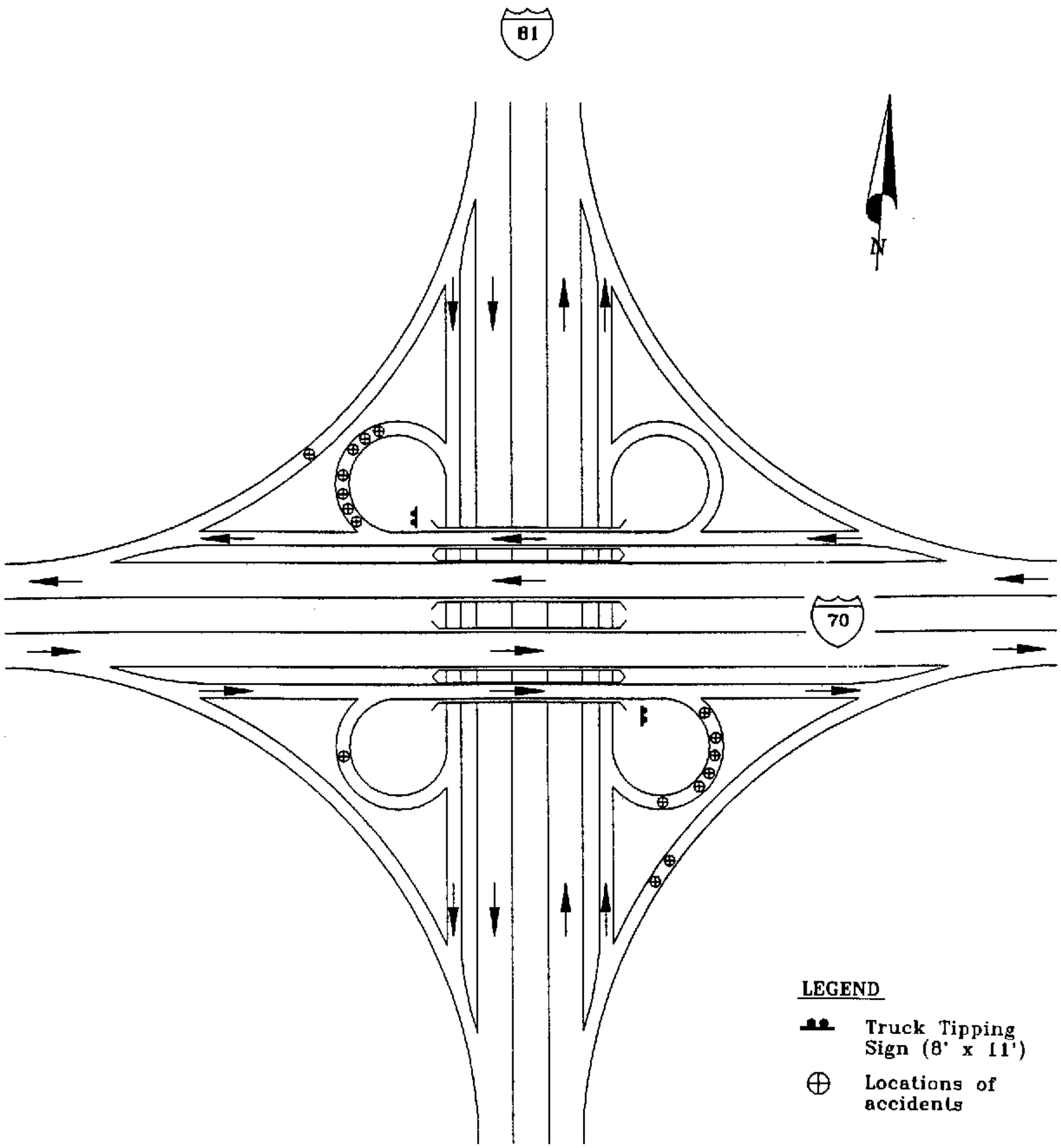


Figure 32. I-70/I-81 interchange layout.

RAMP TREATMENT

Background

The Maryland State Highway Administration (MSHA) installed oversized truck tipping signs on the eastbound and westbound exit ramps of I-70 in an attempt to reduce the number of truck rollover accidents which had occurred there. These ramps were also used for a recent research study sponsored by the Federal Highway Administration to determine the effects of these signs on truck speeds. Both of these ramps are loops, each built with a radius of 70 m (230 ft) and on a descending grade. No truck counts or percentages were provided.

Implementation

The cost of the improvements to these two ramps was not provided. The signs are typically installed with state maintenance monies, whereas the ramp shoulder improvements were completed using construction monies.

An additional improvement to the westbound I-70 to southbound I-81 connector was increasing the shoulder cross-slope to match the ramp superelevation. Originally, the ramp width was 4.8 m (16.0 ft), and at the outside break in the cross-slope a 3-m shoulder (10-ft) sloped away from the ramp mainlane. The maximum superelevation of 6.0 percent was developed over a distance of 60 m (200 ft), beginning with a normal cross-slope of 1.6 percent. A typical section of the improvement is depicted in figure 33. The cross-slope improvement added 1.8 m (6 ft) to the "effective width" of the ramp, so the widened total width was 6.6 m (22 ft). At the outside edge of this width is a break in the cross-slope with a maximum of a 7.0 percent break (algebraic difference). Figures 34 and 35 show the oversized truck tipping sign and the beginning of the ramp overlay which includes the wedge of pavement along the shoulder.

Effectiveness

Truck tipping signs are typically installed based on an engineering study. A key input is the number of truck accidents of the type expected to be reduced by this warning sign. The number of truck overturning accidents that occurred at this interchange between 1985 and 1987 was six on the westbound exit ramp and seven on the eastbound ramp. MSHA officials believe the signs were already in place during the 3-year time period of these accidents.

A traffic engineer with the MSHA believes they should be using a system for setting speeds on ramps and mainlanes that reflects the characteristics of today's vehicles. His agency is using the same techniques to establish advisory speeds as it used several years ago.

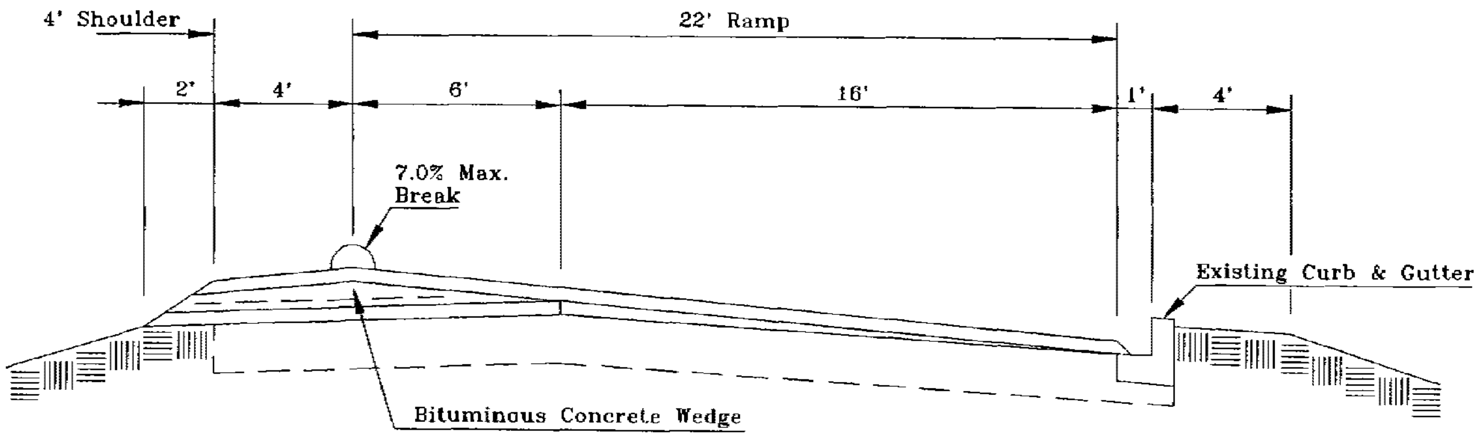


Figure 33. Typical ramp resurfacing section.

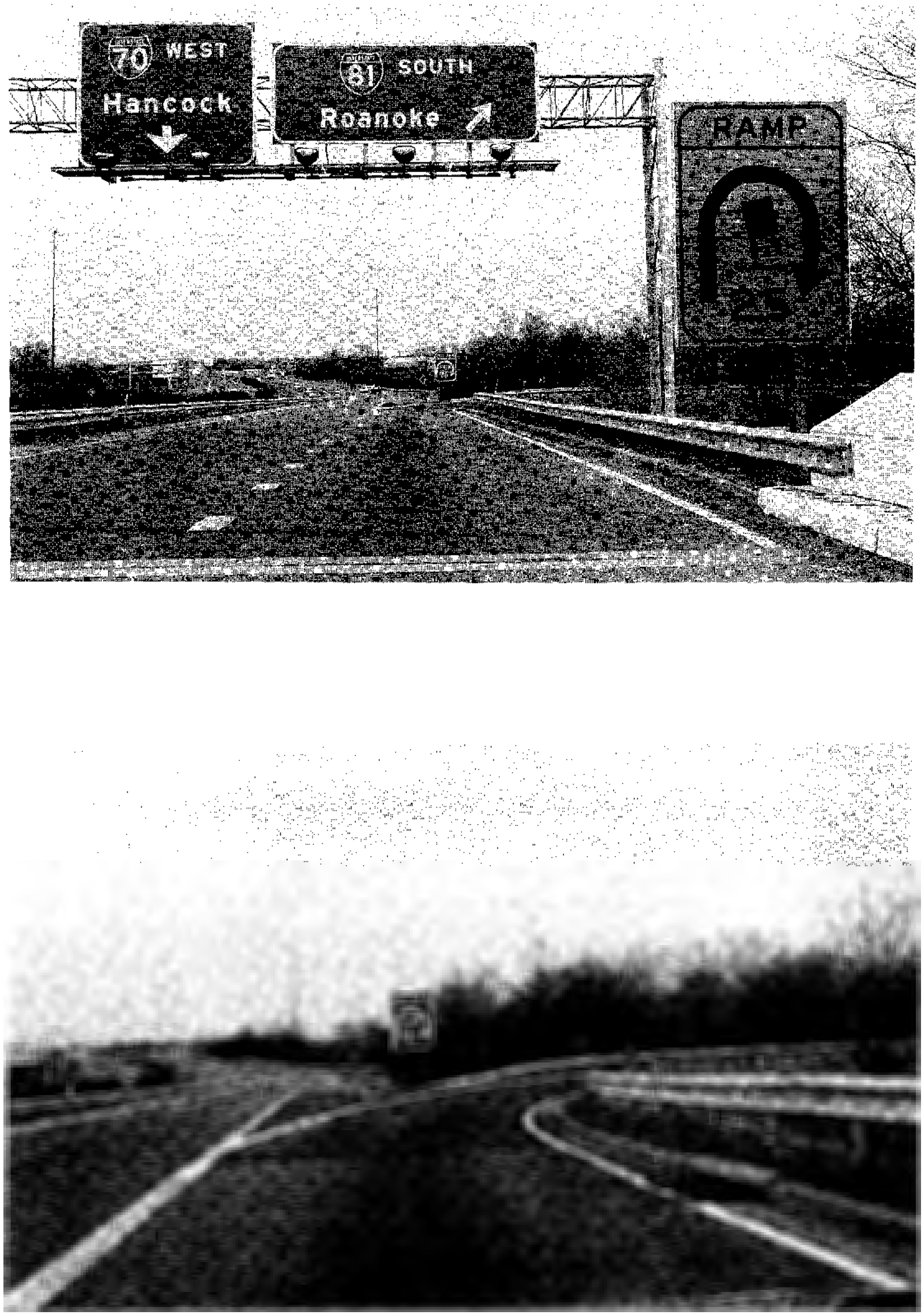


Figure 35. Ramp overlay to widen pavement.

Since he began using the ball bank indicator method, cars have become smaller and are being designed with better cornering capabilities while trucks have become larger. This means that automobiles today can negotiate curves faster than before but loaded trucks might need to travel slower.

Two additional efforts that MSHA has made or is considering will improve sign warning to truck drivers. One is the use of the new diamond grade reflective sheeting that presents a brighter image to motorists at night. Their other effort concentrates on the placement of signs on the approach to ramps. In some cases, signs were placed too close to the actual problem to allow sufficient reaction and deceleration. The signs might be moved upstream, or another sign might be used upstream with the word "RAMP" placed in addition to the sign near the gore area. The main goal is to warn truck drivers of impending ramp conditions.

The sign being used by MSHA is the same as that used previously by CALTRANS. The effectiveness of this sign in reducing truck speeds approaching ramp curves is currently under evaluation in a research study sponsored by the Federal Highway Administration. According to MSHA personnel, there seems to be some misunderstanding of the meaning of the diagrammatic (arrow) used on these signs. Its meaning is intended to reflect the alignment of the ramp. The only other problem which MSHA officials identified with the signs was that they should not be overused. They warned that its overuse would diminish its effectiveness just as it might with any other traffic warning device.

Truck Industry Views

Feedback to MSHA indicates that truck drivers need and appreciate signing specifically for trucks. They perceive that road design is for automobiles, not for trucks. Truck drivers feel that they depend more on these signs because their vehicles have greater rollover potential than automobiles. They would like problems such as sharp curves and limited superelevation on roadways identified through the use of signs intended specifically for them. Truckers, both motor carriers and independents, who use Maryland roadways sent a list of sites to MSHA identifying ramps where these signs should be installed. Maryland truckers have also expressed interest in having a dual advisory speed -- one for trucks and one for cars.

The safety manager was familiar with the specific ramps and the truck tipping signs. He thinks that they were a good idea, however, they would be more helpful if they were placed in advance of the ramp so that they could give truck drivers more time to react.

CHAPTER 8

HARRISBURG, PENNSYLVANIA CASE STUDY

OVERVIEW

Description of Area

Harrisburg, the State capital of Pennsylvania, is a mid-sized urban area located in the south-central part of the State on the Susquehanna River. It is a major industrial center for steel, steel products, meat, and lumber. Passing near Harrisburg to the south is the Pennsylvania Turnpike, which is a major east/west corridor for southern Pennsylvania. The Turnpike connects Harrisburg to Philadelphia to the east and Pittsburgh to the west. Truck tipping signs were installed at two ramps in the Harrisburg area. The locations of the ramps are shown on figure 36 which also includes the major road network in the Harrisburg area.

Countermeasures Implemented

Truck tipping signs have been installed on the following ramps in the Harrisburg area:

- PA Route 283 westbound to I-283 northbound.
- I-81 eastbound to US 22/322 northbound.

Accidents

Pennsylvania Department of Transportation (PennDOT) provided accident summaries for truck-involved accidents on each ramp.

Truck Industry Views

The first trucker, now employed by Pennsylvania Motor Trucking Association (PMTA) as a PMTA representative, drove a truck during the 1940's and 1950's and served as a safety manager, operations manager, and in other administrative capacities for 17 years in the trucking industry prior to his present position. The second trucker is a safety supervisor for a trucking firm. He is on the Safety Advisory Panel of the PMTA and is past president of their PMTA chapter. The third trucker is a general commodities carrier administrator who formerly drove a truck, but is now in an administrative position. He still possesses a commercial driver's license, but no longer drives a truck. The fourth trucker interviewed was a tanker operator in York, Pennsylvania.

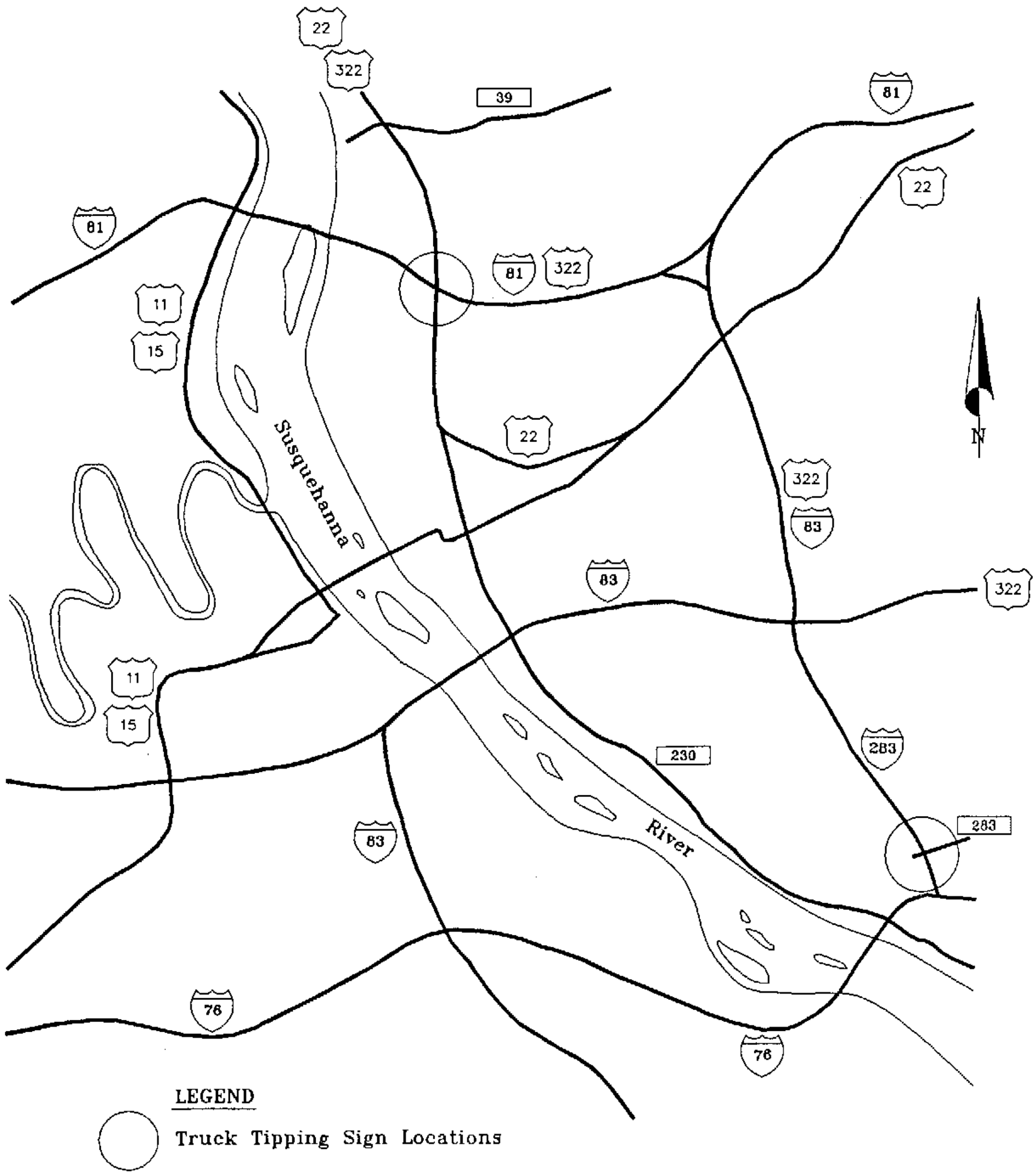


Figure 36. Harrisburg, Pennsylvania roadway system.

RAMP TREATMENTS

Background

Figure 38 shows the layout of the PA Route 283 and I-283 interchange. PA Route 283 near this interchange has an average daily traffic of 40,940 vpd with 13 percent trucks. This roadway serves traffic to and from the Harrisburg airport, the Pennsylvania Turnpike, and the city of Harrisburg; it has four lanes, with two through lanes in each direction at its interchange with I-283. Table 8 lists a 24-hour traffic classification count conducted in August 1991 on the PA Route 283 westbound to I-283 northbound ramp.

The interchange at I-81 and US 22/322 is a fully directional interchange on the north side of downtown Harrisburg (see figure 38). The northbound only traffic volume in July 1991 on I-81 was 31,835 vpd with 21 percent trucks. (The average daily traffic is approximately double this number, or 63,000 vpd.) A ramp classification count was conducted on August 6, 1991 on the I-81 eastbound to US 22/322 northbound ramp. The results are listed in table 9.

Table 8. Traffic classification count on PA Route 283 westbound to the I-283 northbound ramp.

Vehicle Class	Number	Percent of Total
Cars + Trailer	7905	79.2
Two-axle long	364	3.6
Three-axle single	103	1.0
Three-axle semi	79	0.8
Four-axle single	25	0.3
Four-axle semi	237	2.4
Five-axle semi	1155	11.6
Five-axle twin	85	0.9
Six-axle semi	16	0.2
Six-axle twin	9	0.1
Over six-axle multi	6	0.1
TOTAL	9984	100.0

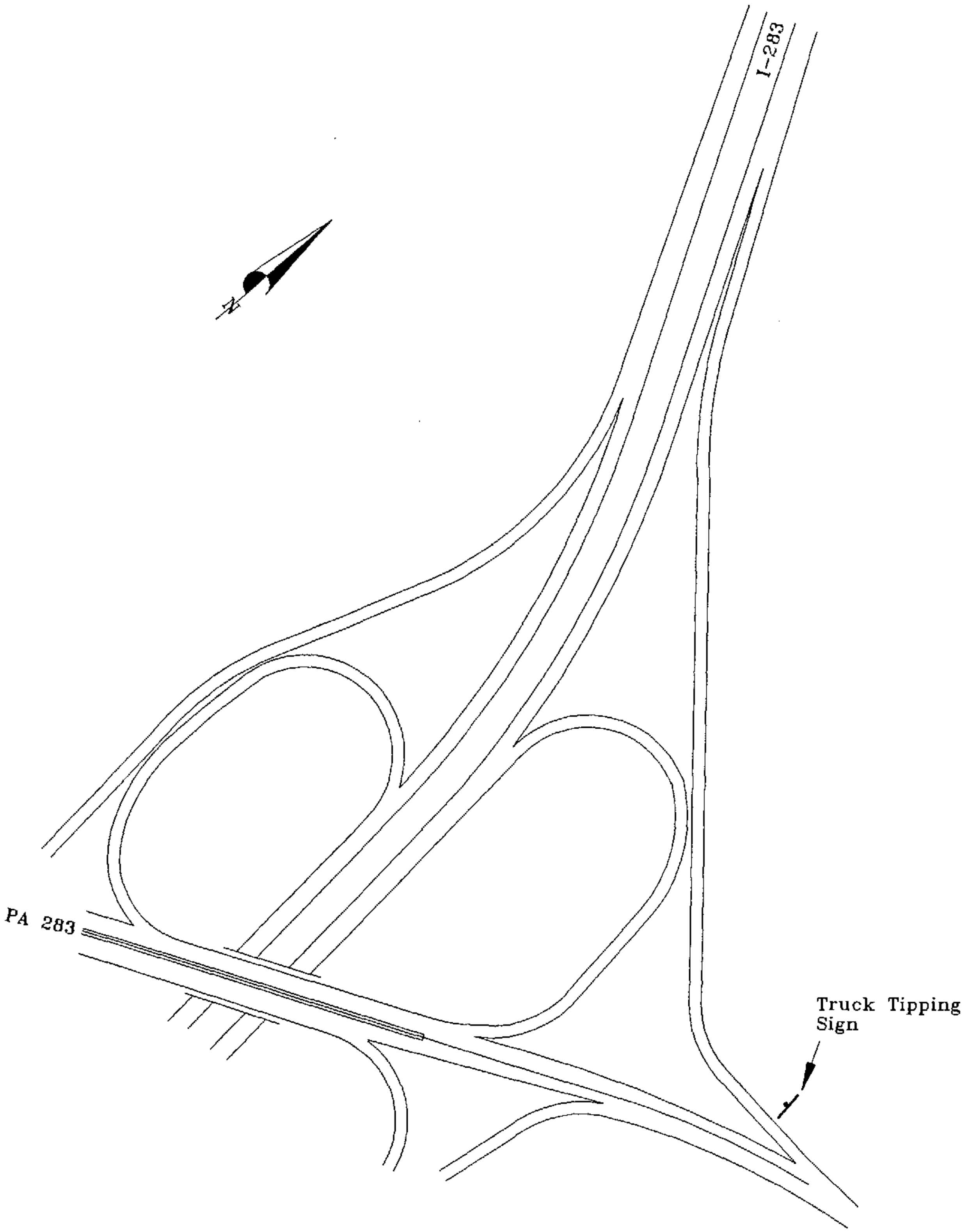


Figure 37. PA Route 283/I-283 interchange layout.

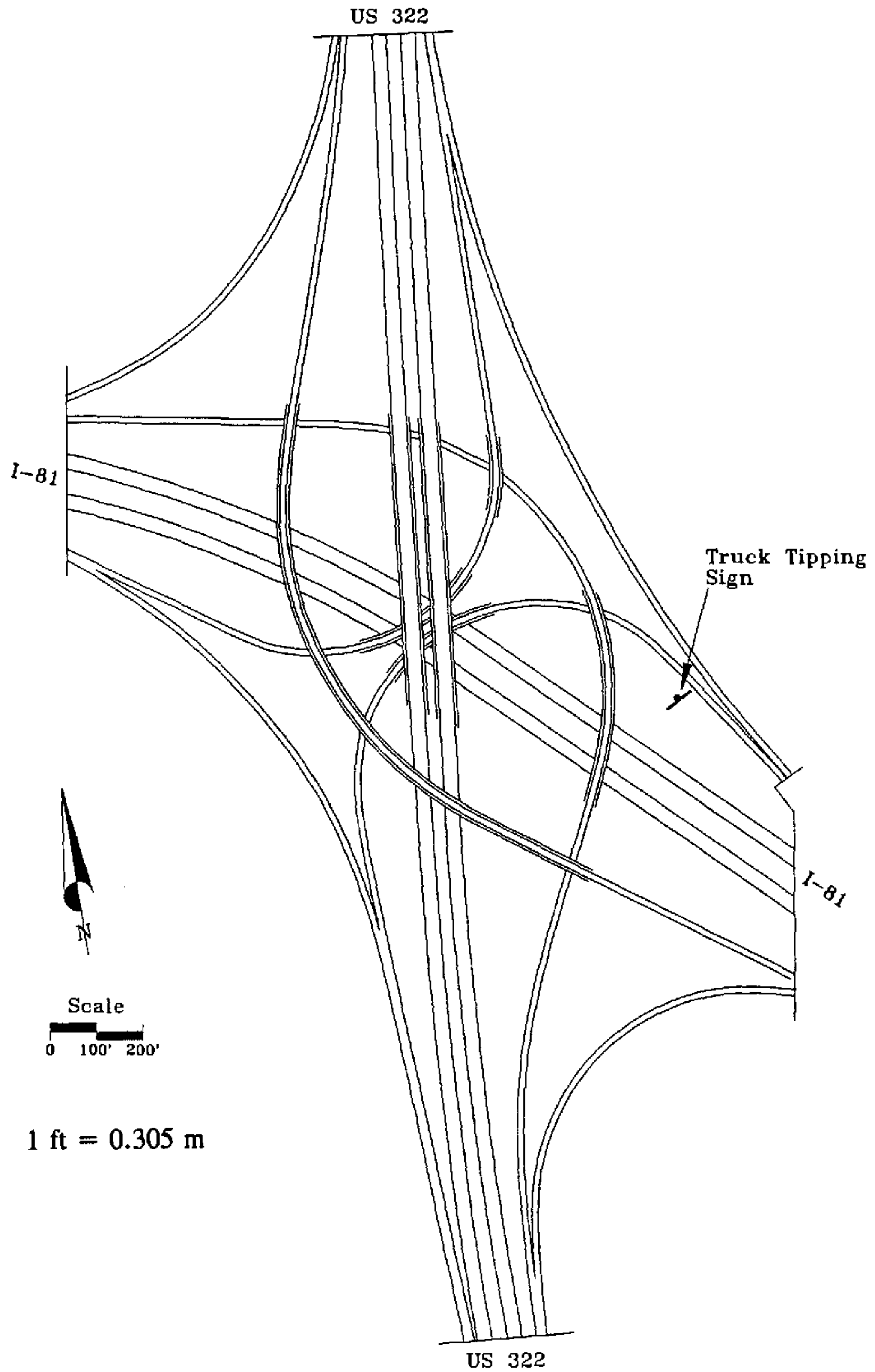


Figure 38. I-81/US 22/322 interchange layout.

Table 9. Traffic classification counts on I-81 northbound to the US 22/322 northbound ramp.

Vehicle Class	Number	Percent of Total
Cars + Trailer	1652	80.5
Two-axle long	91	4.4
Three-axle single	23	1.1
Three-axle semi	10	0.5
Four-axle single	0	0.0
Four-axle semi	31	1.5
Five-axle semi	198	9.7
Five-axle twin	42	2.0
Six-axle semi	1	0.0
Six-axle twin	3	0.1
Over six-axle multi	0	0.0
TOTAL	2051	100.0

Implementation

Truck tipping signs were installed on July 26, 1988 on the two ramps. The westbound PA Route 283 to northbound I-283 ramp also had rumble strips installed several years before the truck tipping sign was installed. Accident reports were not available for this analysis, however PennDOT provided accident summaries for the truck-involved accidents that occurred on the ramps. A summary for each location of the accidents for a before-the-sign installation period (January 1, 1988 to July 25, 1988) and an after period (July 27, 1988 to February 23, 1991) is listed in tables 10 and 11.

The cost of signs in Pennsylvania are typically \$160 per m^2 (\$15 per ft^2) for signs installed by PennDOT. One 1.2-m by 1.2-m (48-in by 48-in) sign was placed on each ramp. Based on this unit cost, each sign would cost \$240. No costs were available on labor and equipment required to install the signs.

Table 10. Truck accident summary for PA 283 westbound to the I-283 northbound ramp.

Date	Accident Factors	Alcohol	Light,Surface	Severity
Before Accidents:				
02/04/86	Large truck overturned	No	Daylight, Rain	Moderate Injury
08/27/86	Large truck hit utility pole	No	Daylight, Dry	Minor Injury
04/10/87	Small truck overturned	Yes	Dusk, Dry	No Injury
09/12/87	Large truck hit sign support	No	Daylight, Wet	Moderate Injury
11/11/87	Large truck jackknifed	Yes	Daylight, Snow	No Injury
After Accidents:				
05/28/89	Small truck overturned	Yes	Daylight, Dry	Fatal
07/05/89	Large truck overturned	Yes	Daylight, Rain	No Injury
08/14/89	Truck hit utility pole and jackknifed	Yes	Daylight, Rain	No Injury
07/02/90	Large truck overturned	Yes	Daylight, Dry	Minor Injury

Table 11. Truck accident summary for the I-81 northbound to US 22/322 northbound ramp.

Date	Accident Factors	Alcohol	Light, Surface	Severity
Before Accident:				
04/27/87	Overturned, hit embankment	No	Daylight, Dry	Moderate Injury
After Accident:				
03/25/90	Overturned, too fast for condition	Yes	Dawn, Dry	No Injury

Effectiveness

No information was available on compliance by truck drivers of the warning sign. One measure of compliance would be speed reduction by high center-of-gravity trucks approaching the curve. No speed studies are available. Informal observation of the before/after accident does not indicate any noteworthy difference in the number of accidents (see tables 10 and 11).

Truck Industry Views

The PMTA representative stated that any vehicle driver after traveling a long distance on freeways at high speeds, loses sense of speed and needs to observe the speedometer in order to know how fast the vehicle is actually going. With automobile operators, the driver can brake and decelerate to overcome the predicament. With a truck driver, the curve may be sharper than anticipated and rollover can result. He suggested a sign that has the message "DON'T TRUST YOUR SENSES, READ YOUR SPEEDOMETER." The most serious problem, according to this ATA State affiliate is irresponsible drivers. They ignore signs that provide warning messages installed for them. He contends the problem often is simply driver error.

With regard to ramp alignment, the regional safety supervisor cautioned that ramps with two drastically different rates of curvature cause truck drivers problems. The driver sees the less severe portion of the curve and bases the vehicle's speed on that portion of the curve. Proceeding at that speed to the sharper curvature can cause the vehicle to rollover or lose control. He suggested that highway departments should "draw the truckers a picture." A symbol sign perhaps showing the break in the ramp curvature would be more effective than a word message sign. A word message also suggested might be "DEGREE OF TURN CHANGES." He stated that the truck tipping sign is also effective in warning truck drivers.

The general commodities carrier administrator was familiar with the two locations in Harrisburg where the truck tipping sign had been used, but he was even more familiar with a ramp in the York, Pennsylvania area which used this sign. The problem with these warning signs is that their placement is so close to the hazard that truck drivers have insufficient reaction time and braking distance. The approach to the ramp in York requires traffic to cross over the cross street (crest vertical curve) and the sign is near the gore. He thinks there should be advanced warning of the impending ramp with the word "RAMP" underneath. He described the ramp alignment as going from a fairly flat curve and progressing to a very sharp curve. He remembers the posted advisory speed for this curve being 24 km/h (15 mi/h).

Posted advisory speeds are appropriate for passenger cars, according to this administrator, but are often too fast for trucks. If a ramp is posted at 56 km/h (35 mi/h), cars can usually negotiate the curve at 56 to 64 km/h (35 to 40 mi/h) without difficulty. Cars have better suspensions and tires and are built lower to the ground compared to those built a few years ago. If a truck is not loaded, the safe speed might be similar to that of a passenger car. For loaded trucks, the safe speed depends on the load. A loaded tanker is less stable than a flat bed or a box van with a dense load (low center of gravity). Loads which shift or those with high centers of gravity require safe speeds lower than those of automobiles. One answer might be two different advisory speeds -- one for trucks and another for cars.

Asked whether he thinks truck drivers pay attention to warning signs, the administrator replied that he thinks most of them do. A few truck drivers ignore warnings as do automobile drivers. If a sign has the word "TRUCKS" on it or shows a picture of a truck, most truck drivers will pay attention to it.

The tanker operator in York, Pennsylvania was not familiar with the specific ramps in Harrisburg but was familiar with a similar situation on US 30 near York, where the same signs had been installed. He stated these signs are helpful to truck drivers if the truck driver is observant and alert. Advisory speeds on ramps and mainline curves are typically set 8 to 16 km/h (5 to 10 mi/h) too fast for loaded tankers. Baffles in tankers today reduce front-to-back movement of liquid but they do not help the side-to-side movement.

CHAPTER 9

LOS ANGELES, CALIFORNIA CASE STUDY

OVERVIEW

Description of Area

Figure 39 shows the Los Angeles area including many of the suburbs within the urbanized area. Los Angeles occupies a land area of 1202 km^2 (464 mi^2) and is surrounded by 87 cities and towns. It is one the Nation's leading manufacturing, oil refining, and trade centers. In addition to being an industrial center, Los Angeles has a large tourism industry. The Los Angeles freeway system is one of the most extensive in the country and includes as its major freeways: I-5 known as the Golden State or Santa Anna Freeway, I-605 known as the San Gabriel River Freeway, I-10 known as the San Bernadino Freeway, I-405 known as the San Diego Freeway, US-101 known as the Hollywood or Ventura Freeway, SR-110 known as the Pasadena Freeway, I-110 known as the Harbor Freeway, and I-210 known as the Foothill Freeway. Los Angeles has the busiest port area in the United States, which includes the Port of Los Angeles and the Port of Long Beach. The port area generates a tremendous number of truck trips year-round.

Countermeasures Implemented

The following countermeasures that have been implemented in the Los Angeles area were investigated. Brief introductions to these countermeasures follow:

- **Ramp Treatments**--One freeway ramp has been treated with countermeasures to mitigate accidents involving trucks. The improvements include installation of static signs and a flashing overhead wig-wag.

- **Restrictive Truck Facilities**--Truck by-pass lanes have been built to overcome weaving problems trucks might otherwise encounter in the vicinity of three major interchanges.

- **Urban Inspection Stations**--One urban inspection station has been built on I-405 in the Los Angeles area for the purpose of weighing and inspecting trucks.

- **Bans/Restrictions**--The City of Los Angeles is evaluating the feasibility of restricting the movements of trucks during the peak periods of weekdays.

- **Incident Response Management**--Systems include: a freeway tow service, a traffic operations center, major incident response teams, electronic surveillance and detection, closed circuit television cameras, changeable message signs, highway advisory radio, and a network of commercial radio stations and other media.

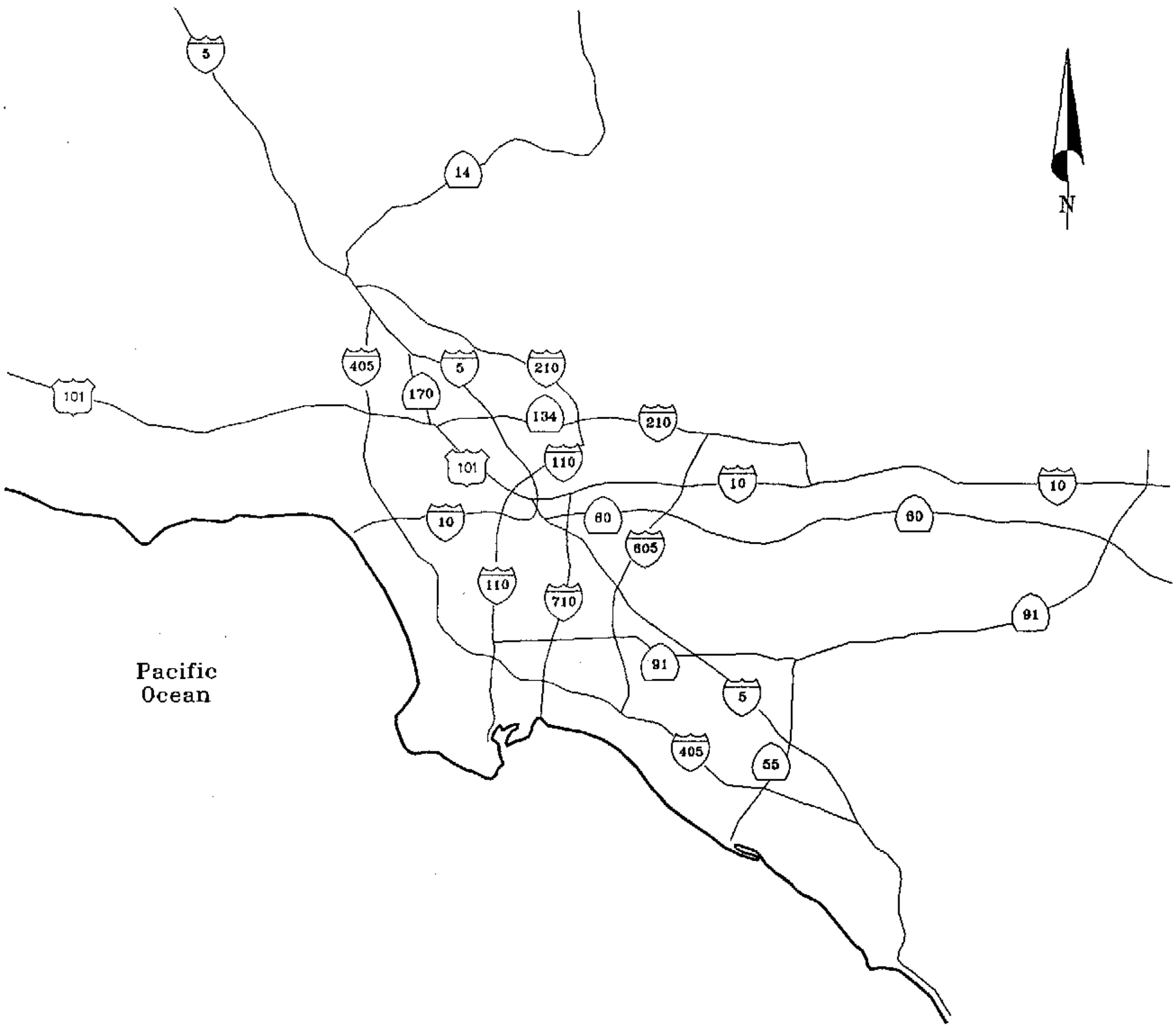


Figure 39. Los Angeles, California freeway system.

Still other truck accident countermeasures have been implemented or have been evaluated in the Los Angeles area. In some cases, they include a concept which is under investigation; in others, there is simply too little information to allow evaluation. Following is a brief description of these countermeasures.

California used increased enforcement for a 12-month period from January to December 1987 to evaluate its effect on truck accidents. Specially marked patrol vehicles (SMPV's) were used to patrol five freeway segments to primarily enforce heavy truck laws. The study found that increased enforcement using specially marked patrol vehicles was successful in reducing the number of truck-at-fault accidents. Changes in truck-involved and truck-at-fault accidents were evaluated by the CHP using 1986 as the before period. Total results for all 5 test sites indicate a 3.5 percent reduction in truck-at-fault accidents (statistically significant at the 90 percent confidence level), compared to a 5.8 percent increase on non-test site freeway beats within the CHP Areas participating in the program. Injury (including fatal) truck-at-fault accidents dropped by 11.2 percent, compared to a reduction of only 0.4 percent on all non-test site freeway beats within CHP areas participating in the program. CHP estimated benefits from the accident reductions for 1 year to be approximately $5 million, whereas the cost of the program was $1,556,355.[15] The CHP recommended retaining the SMPV's for use on any highway segment within the State that meets specified criteria related to truck accidents or noncompliance with highway safety laws.

There is a climbing lane on the Glendale Freeway but truck drivers usually avoid this freeway because of the grades and use more desirable alternatives. Thus this extra lane serves as a fifth traffic lane for all traffic. According to California Department of Transportation (CALTRANS) engineers, problems occur when buses and delivery vans use the freeway because they often use the number three lane (third from the inside), so that faster moving vehicles pass at higher speeds on both sides of them. Motorists ascending the grade typically choose lanes based on their destination because the freeway terminates at its interchange with I-210 at the summit of this grade. The left three lanes transition to outbound (northwest) I-210.

There is also a truck avoidance policy currently in effect for the I-110 (the Harbor Freeway) in Los Angeles during major reconstruction. It is only a voluntary ban and CALTRANS reports that the reduction in trucks in negligible. Los Angeles also recently instituted a truck ban ordinance in the Wilmington (harbor) area which reduced the route options available to truck drivers.

The California Motor Vehicle Code allows CALTRANS or local authorities to limit the lanes in which specified vehicles can operate based on an engineering and traffic investigation. This provision has apparently been in existence since 1963, with the latest revision in 1989. CALTRANS restricts trucks to the right two lanes on freeways with three or more lanes by direction.

A truck and rail freight corridor is being considered along Alameda Street beginning at the ports of Long Beach and Los Angeles and ending at the Santa Fe and Union Pacific rail yards near downtown Los Angeles. One goal is to consolidate all movements from three rail carriers on the Alameda corridor, double track this line, grade separate it, and construct sound barriers, concentrating the port traffic in this one corridor. The preferred option (by cities along the corridor) currently is to provide three highway lanes on each side of the depressed track. The rail facility would be 9.7 m (32 ft) deep and 14.3 m (47 ft) wide. Then, the highway would be at-grade, and rail would also still be required at grade. A consultant has been hired to study various design scenarios at a price of $5.7 million. They are about halfway through the process but they have not begun the Environmental Impact Statement.

Several truck accident countermeasures have also been implemented on the section of I-5 north of the I-5/Route 210/Route 14 truck bypass, primarily because of long, steep grades. Because this is predominantly a rural area, the countermeasures are being mentioned but not covered in detail. The mountainous topography along this stretch of I-5 has created the need for these countermeasures. Included are: a truck escape ramp, a truck speed limit, numerous truck warning signs, and a restriction of trucks to the right lane. This lane restriction is stringent because it only provides *one lane* for trucks. Observations of trucks on the ascending direction is that faster trucks are passing slower trucks by using the middle two of four available lanes. One additional countermeasure was implemented on a long grade, known locally as the "5-mile grade." The road was designed to follow the topography so that descending lanes were constructed where flatter slopes were available. The southbound lanes were built to the east of the northbound lanes along an alignment that was 0.25 km (0.4 mi) longer over its 8-km (5-mi) length. Grade separated cross-overs were employed at the top and bottom of the grade for the southbound lanes.

Accidents

Table 12 is an accident summary for Los Angeles for 1990. In reporting these statistics, CALTRANS estimates that it receives collision reports for approximately 100 percent of all fatal accidents, 90 percent of all injury accidents and 40 percent of all property-damage-only accidents occurring on State highways. Accident rates presented in this table (Total Accidents and Fatals Plus Injuries) are per million vehicle miles (MVM) traveled.

Truck Industry Views

One trucker interviewed for this study is a safety director for a local freight line. This individual is now an administrator, but drove a truck for five years. The second was President and Chief Executive Officer (CEO) for a tanker and hazardous waste hauler. He has never driven a truck. Interviews were conducted by telephone.

Table 12. 1990 accident summary for Los Angeles.

Roadway Type	Road Miles	Accidents				Rates	
		Total	PDO	Injury	Fatal	Acc/MVM	(F+I)/MVM
Non Fwy	250.5	7,401	3,820	3,521	60	2.33	1.13
Fwy	498.8	30,013	19,059	10,744	210	0.96	0.35
Total	749.3	37,414	22,879	14,265	270	1.09	0.42

Source: CALTRANS

RAMP TREATMENTS

Background

The Route 91 eastbound to the I-605 northbound ramp in Los Angeles has been treated with several traffic warning devices. It is a two-lane ramp that exits the mainlanes to the right and follows a sweeping curve to the left to join the mainlanes of I-605 (See figure 40). This ramp has had numerous accidents involving both automobiles and trucks. CALTRANS added chevrons, a large truck tipping sign (approximately 2.4 by 2.4 m [8 ft by 8 ft]), turn warning signs on both sides, and a large overhead sign with 0.30-m (12-in) diameter yellow wig-wags. One CALTRANS engineer stated that they typically use oversized warning signs more than the truck tipping sign.

The process typically used by CALTRANS engineers to identify high accident locations is by evaluating "Table C" output. The Table C printout is generated every quarter and sent to the appropriate engineer(s) for investigation. It lists locations where accident rates exceed a pre-selected value. Once decisions are made regarding remedial measures and the countermeasures have been implemented, the engineer checks subsequent printouts of the Table C to determine if other corrective measures are needed.

Average annual daily traffic (AADT) volumes in 1989 on Route 91 at the point of departure of this connector from mainlanes was 265,000 vehicles per day. Of this total, 23,850 (9.0 percent) are trucks rated at 1362 kg (1.5 tons) or greater with dual rear wheels. Almost half of these (10,732) trucks had 5 or more axles. No traffic volumes were readily available for the subject connector, however, observations indicated a relatively high percentage of trucks. I-605 just north of this interchange had an average annual daily traffic in 1989 of 227,000 vehicles per day. Of these, 5.6 percent (12,712) were trucks rated at 1362 kg (1.5 tons) or greater.

Implementation

CALTRANS installed chevrons to the eastbound Route 91 to northbound I-605 connector in December 1986. The large overhead sign with 0.30 m (12-in) diameter yellow wig-wags was installed in May 1986. The turn warning signs near the gore area were installed in December 1986 and the large truck tipping warning sign (approximately 2.4 m by 2.4 m (8 ft by 8 ft) was installed in May 1977.

Effectiveness

Table 13 lists the truck-involved accidents that occurred on the ramp before the warning devices were installed, and table 14 summarizes the accidents that have occurred following implementation. These tables include only those truck accidents expected to be affected by the countermeasures implemented and not the total number of accidents that

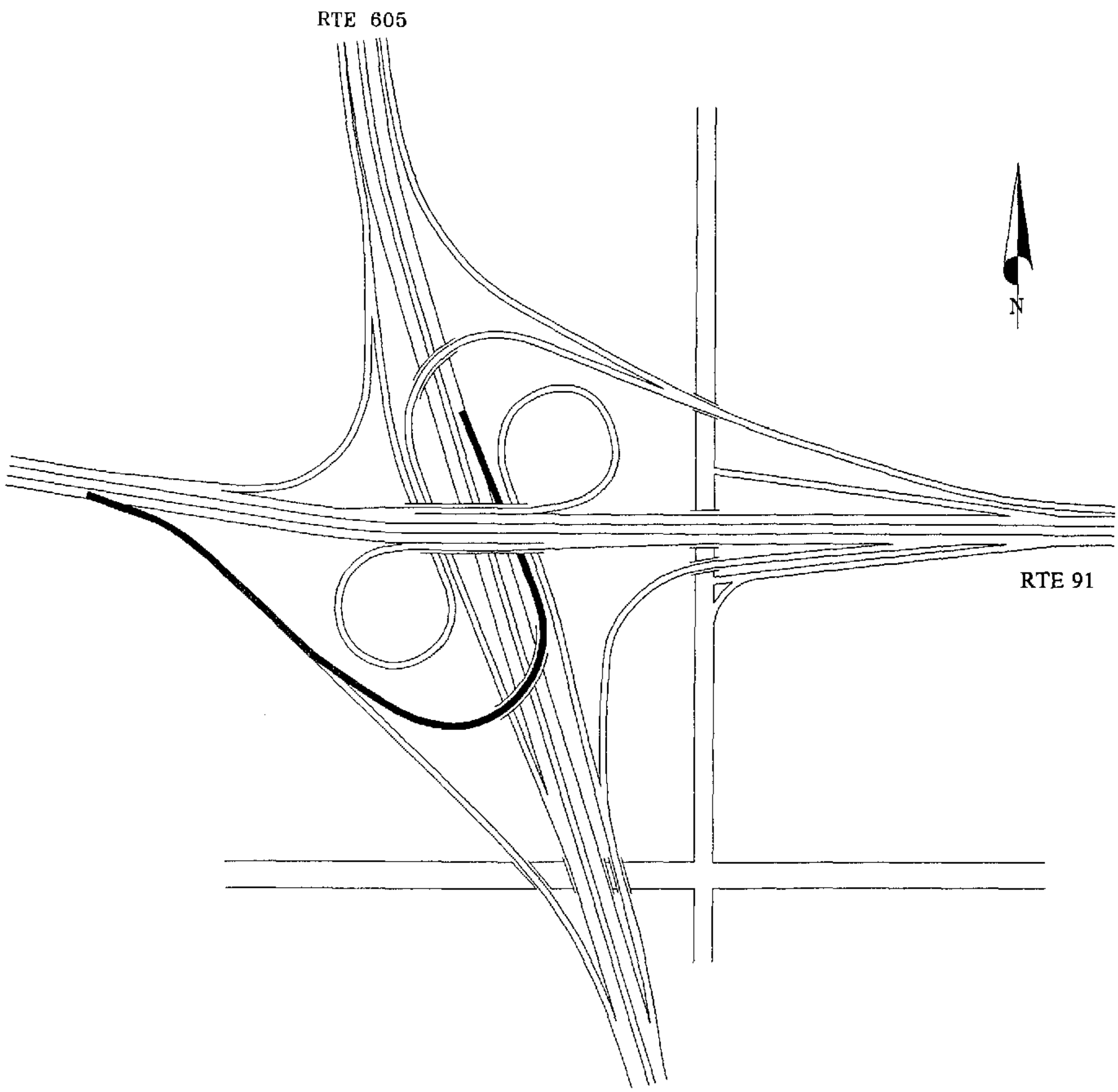


Figure 40. I-605/Route 91 interchange.

involved trucks. Conclusions regarding effectiveness are not as definitive without the more detailed accident reports, however, it appears that the number of accidents during the "after" period is approximately half of what it was during the "before" period. Half of the before accidents involved injuries, whereas only two of the 10 accidents in the after period involved personal injuries. This represents a significant reduction, although most of the accidents in both time periods included overturned trucks--another indication of severity.

Truck Industry Views

The safety director stated that advisory signs are a good idea in that they provide additional necessary warning to truck drivers. The President and CEO commented that these signs are a good idea, but they will only work for the careful drivers.

Table 13. Truck accidents before improvements to the eastbound Route 91 to northbound I-605 connector.

Date	Type of Accident	Light/Road Conditions	Severity
12/05/84	Truck, hit guardrail, overturned	Daylight, Dry	Injury
10/23/84	Large truck overturned	Daylight, Dry	Injury
8/23/84	Large truck overturned[1]	Daylight, Dry	Injury
06/29/84	Large truck hit pole	Daylight, Dry	No Injury
04/09/84	Large truck overturned[1]	Daylight, Dry	Injury
04/09/84	Truck overturned[1]	Daylight, Dry	Injury
12/05/83	Large truck overturned[1]	Daylight, Dry	Injury
11/28/83	Truck overturned[1]	Daylight, Dry	Injury
08/27/83	Large truck overturned[1]	Daylight, Dry	Injury
04/26/83	Large truck, hit gore curb; overturned[1]	Daylight, Dry	No Injury
11/15/82	Large truck hit guardrail; overturned	Daylight, Dry	No Injury
05/04/82	Truck hit curb	Daylight, Wet	No Injury
03/29/82	Truck hit curb; hit embankment; overturned[1]	Daylight, Wet	Injury
02/16/82	Large truck hit curb; overturned	Dark, Wet	No Injury
11/19/81	Large truck hit guardrail	Daylight, Dry	No Injury
10/05/81	Large truck overturned	Daylight, Dry	No Injury
09/30/81	Large truck hit guardrail	Dark, Wet	No Injury
08/25/81	Large truck hit curb; hit guardrail; hit embankment; overturned	Daylight, Dry	Injury
08/20/81	Large truck hit guardrail; overturned	Daylight Dry	No Injury
04/07/81	Large truck overturned; spilled load	Dawn, Dry	No Injury

[1] Accident occurred at "ramp entry"

Table 14. Truck accidents after improvements to the eastbound Route 91 to northbound I-605 connector.

Date	Type of Accident	Light/Road Conditions	Severity
11/20/90	Truck/twin trailer hit guardrail	Dark, Dry	No Injury
10/31/89	Large truck hit curb; hit guardrail; overturn	Daylight, Dry	Injury
09/18/89	Large truck overturned	Daylight, Dry	No Injury
05/30/89	Truck overturned	Daylight, Dry	No Injury
12/31/88	Truck/twin trailer hit left med. bridge rail; hit right med. bridge rail; hit guardrail	Daylight, Rain	No Injury
12/18/88	Large truck overturned	Daylight, Wet	No Injury
10/25/88	Large truck overturned	Daylight, Dry	Injury
04/01/88	Truck overturned	Daylight, Dry	No Injury
04/20/87	Large truck overturned	Dark, Dry	No Injury
01/03/87	Truck hit curb; hit left embankment; hit right guardrail; hit right embankment	Dark, Dry	No Injury

SEPARATE TRUCK FACILITIES

Background

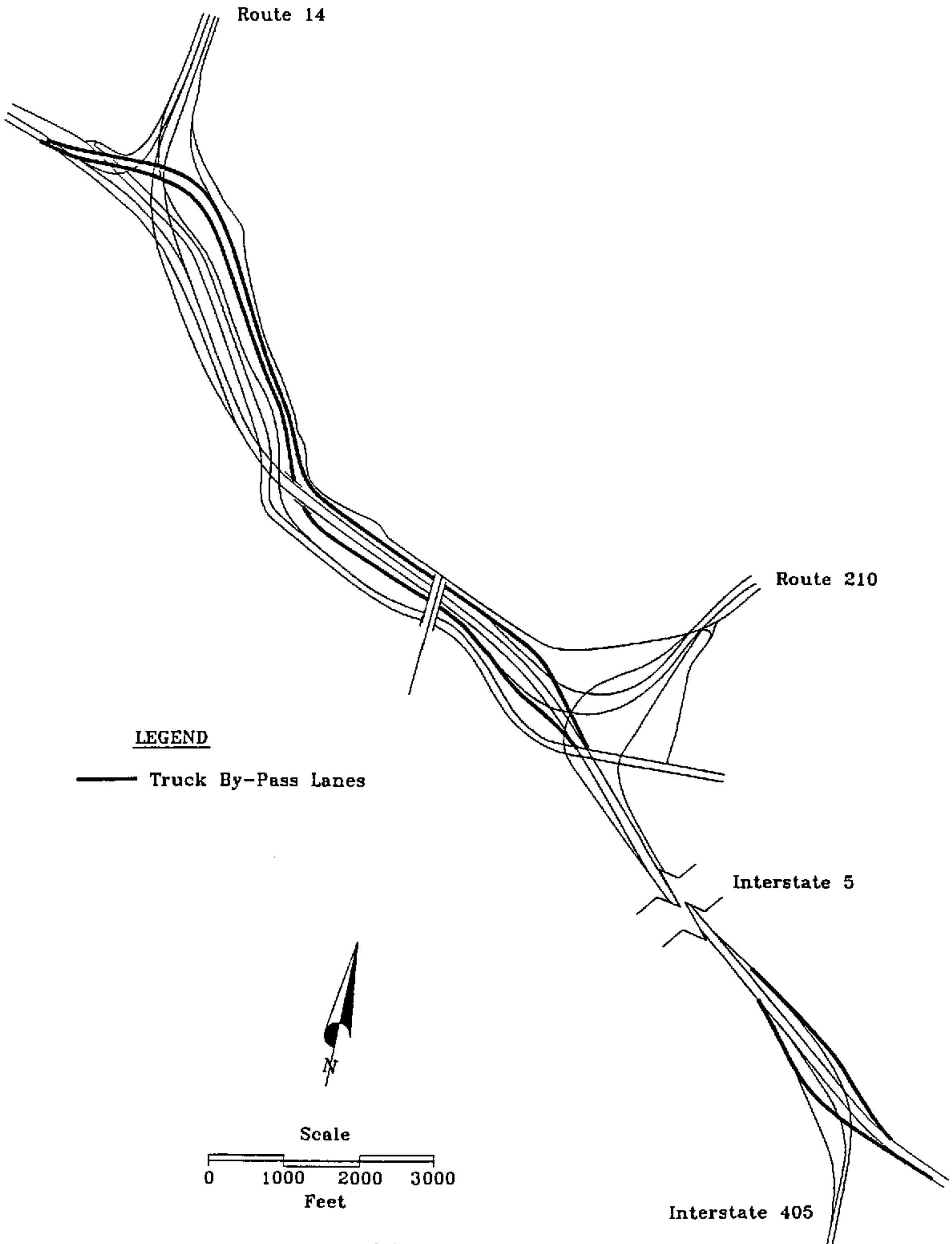
Interstate 5 north of greater Los Angeles is a corridor which accommodates heavy volumes of trucks. The segment of I-5 just south of the I-405 truck facility has an average daily traffic of 93,000 vpd with 12.5 percent trucks. Just to the north of the separate truck facility, the AADT is 210,000 vpd with 13.0 percent trucks. Beyond Route 14 (to the north) the AADT drops to 122,000 vpd with 13.5 percent trucks. According to CALTRANS truck traffic counts, there are as many as 25,000 trucks per day on the truck facility near Route 14 and Route 210. North of this segment at the Kern County line (with Los Angeles County), the truck AADT dropped to 13,365 trucks per day. In Kern County, the truck percentage is as high as 35.8 percent of 18,200 vehicles per day total traffic. Toward Dunsmere just south of the Oregon border, trucks comprise 35 percent of the total traffic stream and these are primarily five axle trucks. The total AADT in this area is 12,000 to 14,000 vehicles per day. For comparison with another freeway with high AADT and high truck volumes, I-710 carries an AADT of up to 210,000 vehicles per day with 14.1 percent trucks.

CALTRANS built truck bypass lanes on I-5 near three volume interchanges to facilitate weaving maneuvers: Route 14 and Route 210. The lanes are shown schematically in figure 41. These facilities have been built to separate trucks from other traffic in the interchange proper even though they are not limited to trucks. Automobiles and other vehicles are also allowed. Trucks are restricted to the right lane(s) in California which means that if trucks exit the mainlanes from the right side and reenter from the right, there is little or no weaving required for the trucks. In locations where weaving capacity is exceeded, one solution is to remove trucks through that section and allow smaller vehicles to utilize available capacity.

Other truck bypass lanes have been built in California such as at I-5 at Route 99 near Grapevine and at the interchange of Route 110 with I-405 in Los Angeles. CALTRANS engineers stated that these truck bypass lanes were not necessarily built where the highest volumes of trucks are located. For example, I-710 carries one of the highest number of trucks in Los Angeles and does not have bypass lanes for trucks. One engineer stated that the locations of truck lanes are motivated by engineering and not political decisions.

Implementation

The separate truck facilities were generally built in the 1970's, so detailed information justifying their construction is scarce. The primary reason for initially constructing these bypass lanes was to reduce weaving problems which were occurring with all traffic passing through the mainlanes at the interchanges. One example is the I-405/Route 110 bypass, which was built strictly to eliminate weaving for trucks. The current emphasis is on building high-occupancy vehicle (HOV) facilities, and if given the choice between these two options, the choice might now gravitate toward HOV facilities.



1 ft = 0.305 m

Figure 41. Schematic of truck bypass near Route 14 and Route 210.

In locations where truck volumes are high, CALTRANS tries to design the geometrics to better accommodate truck operations. Because land is so expensive in California, CALTRANS must evaluate each situation very carefully. Even where economically justified, constructing additional truck facilities might be politically difficult in Los Angeles. The cost of the truck bypass is dependent upon available existing facilities. For example, an existing route was used for the Route 91 interchange and the interchanges of I-5 with Routes 14 and 210 north of Los Angeles, a section of the old roadway, was kept intact and used for the truck bypass.

The truck bypasses are typically two lanes. For a new freeway such as the Century Freeway, freeway to freeway connectors of any type are built with 105 km/h (65 mi/h) design speeds and are two lanes wide. At the design stage, CALTRANS engineers compute an index based on accidents, delay and costs which will determine the priority of the project.

Reactions from motorists on truck facilities are very limited, because truck facilities are so few. Auto drivers often prefer to use them to avoid weaving within the interchange. Truck drivers generally desire to have their use limited to trucks only.

Effectiveness

Table 15 is a summary of accidents involving trucks for the time period from January 1, 1981 through December 31, 1990 on truck bypass facilities in the Los Angeles area. These truck facilities are used not only by trucks but by smaller vehicles as well. This summary is provided simply to indicate the accident history during the "after" implementation period. No accident data was available for the "before" period for comparison.

CALTRANS does not identify accidents by "trucker at fault," however, this information is sometimes apparent from the narrative on individual accident reports. Another problem is that accident data are only available for a time period of 10 years, so that no "before" data is available.

Truck Industry Views

CALTRANS officials stated that truck drivers would like to limit the bypass lanes to trucks only because of different operating characteristics of the two vehicle classes and also because of an apparent lack of understanding by auto drivers of truck operating characteristics.

The safety director was not totally convinced that these truck facilities are effective. He stated that they take traffic off the main artery, but an extra lane would do the same thing. The President and CEO believes the truck facilities are adequate, but that they make little difference. He has noticed that trucks will park on the shoulders of the bypass lanes before parking on other freeways.

Table 15. Truck accident summary for selected truck bypass lanes in the Los Angeles area.

Location	Type of Accident	Number	Injury/ Fatality
I-5 at I-405 Northbound	Sideswipe	2	1/0
	Overturn	1	0/0
I-5 at I-405 Southbound	Sideswipe	8	1/0
	Rear-end	1	1/0
	Hit Object	3	2/0
	Overturn	1	0/0
I-5 at 210/14 Northbound	Sideswipe	18	2/0
	Rear-end	18	12/0
	Hit Object	16	9/0
	Overturn	3	2/0
	Head-on	1	0/0
	Other	6	4/0
I-5 at 210/14 Southbound	Sideswipe	9	2/1
	Rear-end	8	13/0
	Hit Object	19	3/1
	Overturn	8	4/0
	Other	4	3/0
I-405 to I-110 Northbound	0	0	0

Source: CALTRANS

URBAN INSPECTION STATIONS

Background

An urban inspection station was constructed by CALTRANS on I-405 (the San Diego Freeway) in the city of Carson. The California Highway Patrol (CHP) operates this facility. CALTRANS installed permanent scales on both sides of the freeway, but more space to perform inspections exists on the northbound side than on the southbound side. Figures 42 and 43 illustrate the layout of the scales, the CHP building, and the inspection area (northbound only). Improvements installed specifically for inspections included asphalt paving and striping; no buildings were constructed for inspections at this location. In some predominately rural locations, CALTRANS has constructed large buildings with pits, office space, and bays sufficient for parking large combination vehicles. The current cost of such inspection stations is approximately $8 million each, according to CALTRANS.

California Highway Patrol sources stated that the emphasis over the next few years will be on constructing ports of entry at or near the California border on major routes. They currently have scales at a few locations, but none of these existing locations were designed for inspections. Major route numbers that are high priority for ports of entry are: 8, 10, 40, and 15 at California's border with Nevada and Arizona. These ports of entry are being planned with inspection pits with three or four bays per location.

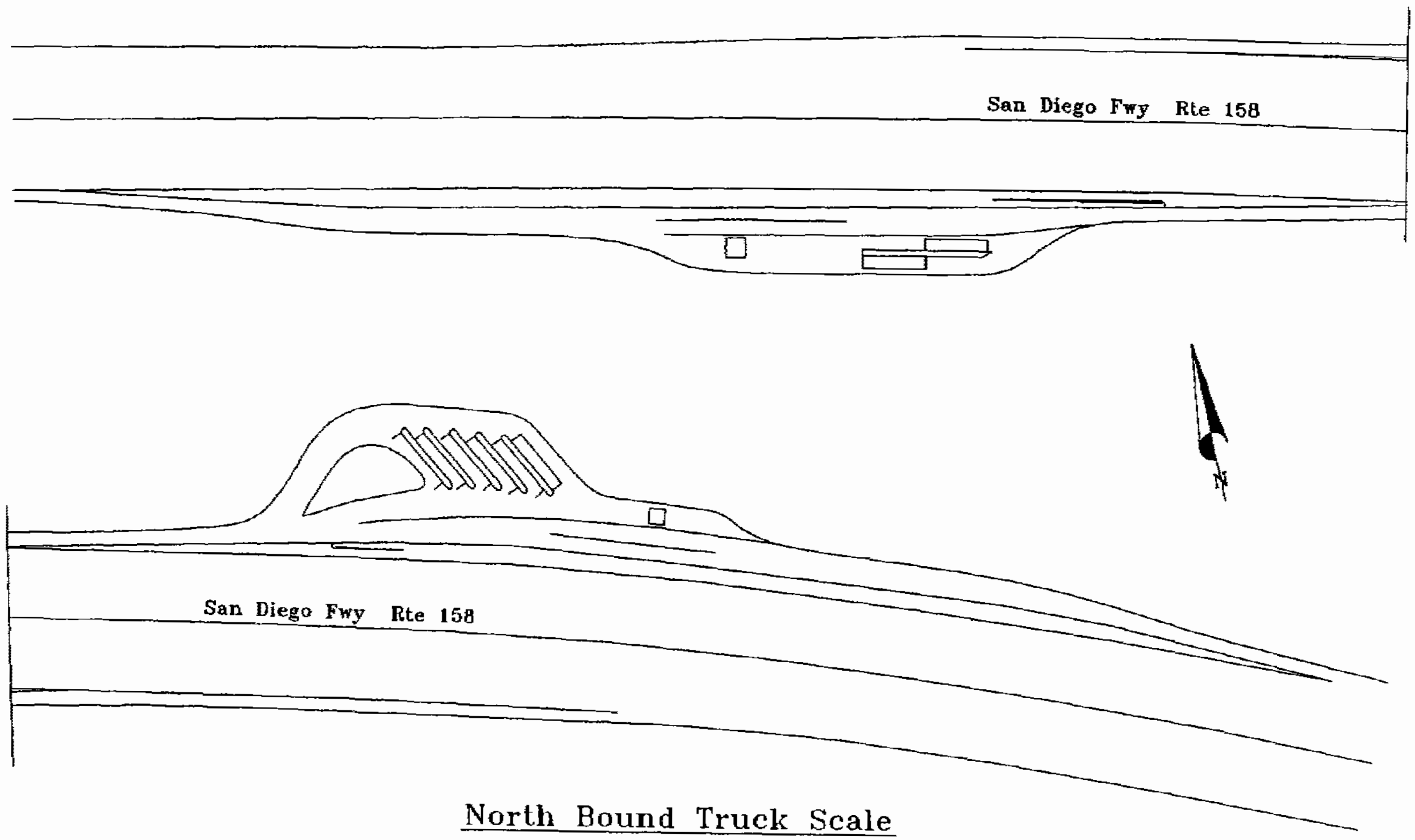
Mobile Road Enforcement (MRE) officers use pickup trucks to inspect trucks at various locations, not necessarily at weigh/inspection stations. They might use widened shoulder locations if available. Locations are generally on non-freeway facilities, although there is at least one on I-40 that is an exception. The locations are selected based on recommendations from local area CHP Commanders to CALTRANS. The number of these MRE locations installed in the past was not available because local Commanders have been somewhat autonomous. The MRE sites are located primarily on routes used by truck drivers to bypass scales. Typical dimensions are not available, however, they include a deceleration lane, an acceleration lane, and sufficient space to inspect and/or weigh a truck. They are used sporadically as the need arises. There is no space provided for parking out-of-service vehicles.

Implementation

The inspection station on I-405 and others in California were constructed by CALTRANS. The money is from the same fund that is available for highway construction projects. Funding for maintaining inspection stations is from the highway maintenance fund. The cost of these urban inspection stations is highly variable, but one currently under construction (not in Los Angeles) is expected to cost $14 million.

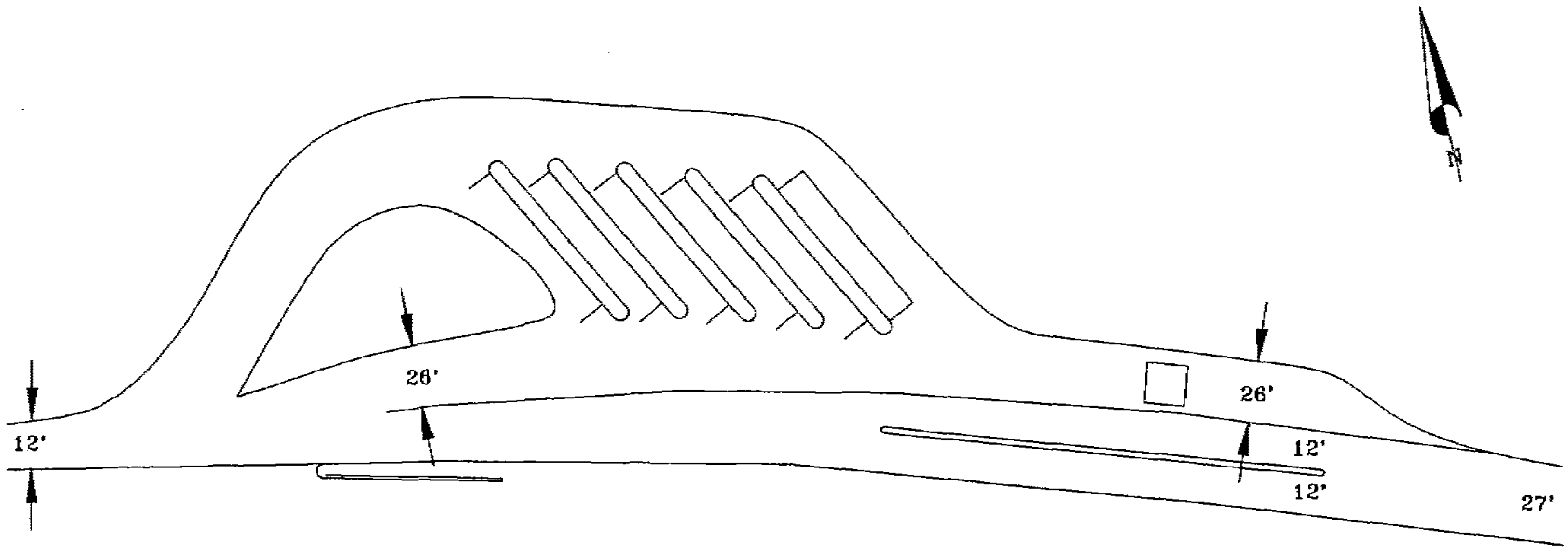
No inspection stations have been constructed in urban areas in several years in the Los Angeles area, but reaction from the general public is expected to be similar to that

South Bound Truck Scale



North Bound Truck Scale

Figure 42. I-405 weigh/inspection facility.



North Bound Truck Scale

Figure 43. Detail of northbound I-405 weigh/inspection facility.

encountered in other States; the public feels safer when trucks are inspected on a regular basis, but residential property owners do not want inspection stations near their residence.

Effectiveness

Some CALTRANS sources do not believe that the relatively large investment required to build inspection/weigh facilities in urban areas is worthwhile. They cite the large construction cost, plus the opportunities for bypassing the enforcement activity by numerous alternate routes. Historically, only 1 percent of vehicles weighed at these locations are overweight, while 20 percent of vehicles monitored using weigh-in-motion systems appear to violate weight laws.

The operation at the I-405 scales allows CHP troopers to first observe the vehicle either in one of two lanes passing by the CHP building. The far lane (relative to their building) is specified for unloaded trucks to simply pass near the trooper building for observation, while the near lane is equipped with scales for weighing loaded trucks. Troopers can select vehicles for inspection from either lane they choose. Neither lane uses weigh-in-motion (WIM) devices; some sites use WIM for screening purposes to verify whether a truck is loaded or unloaded. The number of vehicles inspected and the number of those vehicles taken out of service is shown in table 16. By comparison, the CHP provided inspection data at a "full scale" inspection station in the San Francisco Bay area. This inspection station operates in only one direction of travel on I-680.

Table 16. CHP truck inspection data.

CRITERIA	CARSON I-405		San Francisco Bay Area I-680
	Northbound	Southbound	
No. Inspected	2,651	2,605	18,623
Number Out-of-Service	740	671	4,480
Percent Out-of-Service	28%	26%	24%

Source: California Highway Patrol

The method officers used at I-405 to select trucks for inspection was to choose the "locals" because the Interstate traffic is inspected elsewhere. The officers look for obvious violations as the trucks pass in front of them either being weighed (loaded) or passing through the empty lane. Therefore, the number of trucks taken out of service is not necessarily representative of the entire truck population.

Truck Industry Views

Neither the safety director nor the President and CEO has any reservations concerning urban inspection stations as long as the inspectors are well-trained.

TRUCK BANS/RESTRICTIONS

Background

The increasing length of the peak periods on urban freeways in Los Angeles has caused policy-makers to seek solutions from several possible sources. For example, I-405 (the San Diego freeway) is typically congested on weekdays from 5:00 a.m. until 8:00 p.m. Two examples of freeways in the city of Los Angeles that completely ban trucks are the Ventura Freeway and the Pasadena Freeway. Opened in 1940, the Ventura Freeway is one of the first freeways to be constructed. Engineers believe that its 0.178-m (7-in) thick pavement is too weak to carry trucks, although they allow buses on it. One reason the bans work is because alternative freeways are available to truck drivers.

These bans were initiated by the City of Los Angeles, not CALTRANS. The city, in 1991, was prevented from restricting trucks from all freeways during peak periods. Currently the city is proposing to restrict trucks from arterial streets, except in special cases and to require that deliveries be made at night. Most businesses along these arteries and truck drivers operating on these streets all believe that they will be hurt economically by this restriction. Other problems cited with night deliveries include security and safety.

Truck drivers maintain that they already avoid peak periods voluntarily as much as possible because the cost of being delayed by congested traffic causes them to be less competitive. They also allege that there will be serious problems related to safety and security if they are forced to make deliveries at night. Businesses also contend they will be hurt by this ban because personnel will need to be on hand to receive shipments during off hours.

Implementation

Implementation of the peak period ban on trucks is an outgrowth of the initial ban on trucks from certain urban freeways. Some officials have indicated there is still a possibility the peak period ban will be required to meet provisions of the Clean Air Act.

Effectiveness

Because the restriction has not been implemented, its effects cannot be fully evaluated. However, studies such as the Urban Freeway Gridlock Study by Cambridge Systematics et al, have been conducted to predict its effects. Additional information is available in the Annotated Bibliography, Section P.

Truck Industry Views

The safety director remarked that proponents of mandatory bans should be more realistic. Banning deliveries during daylight hours could increase potential for hijackings, robberies, and other related crimes. Their company attempts voluntary peak avoidance when possible.

The President and CEO of the tanker and hazardous waste hauler stated that this ban will not substantially affect their company because they will be exempt. Yet, they are not in favor of the ban because it will drive up the cost of goods and services and will hurt many retailers.

INCIDENT RESPONSE MANAGEMENT

Background

CALTRANS incident response teams respond only to major incidents. Major incidents are defined as 2 or more lanes blocked for a time period of 2 hours or more. On mainlanes, if the situation is determined to be major, CALTRANS dispatches a sign truck which travels to the upstream end of the traffic queue and displays information for approaching traffic. Their purpose is to reduce secondary accidents and provide information to motorists regarding the incident, including alternate routes. Table 17 summarizes the major incidents that occurred during 1990 involving large trucks in the Los Angeles area, including the length of time lanes were closed.

The CHP officer is the "commander" at an incident site. Tow truck operators are selected from a rotational list the CHP maintains. If there is more than one tow truck operator in the area, the CHP contacts the company at the top of the list. If that company cannot respond, they contact the next, and so on. CALTRANS does not contract with tow truck operators, so there is no penalty to the tow truck operator if the operator does not arrive in a timely manner. There are relatively few companies with large rigs, so the CHP prefers to keep as many of them on the list as possible.

Implementation

Incident response activities covering several hundred miles of freeway in Los Angeles, are carried out jointly by the CHP and CALTRANS. Systems include a traffic operations center, major incident response teams, electronic surveillance and detection, closed circuit television (CCTV) cameras, changeable message signs, highway advisory radio (HAR), and a network of commercial radio stations and other media. Incident response involving heavy trucks includes the CHP's use of special criteria and a rotation list of heavy-duty tow truck operators.

CALTRANS is planning to eventually install approximately 9,900 changeable message signs (CMS) on the freeway system in the Los Angeles district. They are also planning CCTV cameras for quick detection of incidents. About 300 of these cameras will eventually be installed in the district.

The CHP uses their own established criteria to determine which tow truck operators can work on an incident involving large trucks. Their basic criteria include availability at all times, equipment which is in good mechanical condition and large enough to handle large trucks, and proper insurance. The request to be placed on the rotating list is the responsibility of the tow truck operator. Once an operator requests to be placed on the CHP list, the operator's equipment must be inspected by a CHP trooper. If it passes, the operator is added to the CHP list. The CHP also sets allowable rates which can be charged by these operators. These rates are based on an average proposed cost from all operators on the list

Table 17. 1990 truck incident summary for Los Angeles.

Location Direction	No. of Accidents	Overturned Vehicles	Fatal Accident	Min. Time	Max. Time	Avg Time
I-5 Northbound	12	2	2	1:06	10:00	4:40
Southbound	5	2	3	2:08	23:55	8:07
I-605 Northbound	5	1	0	2:17	7:15	4:25
Southbound	5	2	0	2:41	10:00	5:10
Rt 101 Eastbound	1	0	0	3:53	3:53	3:53
Westbound	1	0	0	4:45	4:45	4:45
Southbound	3	0	0	1:41	3:40	2:42
Rt 60 Westbound	8	2	0	1:20	7:10	3:22
Eastbound	7	1	1	1:03	9:12	4:19
I-10 Eastbound	8	5	0	2:10	7:08	4:03
Westbound	11	5	0	0:59	8:44	3:34
I-210 Eastbound	7	3	0	1:10	6:15	3:51
Westbound	5	0	0	2:39	6:35	4:44
I-405 Northbound	3	1	0	3:06	4:05	3:37
Southbound	3	2	0	2:02	3:20	2:52
Rt 57 Southbound	1	0	0	4:59	4:59	4:59
I-110 Southbound	3	1	0	4:00	8:10	5:37
Northbound	1	1	1	7:30	7:30	7:30
Rt 118 Westbound	1	0	0	3:43	3:43	3:43
Rt 91 Eastbound	6	0	1	1:11	4:49	2:35
Westbound	2	1	0	4:48	5:10	4:59
Rt 170 Southbound	2	0	0	7:20	8:50	8:05
I-710 Southbound	6	1	0	1:18	8:10	3:35
Northbound	5	2	0	1:10	4:55	3:04
Total	111	30	8	0.59	23:55	4:31

Source: CALTRANS

plus a pre-approved percentage. The CHP checks periodically to ensure operators are charging these rates fairly.

Effectiveness

The incident response team approach is credited with resulting in the key players arriving at the scene of an incident in a short amount of time. CALTRANS officials estimate a delay savings of approximately 500 vehicle-hours for each major incident and a reduction of one secondary accident for every two incidents in which response teams are used.

CALTRANS has for some time used calculations to determine the delay associated with an incident where all or part of the freeway remains closed. Costs are associated with historical delay values which are based on "density factors." When a CALTRANS crew is called into the field, they observe and document the limits of congestion. This is entered into the computer which computes the accumulated delay. The CALTRANS accounting section developed a motorist cost associated with a delay of $8.50 per hour. Another benefit which might be considered is the reduction in the number of secondary accidents. This calculation is omitted, however.

The traffic operations center also produces data that can be used for estimating savings due to incident response. This process involves calculating congestion due to that incident and subtracting the normal level of congestion. The difference is the net effect of the incident. CALTRANS incident response personnel use a microcomputer program to simplify this process so they no longer need the congestion diagrams from the control center. They found that the microcomputer software is accurate enough to replicate the actual situation.

CALTRANS relies most heavily on observations in the field. The basis of their evaluation is the length of queue after a known elapsed time and the number of lanes at that location. Table 17 is a summary of the durations and severities of incidents for 1990; similar information is available for prior years.

Truck Industry Views

The safety director commented that the teams responding to truck incidents are sometimes very good, however some teams need further knowledge and training in handling hazardous materials incidents. The President and CEO of the tanker and hazardous waste hauler commented that sometimes the teams do a good job, but they definitely need more training, especially in hazardous materials. They need to know who to call and what to do before an incident occurs.

CHAPTER 10

NEW JERSEY TURNPIKE CASE STUDY

OVERVIEW

Description of Area

The New Jersey Turnpike, the first controlled access toll road to span the entire State, was opened in stages as sections were completed (see figure 44). The initial border to border length of 190 km (118 mi) was completed in late 1951 as a four-lane divided roadway. Traffic volumes grew beyond expectations largely because this was the first roadway that allowed motorists to travel non-stop through the State. The previously used routes were US 1-9, US 1, and US 130, which had uncontrolled access and numerous traffic signals. In 1952, this toll road made connections with the Delaware Memorial Bridge on the south and with New York City to the north.

In 1956, the New Jersey Turnpike Authority (NJTA) built the 9.7-km (6-mi) extension from the Pennsylvania Turnpike to the New Jersey Turnpike near Philadelphia. In the same year, a 13 km (8-mi) extension to the Holland Tunnel which feeds lower Manhattan (Wall Street area) was completed. During the 1950's, widening of the turnpike's mainlanes from four to six lanes north of Exit 4 was also completed. In the mid-1960's other portions of the turnpike were widened, and by 1971 the first segment of the so-called "dual-dual" roadway from Exit 10 to Exit 14 was opened. The two parallel roadways in each direction were separated by a double-faced metal beam guardrail between the roadways.

In 1985, a dual-dual segment was also planned north of Exit 14, however, environmental and construction costs prevented it from being built. A 19-km (12-mi) "eastern alignment" and "western alignment" was built instead and opened to traffic in 1971. By 1974, the authority extended the dual-dual roadway for approximately 10 km (6 mi) from Interchange 10 to Interchange 9. In 1984, the NJTA considered widening the roadway again to relieve congestion. After 5 years of working through several permitting agencies, the turnpike authority was allowed to dualize the roadway from Interchange 8A to Interchange 9. Due to projected traffic demand, this cross section was only 10 lanes rather than 12. Prior to 1980, the NJTA was not required to obtain approval from so many agencies; they simply claimed imminent domain and built or widened the roadway when future demand exceeded capacity.

Table 18 lists the daily traffic volume between interchanges for September 1991. It should be noted that this daily volume is the September total divided by 30. Figure 45 illustrates a current cross section of the New Jersey Turnpike between Exits 8A and 9.

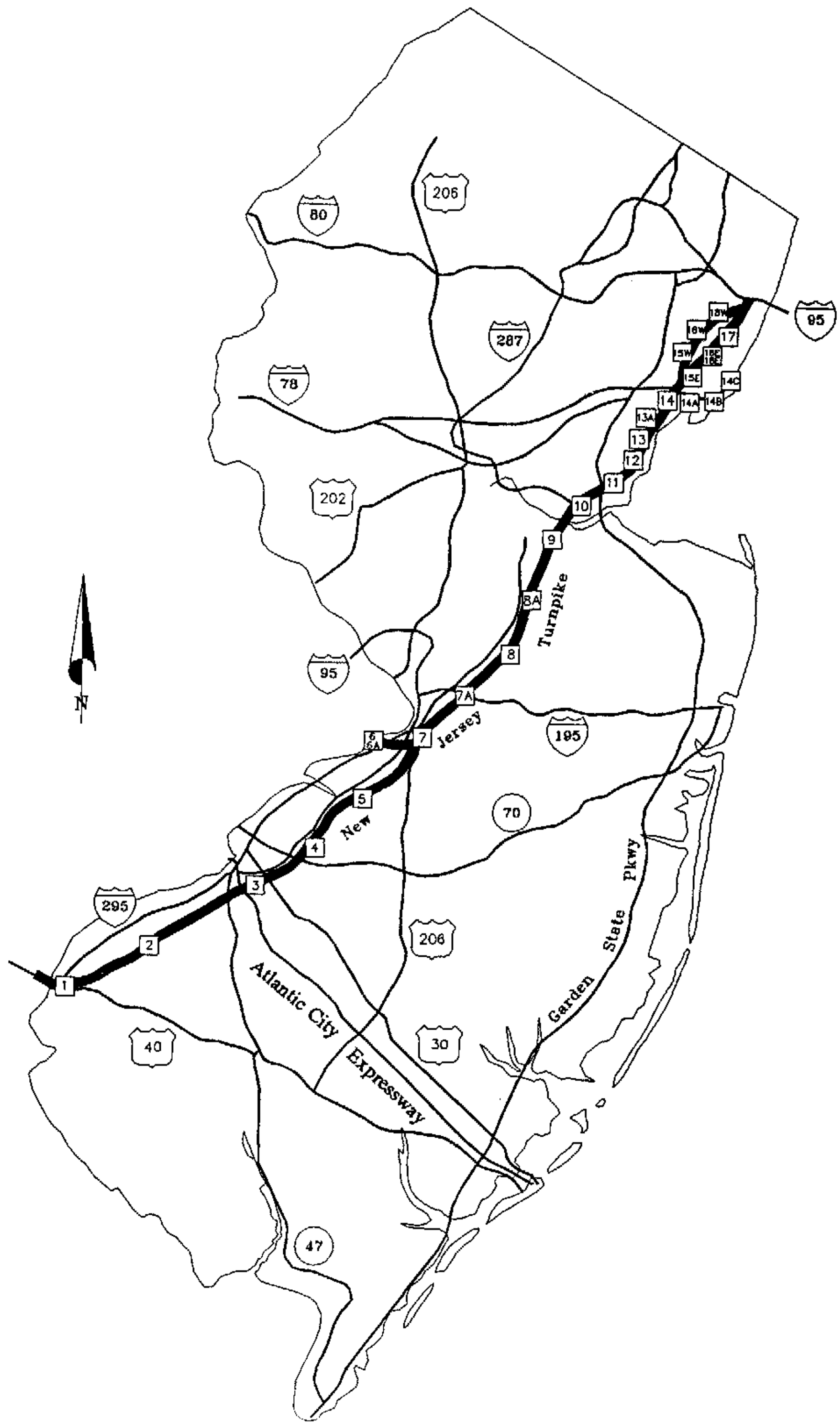


Figure 44. New Jersey roadway system.

Table 18. Daily traffic volume between interchanges by class for September 1991.

INTCHGS	CLASS[1] 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6	CLASS B2&B3	TOTAL
7 - 7A	75934	2508	742	1481	8422	95	505	89687
7A - 8	77101	2567	778	1547	9219	108	530	91850
8 - 8A	79347	2620	782	1500	9278	107	540	94174
8A - 9	90584	2851	896	1646	9800	109	586	106472
9 - 10	123913	3600	1190	1964	10750	108	744	142269
10 - 11	118561	3953	1194	2154	10644	109	712	137327
11 - 12	145040	5164	1565	2371	11919	124	1379	167562
12 - 13	151275	5568	1795	2479	12737	131	1422	175407
13 - 13A	164051	6077	1883	2623	13597	132	1609	189972
13A - 14	145720	5904	1728	2513	12734	118	1469	170186
14 - 14A	54667	1815	699	437	279	33	306	58236
14A - 14B	42666	1442	3306	221	1098	15	309	49057
14B - 14C	4117	1379	265	160	800	8	316	7045
14 - M	157526	6402	2028	2973	14273	138	1976	185316

Source: New Jersey Turnpike Authority; Calculated by dividing September total by 30

[1] Classes:

1 -- Passenger car, motorcycle, light truck
2 -- Two-axle dual-tire vehicle
3 -- Three-axle single-unit truck, dual-axle tractor w/o trailer, three axle semi-trailer combination, passenger car with trailer
4 -- Dual-tire truck and trailer with four axles, single-unit truck with four axles, two cars tandem, passenger car with two-axle trailer
5 -- Any truck and trailer with five axles
6 -- Tractor-trailer with six or more axles, three-axle trucks in tandem
B-2 and B-3 -- Two-axle and three-axle bus, respectively

Countermeasures Implemented

The following countermeasures are used on the New Jersey Turnpike:

- Dual-Dual Roadway.
- Incident Response Management.
- 1.07-m (42-in) Concrete Median Barrier.
- Increased Enforcement.

Other truck accident countermeasures implemented on the turnpike for which less information is available includes lane restrictions and ramp shoulder improvements. NJTA was one of the first to impose lane restrictions for trucks in the 1960's. The restriction does not allow trucks in the left lane of roadways that have three or more lanes by direction. This includes much of the turnpike, however, the outer roadway is only two lanes between Interchange 8A and Interchange 9. On the dual-dual portion of the turnpike from Interchange 9 to Interchange 14, buses are allowed in the left lane of the outer roadway. When an incident or maintenance work forces closure of the outer roadway, lane restrictions are still imposed on the inner roadway. Regulatory signs are used with the following message: " NO TRUCKS OR BUSES IN LEFT LANE." Automobiles are also restricted by the following regulatory sign message: "CARS USE LEFT LANE FOR PASSING ONLY." Automobiles also use the outer roadway; the proportions are approximately 60 percent on the inner roadway and 40 percent on the outer roadway. NJTA sources stated the compliance rate for truck lane restrictions is very high.

Ramp shoulder improvements have recently been implemented along the turnpike. On superelevated ramp curves, the shoulder was sloped toward the outside of the curve to accommodate snow melt *away* from the ramp, however, this was only a problem when snow was plowed to the outside of the curve. NJTA found that it was feasible in many locations to plow snow to the inside, and design the entire ramp surface (shoulder and lane) at the same cross-slope.

Figure 45. New Jersey Turnpike dual-dual roadway cross section.

Accidents

Table 19 lists accident statistics provided by NJTA staff for the entire turnpike. Because these data include both the dualized and non-dualized sections, only general statements of trends are appropriate. A comparison of accident rates between the two roadway types is provided in a later section. There is a consistently downward trend in truck accidents and truck accident rate from 1989 to 1991. The truck accident rate decreased from 347.1 in 1989 to 221.1 truck accidents per 100 million vehicle miles in 1991.

Truck Industry Views

One trucker interviewed is a safety manager for a New Jersey bulk transport company. He was a driver for 5 years before becoming an administrator. He stated that it appears to be a good idea to separate trucks and cars, but he has heard no comments from drivers. Most of his drivers take I-295, which parallels the portion of the turnpike that has the separate roadway.

Table 19. Accident data for the New Jersey Turnpike.

	1986	1987	1988	1989	1990	1991
No. of Accidents	4,489	5,309	5,527	5,588	4,924	4,067
No. of Truck Accidents	1,720	2,062	2,152	2,178	1,681	1,249
Overall Accident Rate[1]	113.7	129.7	128.5	126.7	110.3	95.4
Truck Accident Rate[1]	271.1	317.1	319.9	347.1	257.5	221.1
Percent Truck Accidents	38.3%	38.8%	38.9%	39.1%	34.1%	30.7%
Total Vehicles (1,000)	179,545	184,763	192,380	195,192	198,025	186,060
Total Trucks (1,000)	22,289	23,537	24,086	23,804	23,383	20,860
Percent Trucks	12.4%	12.7%	12.5%	12.2%	11.8%	11.2%

[1] Accident rate per 161 million vehicle-km (100 million vehicle-mi)

Source: New Jersey Turnpike Authority

DUAL-DUAL ROADWAY

Background

In 1971 the NJTA opened the first segment of the dual-dual roadway. Instead of adding a 4th, 5th, and 6th lane in each direction contiguous with the existing roadway, it elected to separate the lanes as two parallel roadways in each direction with physical barriers (metal beam guardrail). The roadway's typical cross section had 12 total lanes with two three-lane "barrels" in each direction.

The dual-dual cross section was used for two reasons: 1) traffic management had a goal of automating traffic control, and 2) to allow flexibility in closing parts of roadway for maintenance activities or accidents. Initially, the dual-dual cross section extended from Exit 10 to Exit 14 (see figure 44), but currently the dual-dual roadway extends from Exit 8A to Exit 14.

Implementation

The additional construction cost of the dual-dual roadway comes from the cost of the additional right-of-way, the metal beam guardrail, additional pavement (shoulders), additional length of overhead structures, and increased interchange costs due to additional ramps.

The approximate construction cost of a dual-dual freeway with 12 lanes is $15 to $19 million per km ($25 million to $30 million per mi) excluding interchanges. Some new interchanges in urban and suburban areas are costing the turnpike authority over $100 million, including toll plazas and related appurtenances. One new interchange in a rural area cost $45 million. It consisted of 11 toll lanes, using existing outside ramps, but new inside ramps were built. The NJTA just recently completed an improvement which widened an 17.6-km (11-mi) six-lane segment of non-dualized freeway to a dualized freeway with 10 lanes (2-3-3-2 configuration). The cost of this improvement including some interchange improvements was $300 million. Another improvement currently underway to add one additional lane in each direction to an existing 22.4-km (14.1-mi) segment of dual-dual roadway, plus some interchange improvements, will cost approximately $368 million.

Rough estimates of non-dualized freeway indicate a cost of approximately $6 million per km ($10 million per mile) excluding environmental challenges which must be addressed. This might include relocation of houses and construction of noise barrier which in one example cost $28 million for a 24-km (15-mi) segment of freeway.

Effectiveness

A comparison of truck accident rates between the dualized and non-dualized roadways of the New Jersey Turnpike is provided in table 20. There is a significant difference between the dual-dual and the non-dualized roadways in terms of design, operations, and safety.

Table 20. 1990 mainlane truck accidents.

Roadway Segment	No. Truck Accidents	Truck Accident Rates
Dual-Dual Roadway (Int. 9 to Int. 14)	216	114.0
Non Dual-Dual Roadway	737	176.7
Total Mainlane	953	157.1
Mainlane, Interchanges, and Service Areas	1,681	257.5

Truck Industry Views

The safety manager of a bulk transport company stated that it appears to be a good idea to separate cars from trucks. There had been no comments pro or con from his drivers, however, most of his drivers take I-295, which parallels the segment of the turnpike that has the separate roadway.

INCIDENT RESPONSE MANAGEMENT

Background

Thirty garages are under contract to NJTA to respond to incidents along the turnpike. State police responding to an incident contact the nearest garage which has a contract for providing this service. NJTA does not require all garages to provide heavy-duty tow trucks which might be necessary to right an overturned combination vehicle, however, approximately 13 of the 30 garages have experience providing "heavy duty tow services."

Implementation

Garages must meet several criteria to be eligible to contract with NJTA. The NJTA requires garages that want to participate in towing to:

- Be located within 8 km (5 mi) of the turnpike. Obviously, response time is critical.
- Be equipped to handle everything from the smallest car to a 36,000 kg (80,000 lb) tractor-trailer for a simple tow. Separate arrangements are made for larger incidents.
- Respond to these incidents or disabled vehicles *immediately*. As soon as they take the call, they must begin moving in the direction of the problem.
- Be able to respond 24 hours a day, 7 days a week and give the utmost priority to all Turnpike calls.
- Give priority to the turnpike, as opposed to the local communities or the State in snowy or icy conditions.
- To have at minimum two types of wreckers -- one conventional and one flatbed.

Effectiveness

NJTA's program with garages providing tow trucks has been emulated by several agencies. This provides some indication of its effectiveness.

The response of NJTA emergency crews varies when spilled loads block the freeway. The load is the responsibility of the driver, but if the driver is hurt the load then becomes the responsibility of State police. NJTA has a rather extensive tracking mechanism to ensure that the load is secured.

Three options exist when cargo is spilled on the turnpike:

- The driver can retrieve the load using another company vehicle and company crews.
- The load can be retrieved by personnel from the contracted garages who either off-load it using the company truck or another refrigerated van, box van, or lowboy provided by the wrecker companies.
- The load can be retrieved by the turnpike's maintenance unit onto their trucks.

The amount charged a trucking company for cleanup of a spilled load varies but, according to turnpike personnel, it is a significant cost to the company. The authority is paid not only for moving the load (if appropriate), but also for State police actions, the cost for turnpike personnel to close a lane, administrative personnel time, and so forth.

Truck Industry Views

No views were expressed by the safety manager of a New Jersey bulk transport company regarding incident response management.

1.07 M (42-IN) CONCRETE MEDIAN BARRIER

Background

The purpose for constructing the New Jersey Turnpike's 1.07-m (42-in) high concrete barrier was to provide a more positive barrier to redirect or contain commercial vehicles while not increasing the risk for passenger vehicles impacting the barrier. The barrier was first used in 1984 to separate opposing directions of traffic; it is not used between parallel roadways where traffic is traveling in the same direction. The authority anticipates completion of the taller barrier by 1994.

In addition to being 250 mm (10 in) taller than the standard 0.80-m (32-in) barrier, it is also built stronger. Its thickness at the top is 0.30 m (12 in) instead of the standard 0.15 m (6 in), it is more heavily reinforced, and it is anchored more securely at the bottom.

Implementation

In full-scale testing in 1983, a 1.07-m (42-in) concrete median barrier was impacted by a loaded 36,402 kg (80,180 lb) tractor-semitrailer at 84 km/h (52.1 mi/h) and an approach angle of 16.5 degrees. The five-axle tractor-semitrailer used a 12-m (40-ft) box van loaded with sand bags distributed uniformly over the floor of the trailer. The composite center-of-gravity of van plus load was calculated to be at 1.64 m (64.4 in) above the ground. The tractor-semitrailer was smoothly redirected with the trailer achieving a maximum roll angle of 52 degrees. The vehicle remained in contact with the barrier for approximately 46 m (150 ft), then veered away from the barrier at a 6-degree angle. The vehicle did not roll over during the test and there was no measurable deflection of the barrier.(16)

The cost of this barrier varies from $560,000 to $621,000 per km ($900,000 to $1 million per mi). The cost of the 0.80-m (32-in) barrier along the New Jersey Turnpike was not available for comparison.

Effectiveness

According to NJTA personnel, this barrier has performed quite well in accomplishing the primary objective of containing all vehicles, including large combination vehicles. During the 5-year period from 1987 through 1991, out of the 55 trucks which struck the 1.07-m (42-in) concrete median barrier, none penetrated into the opposite direction of traffic flow. Because of the positive results from this barrier, the NJTA has begun using this taller barrier throughout the turnpike instead of the shorter 0.80-m (32-in) barrier previously used. The Authority expects to complete this installation by 1994.

Truck Industry Views

The safety manager of the bulk transport company had no comments regarding this barrier.

INCREASED ENFORCEMENT

Background

NJTA employs more State troopers per lane-km (lane-mi) than other jurisdictions in New Jersey. According to NJTA personnel, these troopers make more motor vehicle stops, investigate more accidents, and pick up more disabled vehicles than those in other jurisdictions.

Implementation

The NJTA conducted a study of enforcement activity on the turnpike in 1986 which resulted in an increase of 40 troopers. In the study, comparisons were made with the New York Thru-way, the Pennsylvania Turnpike, the Maryland Toll Road, and others. Because production rates (motor vehicle stops, summons issued, assistance to disabled motorists, and so forth) were better on the turnpike than in the other jurisdictions, the authority hired additional troopers. The State police in New Jersey have a special traffic office assigned to reduce the number of accidents on the turnpike with a concentration on commercial vehicles.

The NJTA is concentrating on maintaining safe speeds for commercial vehicles. They compile violations that commercial drivers have committed and then send the results to the New Jersey Motor Truck (NJMT) Association. The association, in turn, disseminates this information to members. The officer who issues a citation completes a separate form for the driver and the truck or bus company (owner), providing information on the nature of the offense. That information is input into a computer and, at the end of each day, a form letter is sent to the trucking company or bus company informing them that their driver was cited for a specific violation.

In order to ensure continued success with enforcement efforts, NJTA traffic engineers and enforcement personnel meet monthly. In these meetings, engineers identify problem areas where they believe additional enforcement will be effective in reducing accident rates and/or compliance with laws. New Jersey Turnpike Authority engineers believe this good working relationship is essential in maintaining the safest possible environment for motorists.

Effectiveness

The New Jersey Turnpike Authority, in cooperation with the New Jersey Motor Truck Association, the Office of Highway Safety, State police, and the New Jersey State Safety Council, offers "safety breaks." This is a program the NJTA copied from the Pennsylvania Turnpike Commission. The NJTA provides information to motorists, sometimes in the form of a static display at service areas. In one case, in cooperation with the NJMT, it provided a tractor-trailer to allow motorists to climb into the cab. NJMT also has brought a seat belt sled (the "convincer") to replicate a 13- to 16-km/h (8- to 10-mi/h) impact and has shown safety films and distributed brochures. The "safety break" campaign has been well-received by the public. Operators of service areas offer free coffee and donuts to entice motorists to participate in the program. One of the programs the NJTA continues to sponsor is "Sharing the Road with Truckers." This program demonstrates how difficult it is to control a large combination vehicle and where the blind spots are.

Truck Industry Views

The NJTA has received positive feedback on its program of providing trucking companies information on citations issued to their drivers on the turnpike. Sometimes, the company would have been unaware of an operator's violations without this system.

The safety manager of the bulk transport company had no comments regarding enforcement on the turnpike.

CHAPTER 11

PENNSYLVANIA TURNPIKE CASE STUDY

OVERVIEW

Description of Area

The Pennsylvania Turnpike is a toll facility which runs generally east-west through the State of Pennsylvania. It connects Harrisburg, the State capitol, with Philadelphia on the east and Pittsburgh on the west. It also connects Scranton with the Philadelphia area. The Pennsylvania Turnpike Commission is the controlling agency which operates the facility. The turnpike, shown on figure 46, is 757 km (470 mi) in length and is generally a four-lane divided facility. Traffic volumes on mainlane segments and ramps are provided by tables 21 and 22, respectively.

The Pennsylvania Turnpike Commission, with headquarters in Harrisburg, generally follows PennDOT design standards in the geometric design of this facility. New construction plans or improvements to the existing roadway are sent to PennDOT engineers in Harrisburg for review. In a few exceptional cases as noted below, the turnpike design is not consistent with PennDOT standards.

Countermeasures Implemented

Two truck accident countermeasures have been implemented on the Pennsylvania Turnpike. These are:

- **Ramp Improvements**--Exit 12 (Breezewood) eastbound shoulder improvement and Exit 16 (Carlisle) eastbound sign treatment

- **Mainlane Improvement**--MP 299 mainlane shoulder improvement at the east end of the Blue Mountain Tunnel.

Other accident countermeasures have been implemented or are in the planning stages. The turnpike commission has initiated a program of installing "rumble" devices along shoulders because of the number of run-off-road accidents. In 1990, 25 percent of total vehicular accidents, resulting in 29 percent of the fatalities that year, were due to the driver falling asleep or from being inattentive. The number of fatalities involving vehicles parked on shoulders or in rest areas near the shoulder was not available. Currently, the commission allows a vehicle to remain on the shoulder for a period of 24 hours before it is towed.

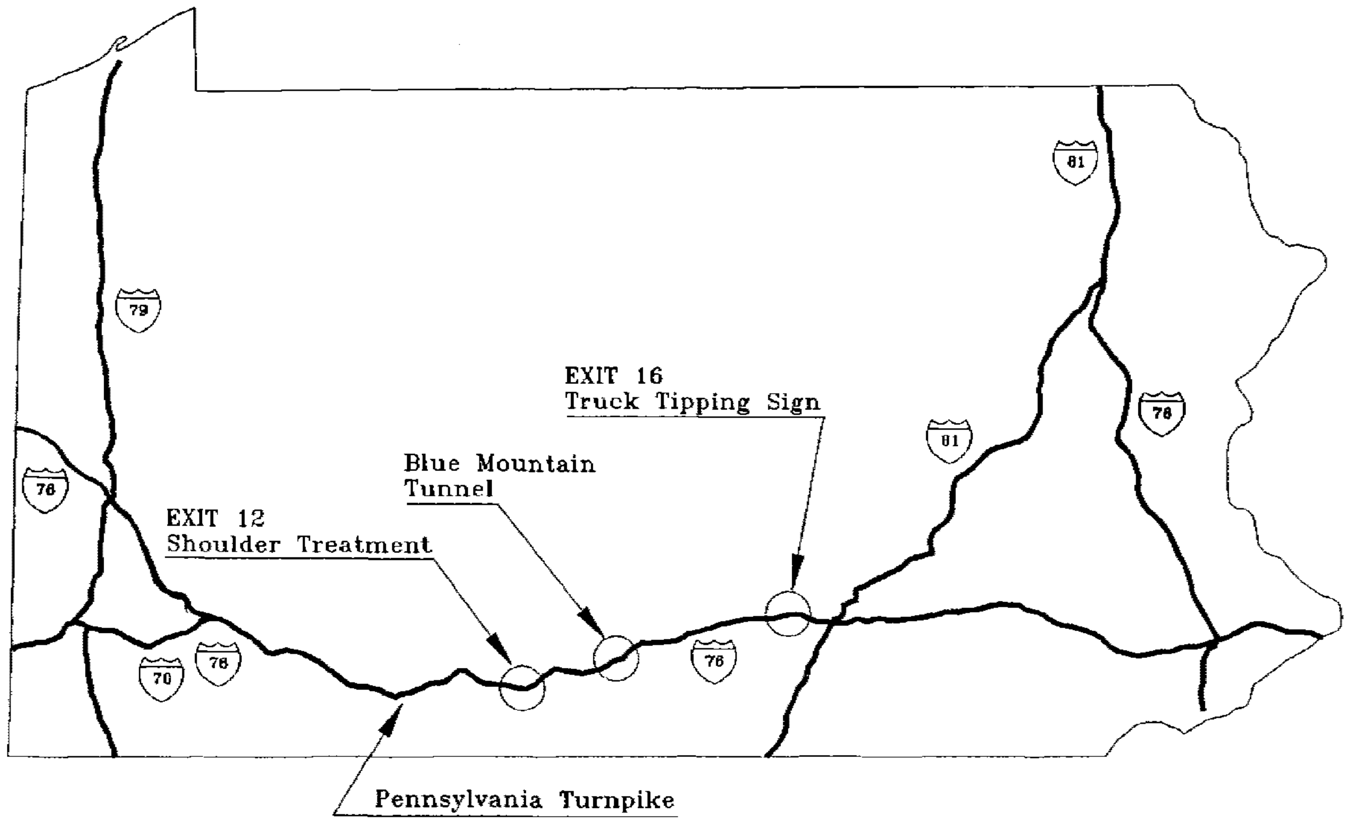


Figure 46. Pennsylvania Turnpike.

Table 21. 1990 mainlane ADT between interchanges.
(Combined EB & WB / NB & SB)

INTERCHANGES	AVERAGE ADT	AUGUST ADT	PERCENT TRUCKS
6 - 7	38,607	47,617	16%
7 - 8	29,695	38,007	20%
8 - 9	31,091	41,457	30%
9 - 10	28,913	38,882	32%
10 - 11	27,360	36,897	31%
11 - 12	29,238	39,129	31%
12 - 13	17,871	22,892	35%
13 - 14	18,435	23,529	34%
14 - 15	18,685	23,796	34%
15 - 16	18,376	23,461	34%
16 - 17	17,344	22,039	24%
17 - 18	20,009	25,237	21%
18 - 19	22,847	28,431	17%
19 - 20	19,208	23,855	20%
20 - 21	20,145	25,449	20%
21 - 22	26,385	32,202	20%
22 - 23	30,059	36,433	19%
23 - 24	31,642	37,768	17%
24 - 25	57,361	63,780	12%
25 - JU	77,732	85,200	11%
JU - 26	68,286	74,626	11%
26 - 27	69,522	76,122	11%
27 - 28	67,044	74,230	12%

Table 22. 1990 interchange average daily traffic.
(Total Entering and Departing)

INTERCHANGE	AVERAGE ADT	AUGUST ADT	PERCENT TRUCKS
6 - PITTSBURGH	33,912	38,324	8%
7 - IRWIN	16,844	19,740	8%
8 - NEW STANTON	22,744	27,640	45%
9 - DONEGAL	4,548	58,00	10%
10 - SOMERSET	5,200	6944	36%
11 - BEDFORD	5,184	6,712	31%
12 - BREEZEWOOD	15,724	20,656	33%
13 - FT. LITTLETON	1,348	1,664	17%
14 - WILLOW HILL	900	1,060	28%
15 - BLUE MOUNTAIN	1,068	1,348	27%
16 - CARLISLE	13,132	15,704	55%
17 - GETTYSBURG PIKE	5,812	6,864	12%
18 - HARRIS. WEST	9,160	10,372	13%
19 - HARRIS. WEST	16,740	19,456	16%
20 - LEBANON-LANC.	4,752	6,440	11%
21 - READING-LANC.	10,840	12,500	20%
22 - MORGANTOWN	8,888	10,428	13%
23 - DOWNINGTOWN	14,384	16,112	11%
24 - VALLEY FORGE	52,868	57,620	11%
25 - NORRISTOWN	29,128	31,728	9%
26 - FT. WASHINGTON	29,476	30,384	6%
27 - WILLOW GROVE	36,272	37,800	8%
28 - PHILADELPHIA	47,316	50,316	12%
29 - DELAWARE VALLEY	12,508	13,320	20%
30 - DELAWARE RIVER BRIDGE	33,144	39,012	18%

Accidents

Table 23 is a summary of accident statistics provided by the Pennsylvania Turnpike Commission. The time periods represented are the months of May 1991 and January through May 1991.

Truck Industry Views

One truck driver voluntarily wrote a letter to the Pennsylvania Turnpike Commission providing constructive criticism based on several years of turnpike use. His letter indicates that he first traveled the turnpike with his parents in 1942, and began using it as a truck driver in 1951. Since that time, he "must have traveled it almost 2,000 times from [New] Jersey to Ohio and up to Scranton."

Table 23. Pennsylvania Turnpike Commission motor vehicle accident comparison report -- May 1991.

ACCIDENT EXPERIENCE	May 1991	January to May 1991
Total All Accidents[1]	337	1408
Accidents per 100 MVM[2]	89.10	89.15
Injury Accidents	50	221
Injuries	67	333
Injury Accidents Per 100 MVM	13.22	13.99
Injuries Per 100 MVM	17.71	21.09
Fatal Accidents	1	7
Fatalities	1	8
Fatal Accidents per 100 MVM	0.26	0.44
Fatalities per 100 MVM	0.26	0.51
Property Damage Accidents	286	1180
Reportable	116	533
Non-reportable	221	875
Property Damage Accidents per 100 MVM	75.62	74.72
Vehicle Miles	378,213,873	1,579,274,777
Number of Vehicles	9,002,729	39,479,135

[1] Includes Reportable and Non-Reportable Accidents
[2] Accident rate is per 161 million vehicle km (100 million vehicle mi [100 MVM])

RAMP TREATMENT

Background

A higher than expected number of truck rollover accidents occurred at two eastbound exit ramps on the Pennsylvania Turnpike. These two ramps are at Interchange 12 (Breezewood) and Interchange 16 (Carlisle).

The exit ramp at Interchange 12 was improved by raising the shoulder to the same cross-slope as the ramp traffic lane. This was contrary to PennDOT's standard design. Their design included a shoulder slope that drained to the outside. To keep melting ice/snow from draining across the lane, the commission installed a slotted drain along the length of the improvement. The ramp layout is shown schematically in figure 47 which also depicts the improvement in the cross-slope and addition of the slot drain.

The exit ramp at Interchange 16 was improved by installing a 1.2-m by 1.2-m (48-in by 48-in) diamond shaped black on yellow truck tipping warning sign on the eastbound exit ramp. The turnpike commission also installed a taller, stronger guardrail along the outside of this ramp curve to the left. It consisted of two "W-beam" sections, one on top of the other on a metal post system making the height greater than the standard 0.80 m (32 in). The layout of this interchange is almost identical to the one at Breezewood, with the eastbound exit ramp also being problematic in this case. The taller barrier was installed here but not at the Breezewood exit because of a difference in topography. The Carlisle exit ramp required a higher fill, resulting in a greater hazard to errant vehicles.

Implementation

The improvement to the eastbound exit ramp at Breezewood included improving the shoulder cross-slope and installing a slot-drain. Cost and construction details were not provided by the turnpike. Construction plans for projects such as this need not be approved by Federal Highway Administration (FHWA), but they must be approved by PennDOT. Typically, the turnpike commission uses PennDOT design standards, however, the shoulder improvements involved a modification of these standards.

The modification involved changing the cross-slope of the shoulder to match the cross-slope (superelevation) of the mainlanes. On a mainlane curve to the left, superelevated sections slope to the inside of the curve (right to left as seen by motorists), but PennDOT standards allow the shoulders to slope downward to the outside of the curve (left to right as seen by motorists). This results in a "break-over" point at the outside pavement edge. When vehicles traversing a curve to the left veer onto this shoulder, their effective superelevation is decreased, causing load shifts and/or rollover in large trucks. Because the

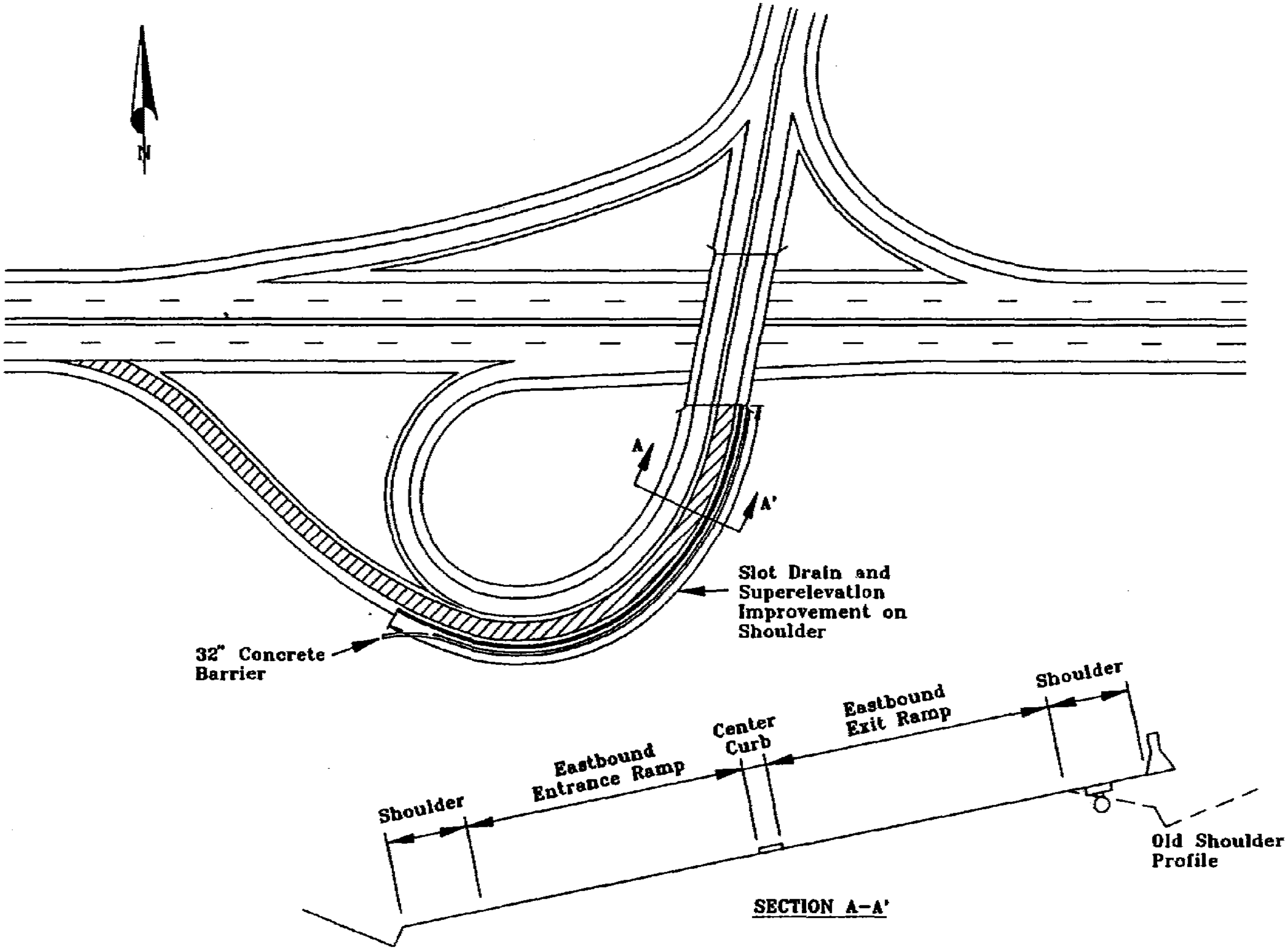


Figure 47. Breezewood interchange layout.

original design facilitated surface moisture drainage (e.g. rain and snow melt) away from the travel lane, a slot-drain became necessary with the new design. Figures 48 and 49 illustrate the application of the drain.

The maximum superelevation used by the commission in road design is 8.3 percent. They considered 10 percent, but decided that was too much for ice/snow. One negative factor to increasing superelevation anywhere is the ice/snow factor (sliding to the inside of the curve).

The cost of improvements for these two ramps was unavailable. Turnpike sources believe other interchange improvements were completed at the same time on the Breezewood ramp and separate costs would not exist. According to turnpike personnel, curve warning signs and reduce speed signs were in place on the Breezewood ramp prior to shoulder improvements.

Effectiveness

Table 24 summarizes accident data for the Breezewood and Carlisle interchanges, indicating there were 16 truck rollover accidents on the Breezewood eastbound exit ramp. The accident histories for these two locations following improvements is shown by tables 25 and 26. Comparing the results shown in the tables, there is an apparent reduction in truck accidents at the Breezewood exit, but not at the Carlisle exit. No attempt has been made to conduct a thorough statistical comparison due to the lack of sufficient detailed information.

Table 24. Pennsylvania Turnpike ramp accidents before improvements.
(June 1985 through December 1988)

Location	Motorcycle	Automobile	Truck
Breezewood Interchange Entry	1	1	16
Exit	0	0	2
Carlisle Interchange Entry	0	1	9
Exit	0	0	2

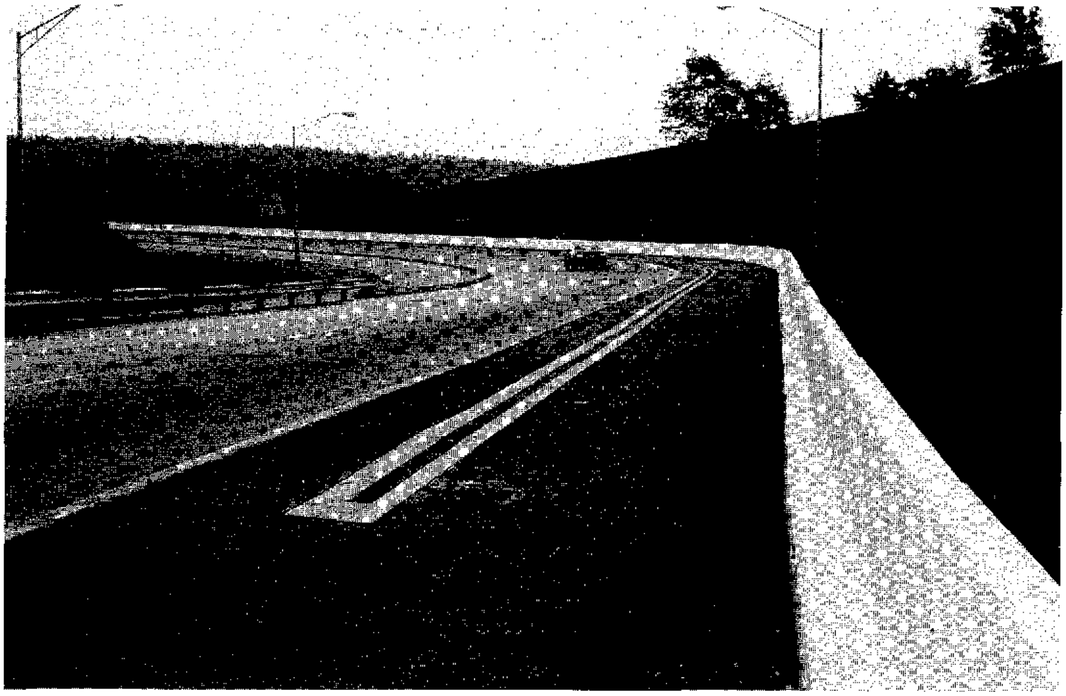


Figure 48. Breezewood eastbound exit ramp.

Figure 49. Close-up of slot drain.

Table 25. Truck accidents on the Breezewood eastbound exit ramp after improvements.

Date	Accident Factors	Light/Road Conditions	Severity
03/31/89	Truck-tractor struck barrier, fire	Dry, daylight	Minor injury
09/08/89	SU truck struck barrier, overturned	Wet, daylight	Property damage
02/01/90	Truck-tractor overturned	Dry, daylight	Minor injury
05/18/90	Truck-tractor struck barrier, overturned	Dry, daylight	Property damage
08/13/90	Truck (type unknown) struck auto	Wet, daylight	Property damage

Source: PennDOT

Table 26. Truck accidents on the Carlisle eastbound exit ramp after improvements.

Date	Accident Factors	Light/Road Conditions	Severity
07/27/89	Truck-tractor hit barrier, overturned	Dry, daylight	Minor injury
07/27/89	SU truck overturned	Dry, daylight	Property damage
11/17/89	Truck-tractor hit barrier, overturned	Dry, daylight	Minor injury
12/13/89	Truck-tractor hit barrier, overturned	Wet, daylight	Minor injury
04/15/90	Truck-tractor hit barrier, overturned	Dry, daylight	Minor injury

Source: PennDOT

Truck Industry Views

The truck driver who wrote the letter to the turnpike commission did not specifically mention turnpike ramps, although he did include a statement regarding the "sudden drop of a low shoulder" in relation to tunnel exits. This is the same problem which has been corrected on the Breezewood eastbound exit. He did mention a phenomenon with radial tires which allows the vehicle to "walk" when negotiating a turn at high speed. He commented that with the newer trucks that are 152 mm (6-in) wider (2.59-m [102-in] width) with radial tires, designs of exits, turns, and bridges need to be reevaluated.

MAINLANE TREATMENT

Background

The improvement at the Blue Mountain Tunnel eastbound exit included the same shoulder cross-slope and drainage improvement as implemented at the Breezewood exit. The problem at both locations was apparently caused by excessive speeds and not being able to recover at the outer edge of the travel surface. Shoulder improvements improved the recovery area which was available to errant vehicles. The tunnel was built with a horizontal curve at its east end for the eastbound direction. Trucks exiting the tunnel at high speeds had trouble negotiating the curve to the left. Upon running onto the shoulder and its negative superelevation, some overturned. Figure 50 illustrates the curve as seen from above the tunnel exit (eastbound direction). A significant number of trucks and smaller vehicles were observed veering onto the shoulder.

Implementation

No information was provided regarding the completion date and cost of the mainlane improvement at the east end of the Blue Mountain Tunnel. Turnpike Commission sources stated that construction plans do not need to be approved by the FHWA, only by PennDOT. The source of funding for these improvements is toll revenues. Typically, the commission uses PennDOT design standards; however, the shoulder improvements involved a design which was inconsistent with PennDOT standards. Turnpike engineers were successful in getting approvals from PennDOT on this design change.

The deviation from PennDOT design standards involved changing the cross-slope of the shoulder to match the cross-slope (superelevation) of the mainlanes. On a mainlane curve to the left, superelevated sections slope to the inside of the curve (right to left as seen by motorists), but PennDOT standards require the shoulders to slope downward to the outside of the curve (left to right as seen by motorists). This means a "break-over" point exists at the outside pavement edge. When vehicles traversing a curve to the left veer onto this shoulder, their effective superelevation is decreased, causing load shifts and/or rollover in large trucks. Because the original design facilitated surface moisture drainage (e.g. rain and snow melt) away from the travel lane, a slot-drain became necessary with the new design. Figures 48 and 49 illustrate the application of the drain.

Sketches provided by the commission show the existing maximum superelevation for this 5° curve at 7.87 percent on the mainlanes. Prior to improving the shoulder, a 1.8 percent negative cross-slope existed, resulting in an algebraic difference of 8.6 percent.

Figure 50. Eastbound exit from Blue Mountain Tunnel.

Effectiveness

Turnpike sources believe the improvements have significantly reduced the number of truck accidents at this location. However, insufficient detailed information was provided to evaluate the effects of the changes.

Truck Industry Views

The truck driver who wrote a letter to the turnpike commission cited the eastbound exits from the tunnels as a prime example of the need for turnpike design engineers to ride with him in his tractor-semitrailer and get the feel of their roadway. He added that these tunnel exits are "dangerous because of the sudden (horizontal) curve, narrow roadway, and not 'banked' into the curve, and sudden drop of a lower shoulder at the edge of this narrow roadway."

CHAPTER 12

PITTSBURGH, PENNSYLVANIA CASE STUDY

OVERVIEW

Description of Area

The city of Pittsburgh, located at the junction of the Monongahela, Allegheny, and Ohio Rivers, is a major transportation hub for water, rail, highway, and air traffic. It is located in western Pennsylvania in very hilly terrain that has contributed to some of the truck accident countermeasures contained in this case study. The topography and rivers form natural barriers to highway transportation, creating the need for many bridges and tunnels, even within the downtown area of the city. Major Interstate highways providing access to the city include Interstate 76 (Pennsylvania Turnpike), that generally runs east-west, and Interstate 79, that runs generally north-south. (See figure 51). The Turnpike connects Pittsburgh with Harrisburg and Philadelphia to the east and Cleveland, Toledo, South Bend, and Chicago to the west. Within the urbanized area, Interstates 279 and 376 provide freeway access from other major freeways to the downtown area. The Fort Pitt Tunnel and the segment of I-279 where it is located (see figure 51) serves as a crucial connector between the downtown and points to the south and west of the city.

The Fort Pitt Tunnel is one of three major tunnels in the greater Pittsburgh area. Squirrel Hill is the other tunnel located on a freeway. The third, Liberty Tunnel, is the oldest, built in 1925. Squirrel Hill was built in 1953, and the Fort Pitt Tunnel was opened in 1960. The 1990 traffic volume at the Fort Pitt Tunnel was 104,000 vehicles per day (vpd), Squirrel Hill 95,000 vpd, and Liberty 50,000 vpd. Historically, the truck proportion at the Fort Pitt Tunnel has been estimated at 9 percent, according to Pennsylvania Department of Transportation (PennDOT) personnel. Liberty is not a freeway application; it has traffic signals on each end. Only the Fort Pitt Tunnel is included as part of this study.

The northbound approach to the Fort Pitt Tunnel on I-279 includes several truck accident countermeasures: an overheight warning device, a truck speed limit, "TRUCK ALERT" warning signs, a lane restriction, and a truck escape ramp (referred to locally as a "truck sandpile"). A changeable message sign is also incorporated, but it exists for the benefit of all traffic. These devices are more important on the northbound approach to the tunnel because, for approximately 2.4 km (1.5 mi) in advance of the tunnel opening, the roadway follows a 5 percent downgrade. At the tunnel proper, a heavy-duty tow truck remains on call on a 24-hour basis in case an incident or accident occurs in or near the tunnel. Each tunnel (tube) cross section consists of two lanes and no shoulders. The I-279 (Fort Pitt) bridge, which crosses the Monongahela River, begins immediately at the north end of the tunnel. For traffic traveling in either direction on I-279, any necessary lane changing must occur on the bridge proper.

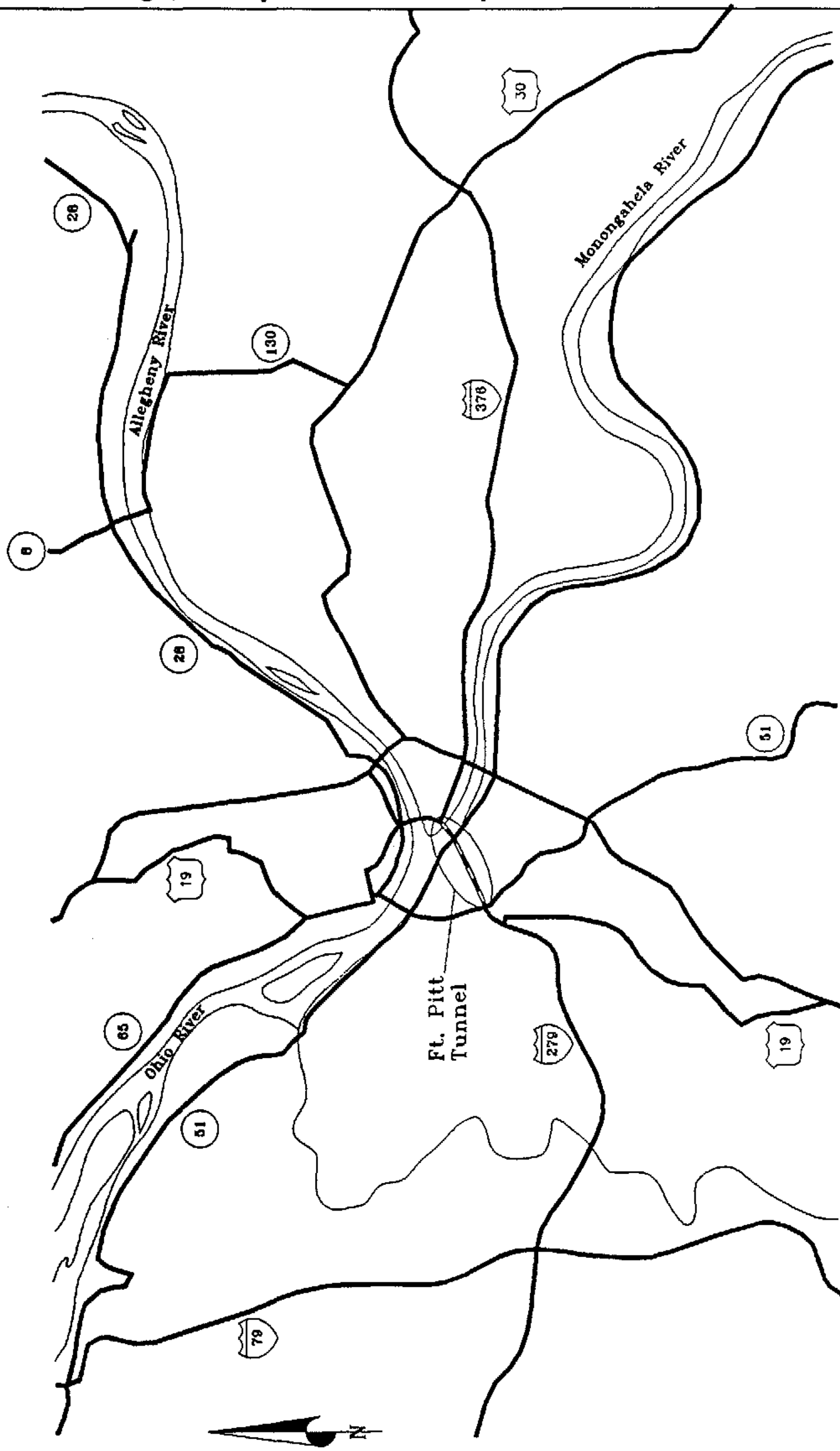


Figure 51. Pittsburgh, Pennsylvania roadway system.

Countermeasures Implemented

Countermeasures for heavy truck accidents implemented in Pittsburgh on the northbound approach to the Fort Pitt Tunnel include:

- Overheight warning devices.
- Truck escape ramp.
- Regulatory and warning signs for trucks.
- Major incident response.

Accidents

Table 27 shows general accident information for a segment of I-279 in Pittsburgh just north of the Ft. Pitt Bridge. However, no traffic classification counts were provided to indicate exposure by type of vehicle. Also, insufficient detail is known regarding the truck-involved accidents to identify trucker-at-fault accidents.

Table 27. Accident data for I-279 in Pittsburgh.
(Fort Pitt Bridge to North/Spring Interchange)

YEAR	Cars and other vehicles involved	Heavy trucks involved	Injuries in cars & other vehicles	Injuries in heavy trucks	Killed in cars & other vehicles	Killed in heavy trucks
1986	145	10	43	1	0	0
1987	174	5	77	0	0	0
1988	179	12	85	0	4	0
1989	71	4	21	0	0	0
1990	101	8	55	0	0	0
TOTALS	670	39	281	1	4	0

Source: PennDOT

Truck Industry Views

The Pennsylvania Motor Transport Association (PMTA) provided information on potential contacts for the interviews. Those contacted were asked about the countermeasures implemented in the Pittsburgh area. The first interviewee, a former truck driver now employed by the PMTA, drove a truck during the 1940's and 1950's. Since then, he has served in the capacity of safety manager, operations manager, and other administrative positions for 17 years in the trucking industry, prior to his position as a PMTA administrator.

Another interviewee is an aggregate hauler in the Pittsburgh area, who is an owner/operator. He has driven a truck in the past, and still drives occasionally. The third interviewee is a general commodities carrier administrator who has previous driving experience. He still possesses a commercial driver's license, but does not currently drive.

OVERHEIGHT WARNING DEVICE

Background

The overheight detection device used in Pittsburgh is similar to those used in several States where overhead clearance is less than expected or unusually high loads are common. The system consists of a transmitter and receiver, mounted on existing poles on both sides of the traffic lanes and set just below the level of the actual obstruction (a pre-selected tolerance is subtracted from the actual obstruction height). If the beam is broken and fails to reach the receiver, flashing beacons (and/or audible alarms) are activated.

PennDOT district personnel provided historical information on this system of devices approaching the Fort Pitt Tunnel. There has been an overheight device at the tunnel since it opened, but another advance warning has been installed for additional warning upstream. If truck drivers are not given this advance warning, they might be forced to stop and back slowly away from the mouth of the tunnel, halting traffic for an extended period of time.

The initial upstream height warning system, purchased from an out-of-State vendor, was beset with problems from the very outset of installation. PennDOT finally gave up completely on the original vendor and hardware, and opted for components purchased locally in Pittsburgh. This current system uses a modulated infrared light emitting diode (LED) source.

Implementation

Because the initial system did not work satisfactorily and other components were added later to make it work, the total cost was difficult to determine. Similar systems used elsewhere that have tested and functioned adequately cost $25,000 to $30,000. One difference in the referenced systems is inclusion of an audible warning message. The five basic parts of the system used near the Fort Pitt Tunnel are:

- Advance warning signs of the height restriction.
- A device to detect overheight vehicles.
- Audible alarm bells that are activated when an overheight vehicle is detected.
- Overhead warning signs with flashing yellow beacons that are activated when an overheight vehicle is detected.
- Regulatory sign(s) with instructions for drivers of overheight vehicles.[17]

Effectiveness

PennDOT reported that florescent lighting sometimes causes the transmitter to malfunction, so the district wants to convert to incandescent Highway lighting. They also stated that the initial system might have worked well if the distance between the transmitter and receiver was small enough. If median space exists for either the transmitter or the receiver as opposed to placement on opposite sides of a wide roadway, the system might perform satisfactorily.

Truck drivers comply with the warning device because of the obvious consequences if they do not. In their applications in Mississippi and North Carolina, the responsible agencies were satisfied with their effectiveness in deterring damage to structures from overheight loads, although the applications in Mississippi were in place for less than 1 year when this judgement was made.

Truck Industry Views

Truckers contacted in the area had not hauled overheight loads on this section of freeway, and therefore could not testify to its effectiveness.

TRUCK ESCAPE RAMP

Background

Truck escape ramps are usually associated with rural areas, however one ramp is located near downtown Pittsburgh. Highway grades in the Pittsburgh area, coupled with high volume-to-capacity ratios and large volumes of heavy trucks increase the frequency of truck braking accidents. Loaded trucks traversing long downgrades are often required to repeatedly slow and even stop on major highway arteries, resulting in brake overheating and/or failure. In 1980, PennDOT engineers evaluated the runaway truck problem in the Pittsburgh area. They found that in the preceding 3 years, 63 runaway truck accidents occurred at 18 sites with steep grades. The grades ranged from 5 to 10.5 percent with lengths over 0.8 km (1/2 mi). One of these hills, known locally as Greentree Hill, had experienced 11 runaway accidents in 3 years. This 2.4-km (1.5-mi) grade of 5 percent is located on the northbound approach to the Ft. Pitt Tunnel. Banksville Road merges from the right at the base of the hill just upstream of the Ft. Pitt Tunnel. The two main lanes on I-279 plus two lanes from Banksville Road merge into two lanes just prior to the two-lane tunnel. This difficult merge, plus frequently stopped traffic, compound the length and grade problems near the bottom of Greentree Hill.

One high visibility accident happened prior to the installation of the runaway ramp. It occurred on April 28, 1980, because of brake failure while the vehicle was descending Greentree Hill. The truck driver negotiated the grade, proceeded through the Fort Pitt Tunnel, onto the Fort Pitt Bridge and then descended a ramp into the city (Pittsburgh). The truck crashed into a crowded noontime city sidewalk, pinning victims against a building. Six injuries and four fatalities resulted.[18,19]

At the time of the four-fatality accident, PennDOT was designing a sandpile arrester bed. The word "sandpile" is a misnomer, since only rounded gravel is used. The design for the bed located on the right side of I-279 prior to the Fort Pitt tunnel is based on the FHWA's <u>Interim Guideline for Design of Emergency Escape Ramps</u>.[20] Vehicles desiring to use the escape ramp exit on a paved shoulder, then onto a paved 68.7-m (229-ft) approach. The bed is 103 m long (338 ft) with its surface smoothed to a 2.2 percent downgrade. It was constructed with 6 830 Mg (6,200 tons) of specially graded gravel which varies in depth from 0.41 to 0.46 m (1 ft, 4 in to 13 ft, 6 in). Because of the confined area available for the arrester bed, designers did not have the full length recommended by the FHWA design criteria. They chose to build an H-beam steel and timber wall which supported a crash cushion at the end of the bed.

Implementation

The original cost of the escape ramp, including the wall and crash cushion, was $597,178. It was constructed in the summer of 1980 by an engineering/construction firm in the Pittsburgh area. The wall accounted for approximately 43 percent of the project cost, but PennDOT engineers stated it would be required on most sites.[21]

Considering the number of trucks using the escape ramp (listed in table 28), and the severity typically associated with a runaway truck accident, it appears that the savings would outweigh the cost of the ramp. In 1980, when the effectiveness of the ramp was evaluated, PennDOT engineers estimated that at least 10 automobiles would have been involved for each runaway truck, had the ramp not been there. The PennDOT estimated cost savings was not available for review.

Another cost associated with the ramp is the cost to a driver to retrieve the vehicle from the gravel pile. At one time PennDOT's Fort Pitt Tunnel tow truck was used to retrieve trucks. Because this tow truck was not powerful enough by itself to retrieve a heavily loaded combination vehicle, its use was discontinued. Quantifying the unrecovered costs associated with this activity was not possible. Private tow companies charge the retrieval cost directly to the driver.

Effectiveness

Some (familiar) truck drivers traveling northbound through this area move into the left lane approaching the Fort Pitt Tunnel in order to merge left just beyond the tunnel. The restriction on changing lanes in the tunnel combined with a short weaving distance between the tunnel and an approaching left-hand exit (especially for trucks in heavy traffic) causes truck drivers to move into the left lane upstream of the tunnel. During some periods of the day, the queue approaching the tunnel is 1.6 km (1.0 mi) or more in length. Because the runaway ramp is near the bottom of the grade, truck drivers are sometimes already in the left lane and the ramp is inaccessible to them.

PennDOT no longer maintains complete records of escape ramp usage and does not document every instance of usage today as it once did. Because private tow rigs currently retrieve trucks, there is a possibility that the incident will not be recorded at all. The ramp is often used by anonymous drivers, sometimes by smaller vehicles that would be gone the next day or by the time anyone saw evidence of its use. PennDOT maintenance crews provide support in restoring the gravel to its original smooth shape. This is done approximately twice a month for these minor uses, but major uses occur two to three times per year. So-called "Gypsy" drivers roam the freeway in their smaller tow trucks near the tunnel to pick up these vehicles in need. They find out by monitoring Citizens Band (CB) radio and police radio frequencies.

A similarly designed gravel arrester bed was built near Kittanning, Pennsylvania in 1977. Twenty-eight trucks have used this facility; none resulted in serious injury to the truck driver or severe damage to the vehicle. One fully loaded coal truck traveling an estimated 104 km/h (65 mi/h) required the entire length of the bed to stop.

Table 28. Sandpile incident summary.

DATE	TIME	ESTIMATED SPEED	DISTANCE INTO PILE	LOAD
11/19/80	7:00 A.M.	30 mi/h	Sandpile not completed	Not Recorded
4/10/81	7:00 A.M.	40 mi/h	148 ft	74,450 lb of Ferro Silicone
08/26/81	4:30 A.M.	15 mi/h	50 ft	Lettuce
09/10/81	1:00 P.M.	40 mi/h	133 ft	Steel Tubing
11/18/81	12:00 P.M.	30 mi/h	50 ft	35,000 lb of Carrots
01/12/82	9:00 A.M	25 mi/h	168 ft	Bananas
02/05/82	8:45 A.M.	25 mi/h	100 ft	Paper Rolls
03/01/82	7:00 A.M.	25 mi/h	63 ft	66,000 lb of Steel Pipe
10/30/82	6:15 P.M.	40 mi/h	178 ft	School Bus or School Children
01/17/83	6:50 P.M.	30 mi/h	32 ft	Furniture
02/22/83	6:30 A.M.	30 mi/h	105 ft	75,000 lb of Lumber
03/04/83	7:15 A.M.	15 mi/h	80 ft	48,000 lb of Corn Syrup
05/24/83	8:50 A.M.	25 mi/h	126 ft	78,000 lb
05/24/84	7:15 A.M.	35 mi/h	120 ft	20,000 lb Xerox Machines
07/03/84	? A.M.	?	75 ft	Vending Machines
10/03/84	7:30 A.M.	?	100 ft	Stainless Steel
04/08/85	7:00 A.M.	35 mi/h	80 ft	Scrap Metal
04/26/85	3:00 P.M.	40 mi/h	87 ft	Paper 47,000 lb
02/21/86	8:30 A.M.	?	?	?
05/19/86	7:30 A.M.	?	50 ft	Dog Food 42,000 lb
08/24/89	7:00 A.M.	45 mi/h	168 ft	Steel Plates

Metric conversion: 1 mi/h = 1.61 km/h; 1 ft = 0.305 m; 1 lb = 0.454 kg

Truck Industry Views

In 1980, PennDOT engineers met with trucking association representatives and experienced truck drivers regarding Greentree Hill. The truckers voiced their concerns regarding signing on this and other hills:[21]

1. "STEEP GRADE and LONG GRADE" messages do not convey specifics of how long and how steep grades are. Drivers suggested a national system for making grade signing information uniform so they know what to expect.

2. "POSSIBLE CONGESTION AHEAD" was not nearly as effective as "TRAFFIC MAY BE STOPPED AHEAD."

3. Signs supplemented with alternating amber flashing lights are the most effective devices for severe problem areas.

4. Mandating large headways between vehicles on downgrades is not effective because automobiles tend to pull into those spaces. Lane and speed limitations for trucks on downgrades are preferable.

INCIDENT RESPONSE MANAGEMENT

Background

Heavy-duty tow trucks are stationed at major tunnels in the Pittsburgh area. The tunnel patrol at Fort Pitt consists of an on-call tow truck stationed at the southern end of the tunnel. PennDOT responds to an average of nine incidents per day in the tunnel. Most of these are simple situations, such as running out of fuel or flat tires that only require a quick tow to clear the traffic lane. The Fort Pitt tow truck is a heavy-duty diesel powered unit that can move large combination vehicles from within the tunnel, if the wheels are not locked. It is not powerful enough to right an overturned truck, however. The basic crew at the tunnel includes three persons. Two are stationed on the north end where the tow truck is parked and one on the other end. They are on 24-hour call to respond to incidents, 7 days a week.

These tow trucks are only used to remove vehicles or render other aid to motorists *within* the tunnel. State police summon private tow trucks to incidents elsewhere based on their knowledge of local private tow truck operators and the size machine needed to handle a situation. State police typically use a rotation list to contact tow trucks. If more than one tow truck is located within the area, they select the next one on the list.

At one time the tunnel tow truck was used to retrieve trucks from the runaway ramp, however, the PennDOT truck was not heavy enough to handle difficult situations. Some loaded trucks required as many as three larger tow trucks to pull the truck from the gravel pile. Currently, private tow trucks remove vehicles from the gravel bed.

When PennDOT was retrieving trucks from the gravel bed, it required payment from the driver being assisted or from the company's insurance company. Unfortunately, not all truck drivers were faithful in paying for services rendered, resulting in a direct cost to PennDOT. Now, with private tow trucks performing this service, there is less cost associated with its use--only the cost to smooth the gravel. Payment is now made directly from the truck driver or insurance company to the private tow truck company.

Implementation

With the high traffic demand that exists at the Fort Pitt Tunnel, it is important to clear the tunnel as quickly as possible following an incident. According to PennDOT records, the 1990 average daily traffic at the tunnel was 104,000 vpd. Each tunnel tube (direction) has only two lanes and no shoulders.

The current tow trucks use an R-Model Mack truck chassis with a Holmes 750 wrecker. These units were purchased in 1977 at a cost of $44,387 each. One is used at Fort Pitt and another at the Squirrel Hill Tunnel, also located on a freeway near downtown Pittsburgh. PennDOT previously used a short wheelbase truck which could turn around in the tunnel without backing, the current Mack trucks with a longer wheelbase cannot turn within the tunnel. A third major tunnel, not on a freeway uses a smaller 30 Series Chevrolet chassis tow truck which was purchased in 1981 at a cost of $18,950. The total annual budget for all three tunnels in the Pittsburgh area is $4.5 million. This includes lighting, ventilation, maintenance, personnel, and vehicles. Figure 52 shows the current tow truck used at the Ft. Pitt Tunnel.

Figure 52. Fort Pitt tow truck.

Effectiveness

Because tow trucks are stationed at the entrance to the tunnel at all times, response time is very short. Private tow companies, on the other hand, might not be available immediately to respond to an incident at the tunnel. Also, operators from a private firm would probably not be as familiar with the tunnel as PennDOT drivers, and therefore would not be as efficient.

Given the traffic volume using this tunnel, any blockage within the tunnel quickly causes serious traffic delays. In fact, delays are common even with no blockage at all.

Truck Industry Views

The truck drivers interviewed had not been involved in an incident at the tunnel. They were knowledgeable of the tow service and felt that the quick response technique is very positive.

MAINLANE TREATMENTS

Background

Some of the signs being used on the approach to Greentree Hill and the tunnels inform truck drivers of the truck escape ramp. These static signs were installed in 1980 when the escape ramp was completed. The changeable message signs were already in place at that time. There are presently approximately 60 signs providing information to motorists in the Greentree Hill area on I-279. Of these, 23 signs give truck warnings and restrictions in the 3.2-km (2-mi) segment of freeway.

Implementation

The truck signs include lane restrictions, regulatory speed limits for trucks, "TRUCK ALERT" warning signs, and signs with the message "RUNAWAY TRUCK SANDPILE." The truck warning signs at the top of the hill are special 3-m by 4-m (11-ft by 14-ft) signs with flashing yellow lights. Figure 53 illustrates this black on yellow sign.

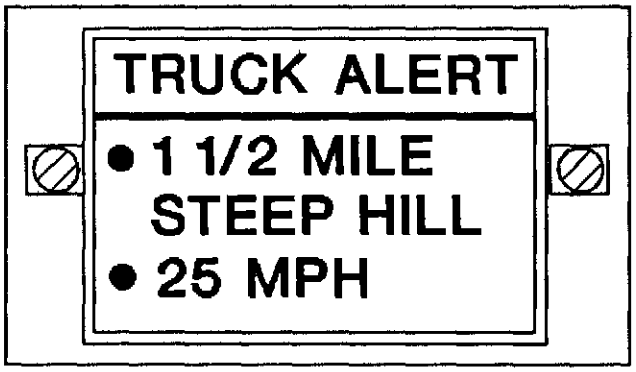


Figure 53. Truck alert sign.

The lane restriction signs (black on white) are regulatory signs that restrict trucks to the right lane (total two lanes northbound). The message used is "LEFT LANE NO TRUCKS." Truck speed limit signs are also used along I-279. Figure 54 shows the message used on the sign.

Two of the approximately 60 signs are overhead changeable message signs, installed in 1981. At first, the message on these two signs was controlled by the State police, but due to their frequent reassignment and other changes, control was passed to PennDOT. Easily accessible and user-friendly microcomputers have helped PennDOT personnel stationed at the tunnel to control the message of the sign. If they encounter difficulties they cannot solve, assistance is requested from the District office.

The first upstream changeable message sign is positioned over the traffic lanes 3.2 km (2 mi) in advance of the truck sandpile. A warning to truck drivers of the steep grade ahead is the message typically displayed. The second overhead changeable message sign is located 1.2 km (1 mi) upstream from the sandpile. It flashes one of the three- or four-line messages shown in figure 55.

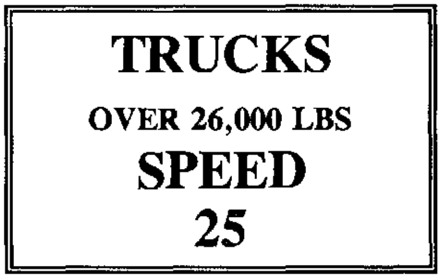


Figure 54. Truck speed limit sign.

Figure 55. Changeable message sign messages to truck drivers.

Sign costs when fabricated and installed by PennDOT are \$161/m^2 (\$15/ft^2) of surface area. The TRUCK ALERT sign was 3 m by 4 m (11 ft by 14 ft) for a cost of \$2,310. The flashing lights are additional to this subtotal.

Effectiveness

Tables 29 and 30 summarize accident data for the 2.4 km (1.5 mi) segment of I-279. The effectiveness of these signs must be compared to the situation that existed before they were installed. Insufficient information was available from the before time period to conduct an analysis.

Table 29. Accident data for I-279 northbound in Pittsburgh.
(Greentree Interchange to Fort Pitt Tunnel northbound only)

YEAR	Cars and other vehicles involved	Heavy trucks involved	Injuries in cars & other vehicles	Injuries in heavy trucks	Killed in cars & other vehicles	Killed in heavy trucks
1986	376	20	165	1	2	0
1987	393	25	176	6	0	0
1988	434	25	206	5	4	0
1989	222	8	83	0	0	0
1990	422	44	231	7	0	0
TOTALS	1847	122	861	19	6	0

Source: PennDOT

Table 30. Accident data for I-279 southbound in Pittsburgh.
(Greentree Interchange to Fort Pitt Tunnel southbound only)

YEAR	Cars and other vehicles involved	Heavy trucks involved	Injuries in cars & other vehicles	Injuries in heavy trucks	Killed in cars & other vehicles	Killed in heavy trucks
1990	30	1	10	0	0	0
TOTALS	30	1	10	0	0	0

Source: PennDOT

Truck Industry Views

The aggregate hauler, who is an owner/operator commented that signs such as those used on I-279 are effective in conveying the message intended. The problem stems from drivers who ignore the signs. He further stated that changeable message signs provide valuable information regarding traffic conditions in approaching the tunnel.

The general commodities carrier administrator believes that most truck drivers notice signs and heed their warnings, but a few, like some automobile drivers, do not. He added that if a sign uses the word "TRUCK" or depicts a truck, most truck drivers will pay attention to it.

RAMP TREATMENTS

Background

Several warning devices, additional superelevation, and a tall reinforced concrete barrier for containing cars and trucks were installed at the interchange of I-70/I-79 near Washington, Pennsylvania approximately 48 km (30 mi) south of Pittsburgh. PennDOT engineers reported that prior to the improvements several fatalities had occurred at the location. The ramp geometry is shown in figure 56 and signs located along I-79 prior to the interchange are shown in figure 57.

Implementation

The initial countermeasure for the ramp was to modify and/or increase the number of signs located prior to the ramp. The signing contract work began on August 2, 1984 and was completed on June 12, 1986. Based on additional evaluations before and after installing the new signs, PennDOT investigated additional countermeasures including alternative designs for barriers. A tall barrier, which would contain large combination vehicles as well as smaller vehicles, was selected. The tall barrier contract was awarded on January 21, 1985 and was completed on June 27, 1985. A detour was in place from March 22, 1985 to June 28, 1985 for construction of the tall barrier.

The total cost of the signing project was $232,011; the cost of the high wall barrier project was $602,333. The signing project included removal of certain existing traffic signs, installation of structure-mounted signs, and installation of a guard rail (excludes tall barrier). The high wall project included construction of 204 m (669 linear ft) of reinforced concrete barrier, installation of a safety guard rail, paving, drainage, and pavement markers. Funding on each contract was 90 percent Federal and 10 percent State.

Effectiveness

PennDOT provided before/after accident history, however, the after data were affected by a detour in place during 1989-1990 to rebuild the roadway. During the signing and tall barrier construction, traffic was also maintained and could be a factor in the number of accidents during that period. Table 31 provides accident information provided by PennDOT for periods before and after the countermeasure implementation on the ramp. These accidents are only those truck accidents expected to be affected by the countermeasures implemented. Analysis of the "after" period of 1987 through 1990 revealed no accidents, whereas two to six truck accidents occurred during each year of the "before" period.

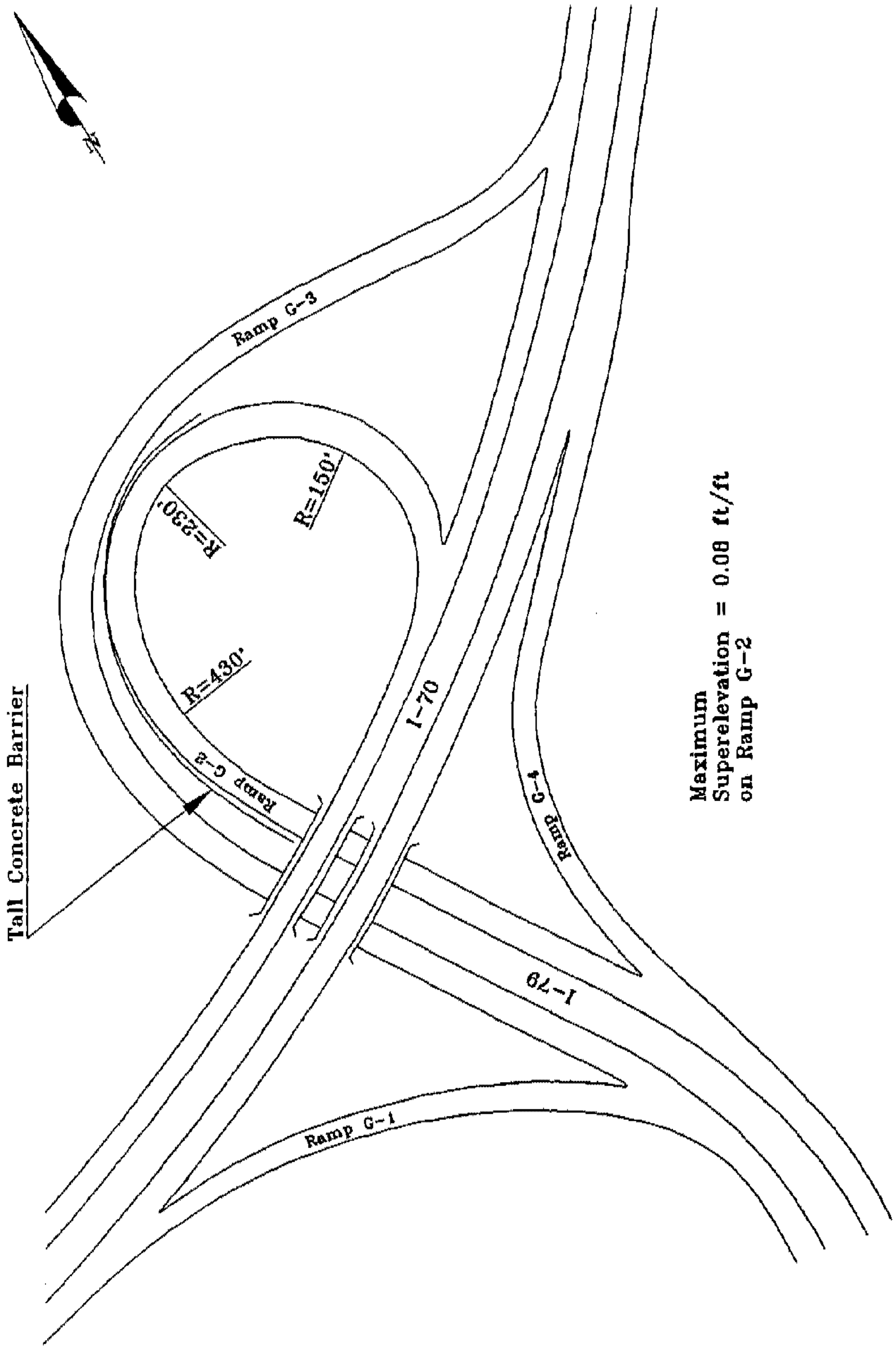


Figure 56. I-70/I-79 interchange layout.

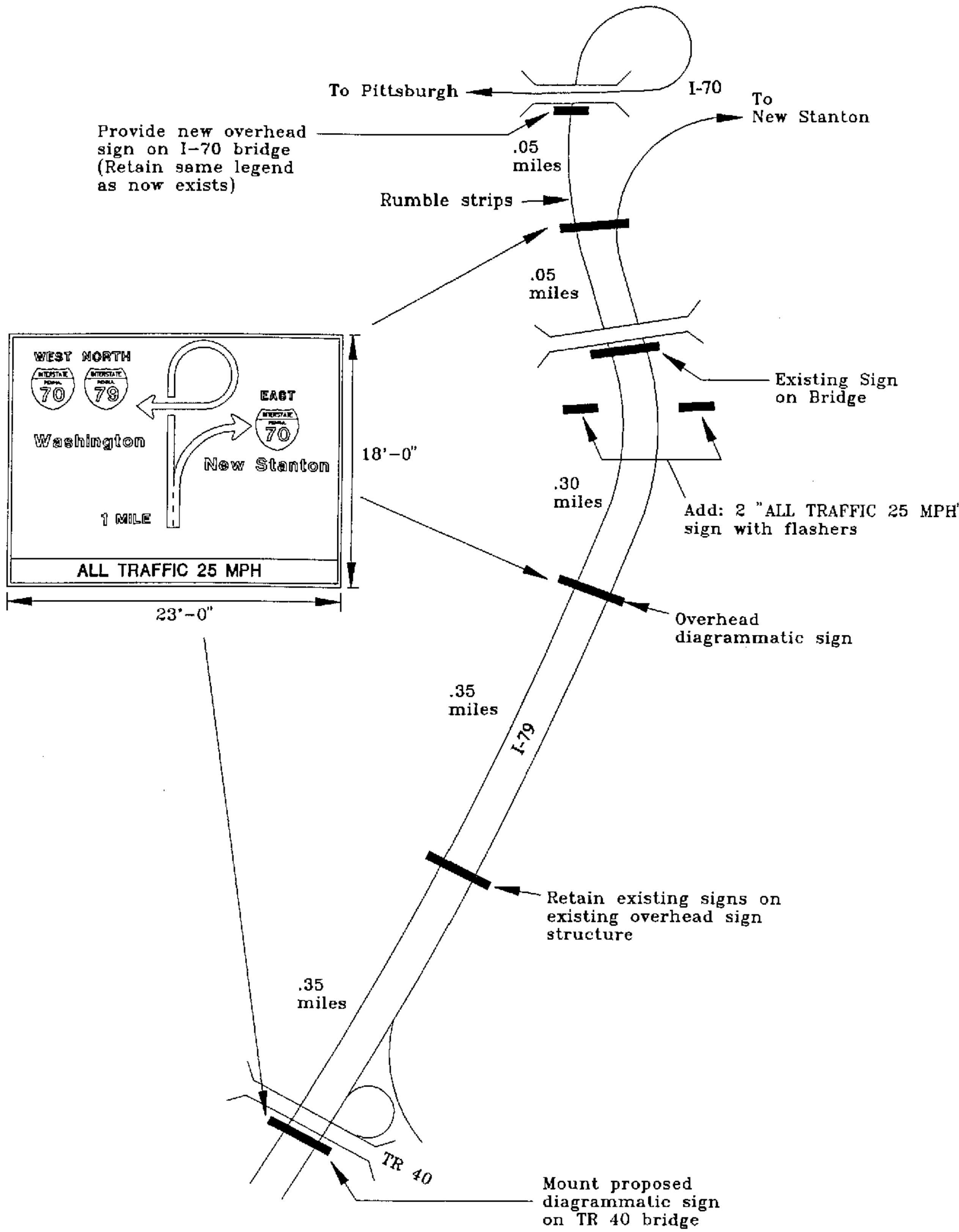


Figure 57. I-79 northbound approach to improved ramp.

Table 31. Truck accident summary at I-70/I-79 near Washington, Pennsylvania.

Date	Accident Factors	Light/Road Conditions	Severity
Before Accidents:			
11/07/80	Large truck hit med. barrier	Dawn, Dry	Injury
12/10/80	Large truck hit med. barrier	Dark, Dry	No Injury
05/15/80	Large truck overturned	Daylight, Dry	No Injury
01/04/80	Large truck hit guardrail; hit embankment	Daylight, Sleet	Injury
08/04/81	Large truck hit embankment; overturned	Daylight, Dry	Injury
02/27/81	Large truck hit med. barrier; overturned	Dark, Dry	Injury
05/07/81	Large truck hit med. barrier; overturned	Dark,Dry	Injury
05/10/81	Large truck hit med. barrier; overturned	Daylight, Rain	Injury
05/27/81	Large truck overturned	Daylight, Rain	No Injury
05/31/81	Large truck overturned	Daylight, Dry	Injury
09/09/81	Large truck hit med. barrier; overturned	Dark, Dry	Injury
09/15/82	Truck hit med. barrier	Daylight, Dry	Injury
12/03/82	Large truck hit embankment	Daylight, Dry	Injury
12/21/82	Large truck hit med. barrier; hit guardrail	Daylight, Dry	Injury
04/29/82	Truck overturned	Dark, Dry	Injury
02/21/83	Large truck hit med. barrier; overturned	Daylight, Dry	Injury
03/10/83	Large truck hit med. barrier; overturned	Dark, Snow	Fatality, Injury
After Accidents:			
None			

Note: Only one accident (04/29/82) involved alcohol

Truck Industry Views

The PMTA representative in Harrisburg stated that any vehicle driver, after traveling a long distance on freeways at high speeds, loses sense of speed and needs to observe the speedometer in order to know how fast the vehicle is actually going. With automobile operators, the driver can brake and decelerate to overcome the predicament. With a truck driver, the curve may be sharper than anticipated and rollover can result. He suggested a sign that warns: "DON'T TRUST YOUR SENSES, READ YOUR SPEEDOMETER."

The most serious problem, according to this ATA State affiliate is irresponsible drivers. They ignore signs that provide warning messages installed for them. He contends the problem often is simply driver error. He also maintains that management can have a significant impact on the way drivers drive.

CHAPTER 13

PORTLAND, OREGON CASE STUDY

OVERVIEW

Description of Area

Interstate 5 connects southern California and the State of Washington, serving a large number of trucks along this north/south corridor. The freeway network in Portland, Oregon is shown in figure 58. Because Portland is the major metropolitan area in Oregon, it has a concentration of transportation activity in the area.

Countermeasures Implemented

There were two implemented truck accident countermeasures in the Portland area. They were:

- Mainlane Improvement on I-5 near Terwilliger Street.
- Truck Bypass at Tigard Street Interchange.

Accidents

Oregon DOT did not provide general accident information for Portland area freeways, however they did provide a summary of the accidents that occurred along the Terwilliger Curve.

Truck Industry Views

Results of interviews with truck drivers at truck stops are included for the two truck accident countermeasures. Two teams of drivers (totalling four) responded to questions regarding the two countermeasures. The four drivers interviewed were based in Salem, Oregon and drove for a van line which operates nationwide.

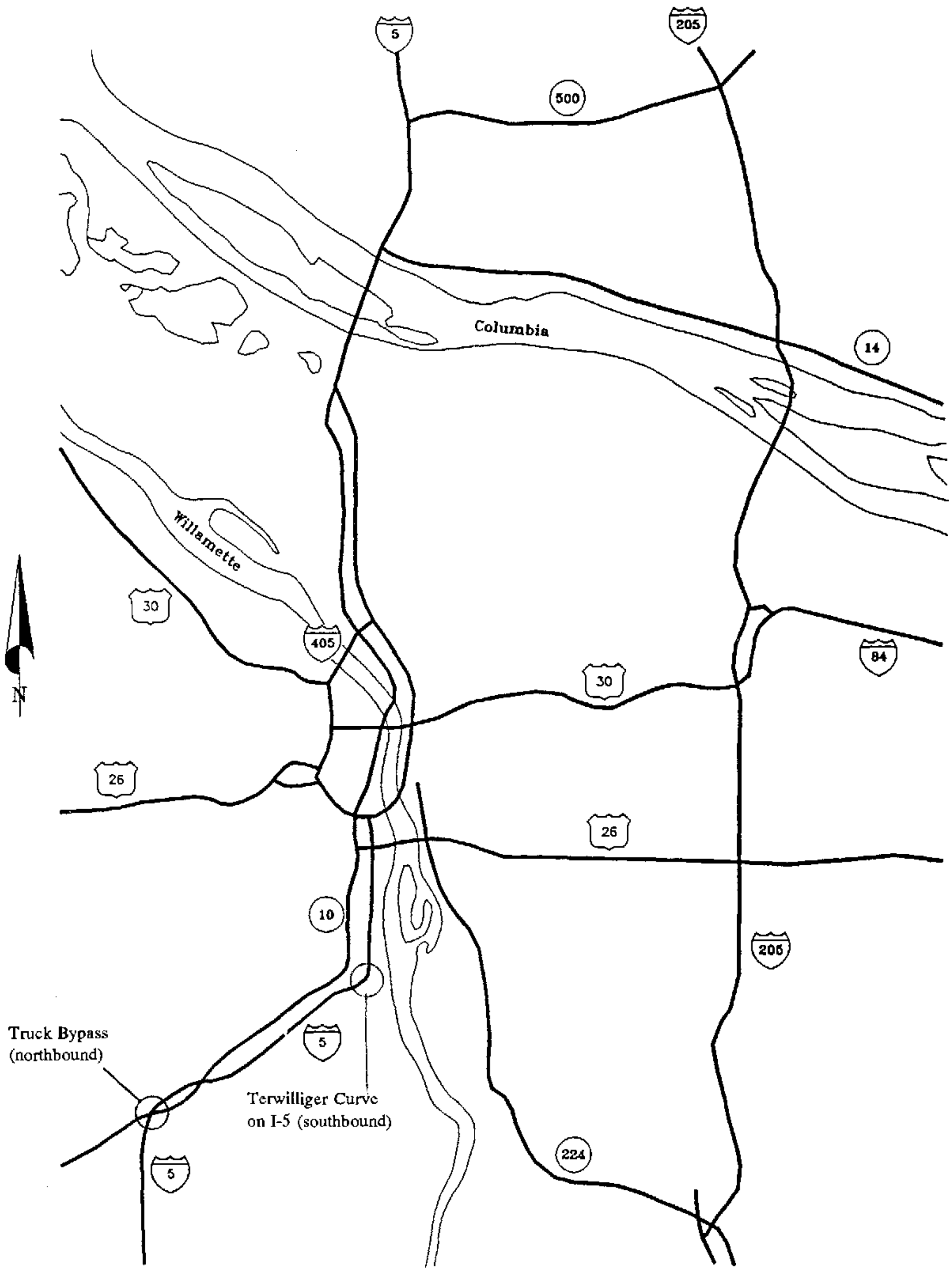


Figure 58. Portland, Oregon roadway system.

MAINLANE IMPROVEMENT

Background

The Terwilliger curve in Portland, Oregon occurs at or near MP 299 on Interstate Highway 5. When this segment of I-5 was built in 1968, both the northbound and the southbound lanes in the so-called "Terwilliger Curve" were built with no superelevation. The roadway cross-section where the curve is located has three lanes in each direction. The design plans show that the cross-slope for both directions of traffic flow was 2 percent on the two inside lanes and 2.5 percent on the outside lane. Water drains across the pavement from the median to the outside for both directions of traffic flow. Approximately 8,000 trucks per day use this section of I-5.

Implementation

The mainlane improvement on I-5 in the Portland area includes an improvement in superelevation. During the summer of 1987, the superelevation was increased to a maximum of 5 percent within the curve. This was done by using an asphalt "wedge" to build up the pavement across its full width, with the depth increasing from the inside toward the outside of the curve.

The degree of curvature (D) at the freeway centerline is 7° 30' (northbound and southbound directions are parallel). The median width is 2.6 m (8.4 ft) which includes a safety-shape concrete barrier in its center. The northbound direction also has a concrete safety-shape barrier on the outside in this left-hand curve. Both barriers were apparently the standard height of 0.80 m (32 in). The outside barrier had numerous black tire marks and scrapes along the curve section indicating it had been hit repeatedly by vehicles negotiating the curve. The northbound curve to the left was preceded by a descending grade of approximately 3 percent for a distance of 1.83 km (1.14 mi) which added to the problem because of the tendency to accelerate.

The southbound direction follows a 2 to 3 percent ascending grade for at least 2.13 km (1.33 mi) before the Terwilliger curve. The speed of trucks at the curve depends on several factors including their weight-to-horsepower ratio, whether they are loaded or empty, effects of other vehicles in the traffic stream, and the approach speed at the bottom of the grade. Observed truck speeds were in the range of 72 to 112 km/h (45 to 70 mi/h).

The superelevation improvement was completed in 1987. Another improvement included the addition of two "50 MPH" black-on-yellow advisory speed plates mounted overhead in each direction. The signs included a large curved arrow over the top of the "50 MPH" (same sign face) indicating the direction of the curve to the left. The two signs are mounted with one over the inside lane and one over the outside lane.

Two-way average daily traffic near this section of I-5 in October 1988 was 123,582 vehicles per day. The directional split is 50.5 percent northbound and 49.5 percent southbound. In both the northbound and southbound directions, 93 percent were cars, pickups, or other small vehicles while 7 percent were large trucks or school buses.

Effectiveness

Table 32 provides a summary of computerized data on all truck accidents in the curve. Two of these accidents involved rear-end collisions, however, the accident coding suggested the trucks were out-of-control at the time of the collision. Individual accident reports were not available for this analysis. Only general observations can be made on accidental trends because data needed for statistical analysis, such as traffic volume by class of vehicle, were not available. Before the improvement, there were 26 accidents over 3 years, 5 months. After the improvement, there were 14 accidents over a time period of 2 years, 4 months. Adjusting for the time periods, 7.6 truck accidents per year occurred in the before period, while only six truck accidents per year occurred in the after period. This suggests a reduction in truck accidents near 20 percent resulting from the superelevation improvement. Yet, this analysis must also recognize that nine accidents occurred in one of the after years, which equals the highest number of accidents in the before years, and that it does not account for exposure. More detailed information is needed before any conclusion on the effectiveness of the countermeasure can be made.

Table 32. Number of truck accidents at the Terwilliger Curve.

YEAR	NO. TRUCK ACCIDENTS
1984	9
1985	6
1986	7
1987	4 before, 1 after [1]
1988	4
1989	9

[1] None in the summer of 1987

Truck Industry Views

Interviews at a nearby truck stop provided insight from truck drivers regarding the Terwilliger Curve improvement. The four drivers interviewed were based in Salem, Oregon and drove for a van line which operates nationwide. They were asked whether they were "...aware of the improvements that were made in the banking on the curve at I-5 and Terwilliger in Portland?" They responded:

> "I know that curve well. It's better than it used to be but its still a tough one if you're going a little too fast."
>
> "It's a bad curve alright, but I was not aware it had changed."
>
> "We go through there often and it's a sharp curve, but I didn't think they did anything but put new pavement on it a couple of years ago."
>
> "It's just another curve to me. I don't have much trouble with it."

TRUCK BYPASS

Background

The second countermeasure implemented in the Portland area was a truck by-pass at the Tigard Street interchange. Figure 59 shows a schematic of the interchange configuration, including the truck bypass. The bypass lane allows trucks to stay in the right-hand lane, exit onto a truck roadway (cars permitted also), and re-enter the traffic downstream of that interchange on the right-hand side. The mainlanes were built on a significant grade such that, without the truck roadway, larger vehicles were forced to climb a grade then weave across faster moving traffic entering the mainlanes to the right of trucks in the merge area. These speed differentials created operational as well as safety problems. This segment of Interstate 5 has three lanes in each direction. Traffic volumes along this stretch of Interstate 5, were 125,582 in 1988.

Several advance signs provide information to truck drivers. The first sign indicating the truck bypass is a large sign support in the median with the third entry on the sign providing the message "I-5 TRUCK LANE 1/4 MILE." The sign has white letters on a green background. The second sign approaching the truck bypass, also white on green, is a sign with the Interstate shield on the top line and the words "TRUCK LANE" on the second line supplemented by an arrow pointing upward to the right. The third sign is a regulatory sign using black letters on a white background mounted overhead with the message "ALL TRUCKS MUST USE TRUCK LANE." The fourth sign, also mounted overhead, has the Interstate shield on the first line, "TRUCK LANE" on the second line, and "3/4 MILE" on the third line with a downward arrow indicating the outside lane. The fifth sign is also overhead with the first line the Interstate shield and the second line "TRUCK LANE" with an arrow pointing upward and to the right. This white on green sign is placed just upstream of the location where the truck bypass exits the mainlanes.

Design drawings for this truck lane were not available, so the following dimensions are approximate. The bypass is a single lane until the ramp merge, with a 1.22-m (4-ft) inside shoulder and a 3-m (10-ft) outside shoulder. This segment is 0.5 to 0.6 km (0.3 to 0.4 mi) in length. The single lane truck bypass joins a two-lane entrance ramp which then merges with I-5 (see figure 59).

Implementation

Observations of trucks traveling northbound indicate nearly every truck uses the truck bypass. Regulatory signs require all trucks to use it, which means a citation could be issued when trucks did not use the truck lanes. Only one large truck out of several hundred observed did not use the bypass. This truck reduced its speed approximately 32 km/h (20 mi/h) negotiating the grade then moved over from the third lane to the outside lane just downstream of the interchange. This trucker had no problem moving over, but this was an unusual situation. In heavier traffic, this move would almost always be difficult.

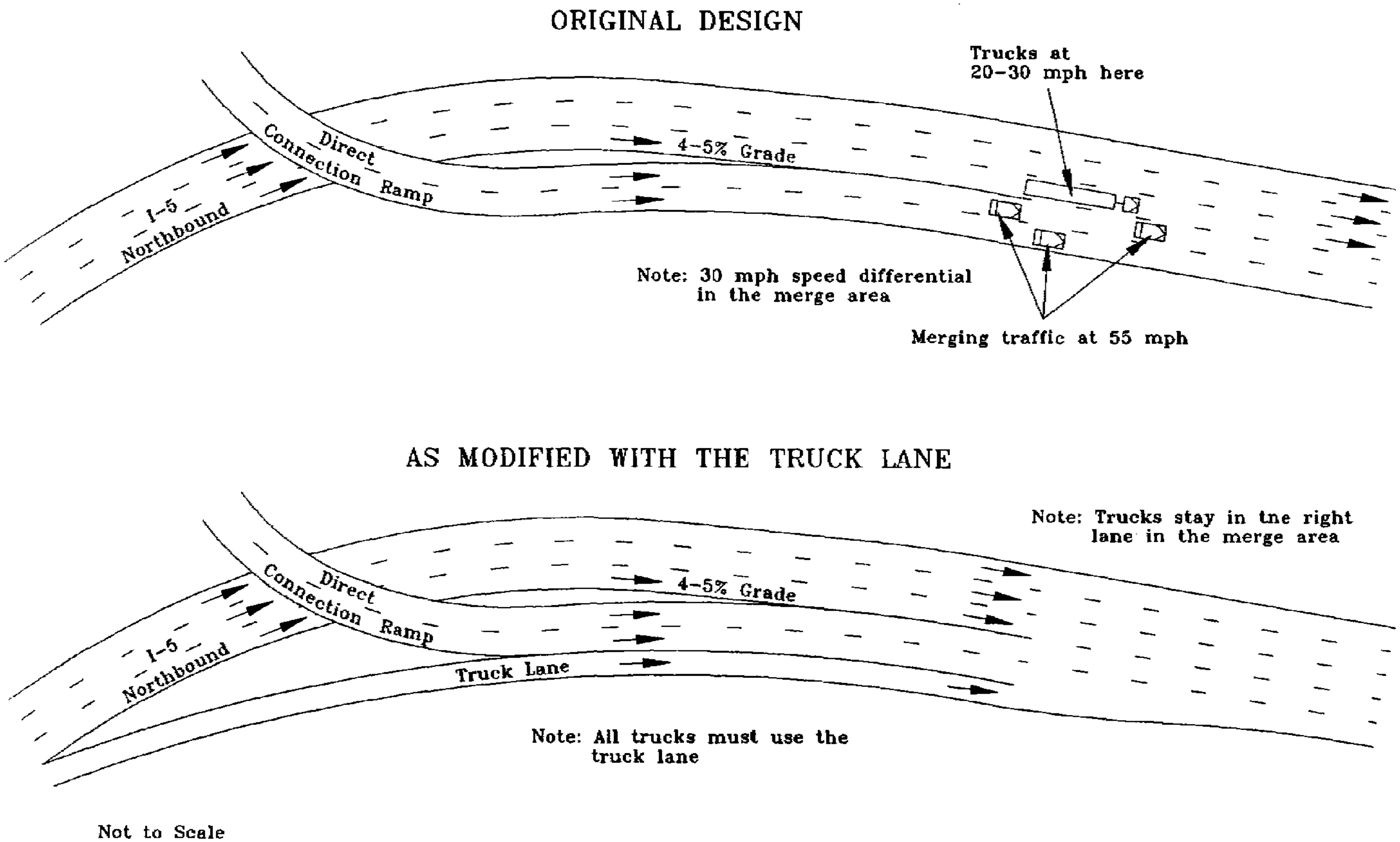


Figure 59. Schematic of truck bypass lane.

Effectiveness

The truck bypass lane is effective in removing trucks from the weaving situation that would be required without it. Only one large truck out of approximately 200 was observed to not use the bypass lanes. The truck slowed to approximately 32 km/h (20 mi/h) ascending the grade and changed from the third lane to the outside lane just downstream from the truck bypass merge.

No before and after accident data were available for the truck bypass lane. Removal of the slow-moving trucks from the complex weaving section has substantially eliminated the operational problem at this site, according to Oregon DOT officials. Truck speeds in the merge area now are typically 80 km/h (50 mi/h) with the truck lane where they had been 32 to 40 km/h (20 to 25 mi/h) without it.

The cost of the truck bypass was included in the cost of a major rehabilitation of I-5 south of Portland. No specific cost data for this portion of the project were available.

Truck Industry Views

Interviews at a nearby truck stop provided insight from truck drivers regarding the truck bypass lanes. Four responses are provided below of the interviewer's question, "What do you think of the truck lane at the Tigard Street interchange on I-5?" These are the same four drivers responding to questions about the Terwilliger Curve above. They drive for a van line which operates nationwide.

"It's great!"

"I agree, when you are loaded it really makes it easier to get through that section."

"Yes, it is very helpful."

"We use it all the time."

CHAPTER 14

SEATTLE, WASHINGTON CASE STUDY

OVERVIEW

Description of Area

Seattle is a major metropolitan center in the U.S. Pacific Northwest, and is the major employment center in Washington State. The city is located on Puget Sound, and the Port of Seattle is located on the natural harbor of Elliot Bay. Each year, the port serves more than 2,000 commercial vessels, and is linked to Interstate 5, the main route for Western Canada and the US West Coast. The city's freeway system is a circumferential ring system, which operates at or near capacity during peak periods. Figure 60 shows the freeway system in Seattle. The I-5 corridor which traverses central Seattle, has few feasible diversion routes for traffic within the metropolitan area. In addition to the lack of alternate routes, the freeway system within the Seattle metropolitan area requires several bridges to traverse Lake Washington. Methods to control the developing congestion on Seattle freeways has become an increasing concern for State and local transportation agencies in recent years.

Countermeasures Implemented

The truck accident countermeasure investigated in this study in the Seattle area is Incident Response Management. Seattle's equipment includes a high volume pump that can remove fuel from an overturned truck. This pump is not widely used elsewhere but has been effective for the Washington State Department of Transportation (WSDOT).

Accidents

Washington State DOT did not provide general accident information for the Seattle area.

Truck Industry Views

Truck driver interviews were conducted at a truck stop in the Seattle area. Most of these drivers were from the Seattle or Tacoma areas.

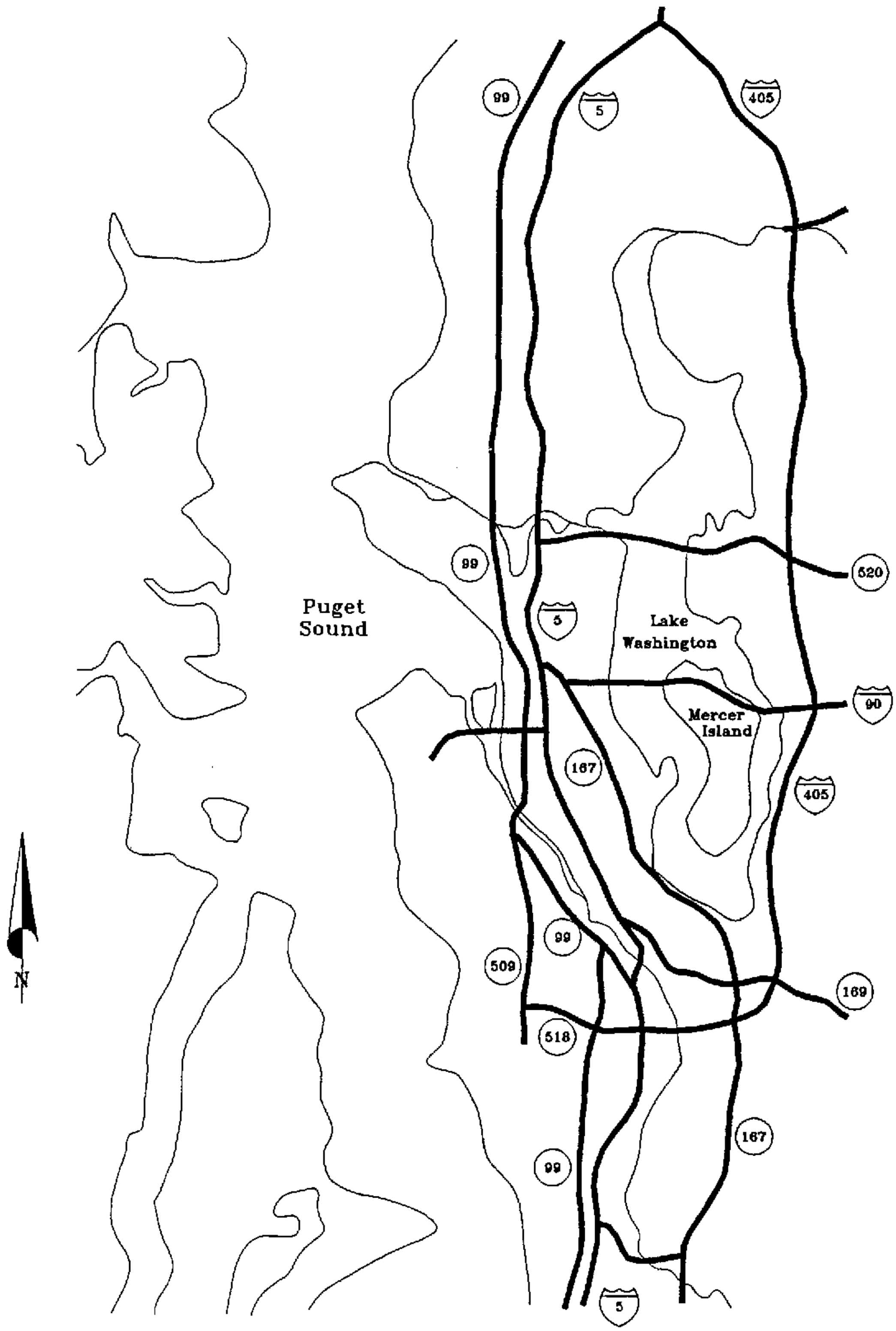


Figure 60. Seattle, Washington roadway system.

INCIDENT RESPONSE MANAGEMENT

Background

On February 1, 1990, the WSDOT began operating an incident response program covering several freeways in the Seattle area. The program established one full-time position, an incident response engineer, dedicated to organizing and operating the incident response program. When an incident occurs, the incident response engineer is the single point of contact for other incident response personnel in establishing traffic control and detours and oversees the activities of WSDOT personnel and private towing and cleanup companies. The incident response engineer also provides traffic information to operators of WSDOT's motorist information system at the Traffic Systems Management Center (TSMC) in Seattle.

WSDOT operates a system of closed-circuit television cameras (CCTV) and data collection stations on the urban freeway system throughout the Seattle area. This system is managed from the TSMC and helps detect and verify traffic incidents. In addition, WSDOT also provides direct feed to several area radio and television stations to allow them access in real time to the WSDOT CCTV output and a real time computer graphics interface that indicates congestion levels on major freeways. This allows the news media to provide timely and accurate traffic reports. In addition, variable-message signs and highway advisory radio provide information to the public on road conditions.

Implementation

Washington State Patrol (WSP) troopers call for the incident response team if they estimate at least one lane will be blocked for a period of at least 1 hour. During the first 13 months of operation, this criteria resulted in 191 calls from WSP. The geographic region selected for this service was the Seattle metropolitan area, largely due to the severe impacts that incident-related closures had on the motoring public. One major objective of the program was to have incident response personnel located throughout the area such that response times would be no more than 20 minutes.

Incident response trucks are four-wheel drive extended-cab pickups equipped with an enclosed utility box for storing and transporting emergency gear to an incident site. It is a self-contained command center with communications equipment, flood lights, and standard traffic control equipment such as signs and an arrow board which would be used to mitigate the effects of a major incident. The floodlights provide illumination for nighttime incidents by using a 4-million candlepower light system. In addition, the trucks carry a diesel pump system for unloading leaking diesel fuel tanks, equipment to handle a 380-l (100-gal) spill (sand and absorbent material), a backpack blower for quickly removing road debris, a 35-mm camera for documenting incident details, and a fusee dispenser to allow the operator to set up flare lines without having to leave the truck. The diesel pump, with a capacity of 417 l (110 gal) in 8 minutes, is sometimes used to pump diesel into another available truck at the scene instead of filling barrels to be disposed of later. As equipped, these WSDOT vehicles cost approximately $35,000, according to WSDOT sources.

WSDOT owns equipment for cleanup and clearance of incidents such as loaders, sand trucks, and street sweepers. Vehicle removal is typically handled by WSP using a rotation list of tow companies in the area. For large combination vehicles, WSDOT can call a privately owned, specialized heavy-duty recovery truck. This is a five-axle truck with a rotating boom able to upright overturned semitrailers and other equipment weighing up to 54 500 kg (120,000 lb). Because of its size and lifting capacity, this large tow truck can move a loaded tractor-trailer combination to the side of the road in as little as 20 minutes, according to WSDOT sources.

Effectiveness

The incident response strategies used in Seattle have reduced response and clearance time when freeway blockages occur. A study conducted at the University of Washington in the late 1980's praised the quickness of the incident response time in Seattle.[22] An average of 10 minutes transpires between an accident and the State trooper arriving on the scene. WSDOT's response time to an incident now averages 15 minutes, with an average 15 minutes more required to establish traffic control. Traffic control upstream of the queue provides motorists with information regarding the incident before actually arriving at the queue.

The incident response engineer documents the incident for WSDOT using reporting forms entered into a portable computer. Critical information related to personnel and equipment usage, and damage to WSDOT property, are recorded to determine the amount the responsible party must reimburse WSDOT. The WSDOT claims a near 100-percent recovery of costs associated with incidents, primarily because of the comprehensive documentation.

The authors state that while the short amount of time is impressive, the time factor is still very costly in terms of lost vehicle-hours. The authors provide recommendations for future incident management strategies in three broadly classified areas: (1) education and awareness, (2) resource and personnel allocations and (3) detection and reporting. The report also includes detailed discussions on two recent incident management strategies used in the Seattle area: incident response storage sites and accident investigation sites. According to WSDOT sources, the average freeway clearance time for large trucks is now 1 1/2 hours, compared to 5 to 7 hours without the incident response team. WSDOT's incident response engineer estimates that, in general, the incident response program reduces clearance time at an incident by as much as 1 or 2 hours. In addition, total roadway closures at major accident sites are now the exception, rather than the rule. In addition, the program has contributed to a positive public image of the WSDOT.

Finally, WSP has initiated a new procedure using electronic measuring equipment for collision investigation to save time at the scene. The use of this equipment has resulted in an average reduction of 50 minutes in the clearance time for major freeway incidents and has cut the number of personnel needed to perform the investigation.[23]

Truck Industry Views

Truck driver interviews were conducted at a truck stop in the Seattle area. Of the seven truck drivers interviewed, only one seemed to know anything regarding the incident response van. He responded that he had heard other truck drivers mention something about pumping diesel from an overturned combination vehicle into another truck at the scene. All the truckers knew something about emergency vehicles in general, but none claimed to know anything about Seattle's incident response team or the incident response trucks.

CHAPTER 15

TAMPA, FLORIDA CASE STUDY

OVERVIEW

Description of Area

The Howard Frankland Bridge (I-275), which runs generally east-west, connects Tampa with St. Petersburg across Tampa Bay (see figure 61). The bridge is approximately 5.0 km (3.1 mi) long and has four lanes. The grade is flat over much of the bridge, however, near the center, a 3-percent grade was designed to permit barge traffic below to clear the structure. The vertical curve at the crest of the grade is fairly short, but according to Florida Department of Transportation (FDOT) sources, this feature has not caused a concentration of accidents at that location on the bridge. Single solid white lines exist on the right side and on the lane line, while a solid yellow edge line is used on the left side. Motorists can legally cross the solid white lane line. Figure 62 is a view along the bridge.

Currently, there are no turn outs, shoulders, or other areas for disabled or damaged vehicles awaiting assistance on the bridge. Thus, any stopped vehicle blocks at least one traffic lane. The bridge has a current AADT of approximately 80,000 vpd with 5 percent trucks. For short periods during the day trucks account for 20 to 25 percent of the traffic stream. Off-peak traffic speeds are 88 to 97 km/h (55 to 60 mi/h), although operating speeds during peak periods tend to be erratic so that sudden speed changes are frequent.

I-275 near the bridge is an older, four lane divided roadway. The cross section evolved as two roadways approximately 8 m (26 ft) wide, and is presently divided by a concrete median barrier. Figure 63 shows the roadway and the Courtesy Bridge Patrol parked at the roadside.

Countermeasures Implemented

A courtesy Bridge Patrol on the Howard Frankland Bridge was the countermeasure investigated in Tampa, Florida. Two heavy duty wreckers are stationed, one at each end of the bridge, and move to the other end of the bridge on a 15-minute sweep interval. The goal of the patrol is to clear an incident as quickly as possible.

Accidents

A detailed summary of accidents was available for review only during the site visit with FDOT. A less detailed data base provided the accident information shown in table 33. This table shows truck-involved and total accidents which occurred on the bridge for a 5-year time period. Both total accidents and accidents which occurred during the patrol period are included. Average daily traffic and travel information are also included for the same years.

Table 33. Accident and travel summary for the Howard Frankland Bridge.

YEAR	AADT	MVM	ACCIDENTS			
			TRUCKS ONLY		ALL VEHICLES	
			PATROL PERIOD	ALL DAY	PATROL PERIOD	ALL DAY
1985	60,600	79.5	20	25	102	127
1986	71,300	85.9	12	13	92	97
1987	71,700	86.4	21	22	89	94
1988	74,400	89.6	48	49	126	128
1989	75,500	90.9	16	16	125	125

Source: Florida DOT

Truck Industry Views

No truck driver interviews were conducted because few truck operators in the immediate area have been directly impacted by the bridge patrol. FDOT personnel who administer the contract stated that the reason for requiring the larger tow trucks was for their capability in handling larger vehicles. However, in some extreme cases, these larger tow trucks are still not large enough. If a large truck is damaged beyond the towing capability of the courtesy patrol, additional specialized equipment is requested.

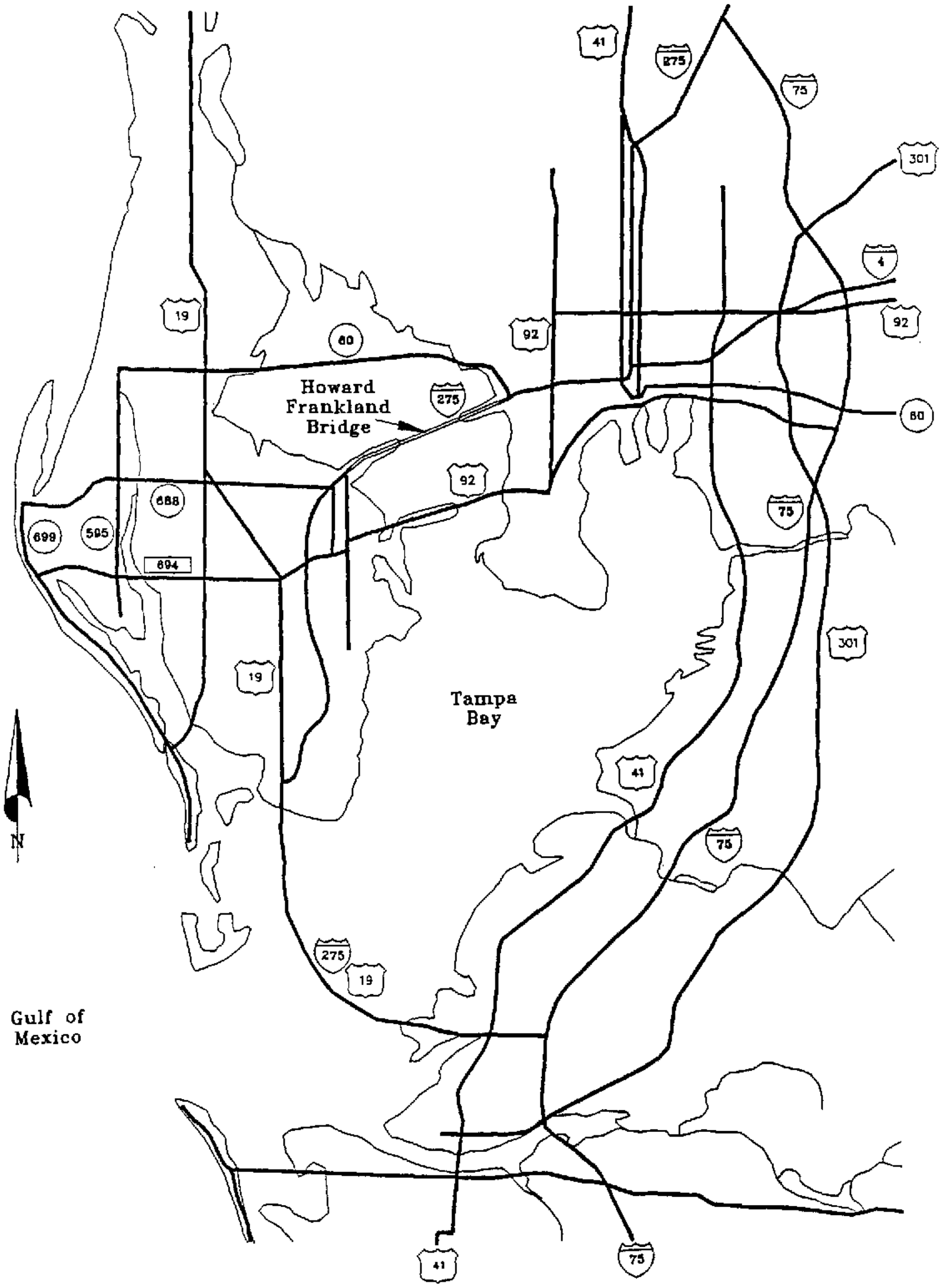


Figure 61. Tampa, Florida roadway system.

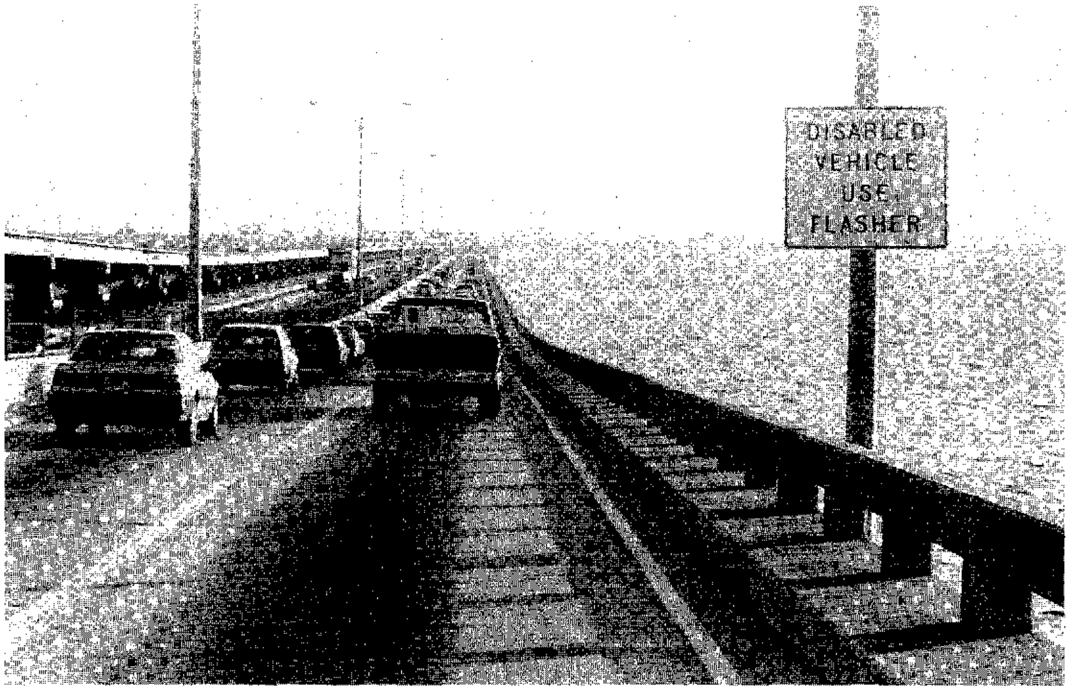


Figure 62. View along the Howard Frankland Bridge.

Figure 63. View along I-275 approaching the bridge.

INCIDENT RESPONSE MANAGEMENT

Background

The traffic control system which existed on the Howard Frankland Bridge prior to construction consisted primarily of loop detectors at approximately 0.4-km (1/4-mi) intervals. These were used to sense stalled vehicles. Input from the detection system was visually confirmed through eight television cameras placed along the bridge. Overhead lane control signals displaying the red "X" could be illuminated by the Florida Highway Patrol from a remote location (see figures 64 and 65). The illuminated red "X" was displayed on the approach signals to the incident site. Compliance with the red "X" vacate lane sign followed the national trend; it was reported to be very low.

An on-the-bridge control system is a component of a larger operating system involving another bridge across Tampa Bay. This system can divert traffic away from the Howard Frankland Bridge during partial or complete blockage. Rotating drum signs are still available on the approaches to the Howard Frankland Bridge, displaying either the regular routing or one of two alternate messages: 1) "ACCIDENT AHEAD EXPECT DELAY," or 2) "BRIDGE CLOSED FOLLOW I-5." With either of these two messages, the motorist is advised to follow a trail blazer symbol to an alternate bridge crossing. The northbound diversion is designated by a sign that has the white letter "N" against a black background, and a red background with the white letter "S" for the southbound diversion. These signs have the Interstate shield-shape, so to avoid confusion with Interstate Route Markers, the black and red backgrounds were chosen. Because the trail blazed route is not the fastest diversion route, many people switch to local streets to save time.

Implementation

A Courtesy Bridge Patrol was initiated on December 7, 1989 as a response to gubernatorial pressures. The patrol operates during peak periods Monday through Friday. Typical hours are 6 a.m. to 10 a.m. and 3 p.m. to 7 p.m. Two heavy duty wreckers (SU class vehicle up to 22 700 kg (50,000 lb gross weight) operate on a 15-minute sweep interval. The goal of the patrol is to clear an incident as quickly as possible.

Three formal systems were available prior to construction to alert personnel to an incident on the structure: 1) roadside call boxes, 2) incident detectors, and 3) a 911 emergency number for cellular phone equipped vehicles. A fourth, informal system involved using a CB radio. Detectors and call boxes have recently been removed from the old bridge because traffic is currently using the new bridge exclusively. A courtesy patrol operator stated that truckers are usually the first to report an incident on the bridge. Occasionally, the courtesy patrol vehicle will encounter a stalled vehicle on one of their sweeps before the CB radio

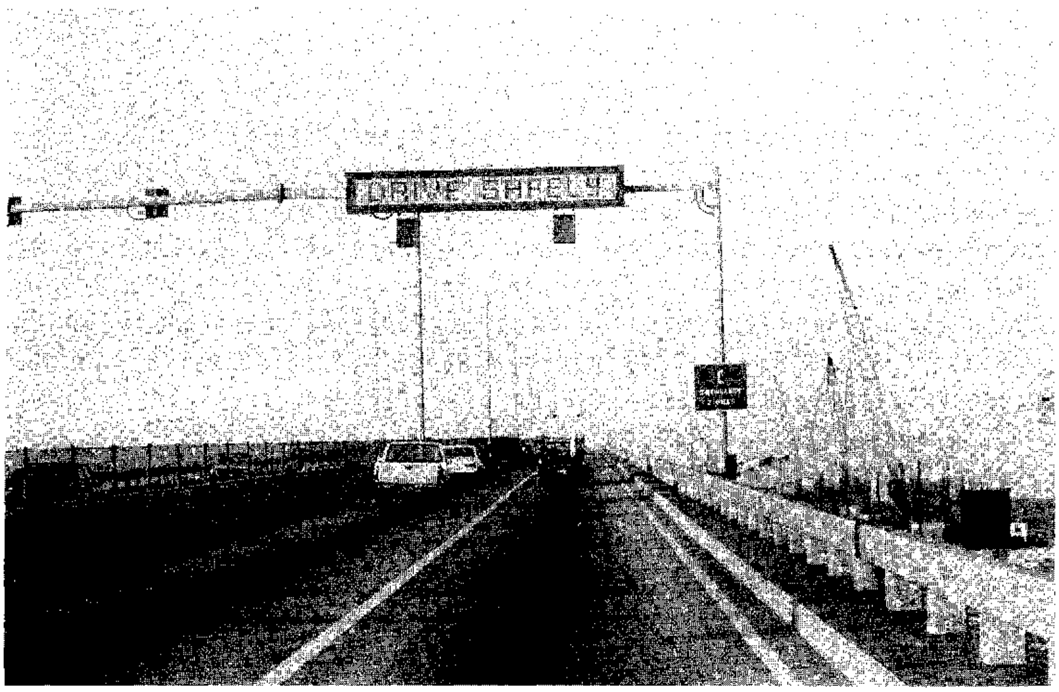


Figure 64. Overhead lane control signal and emergency call box sign.

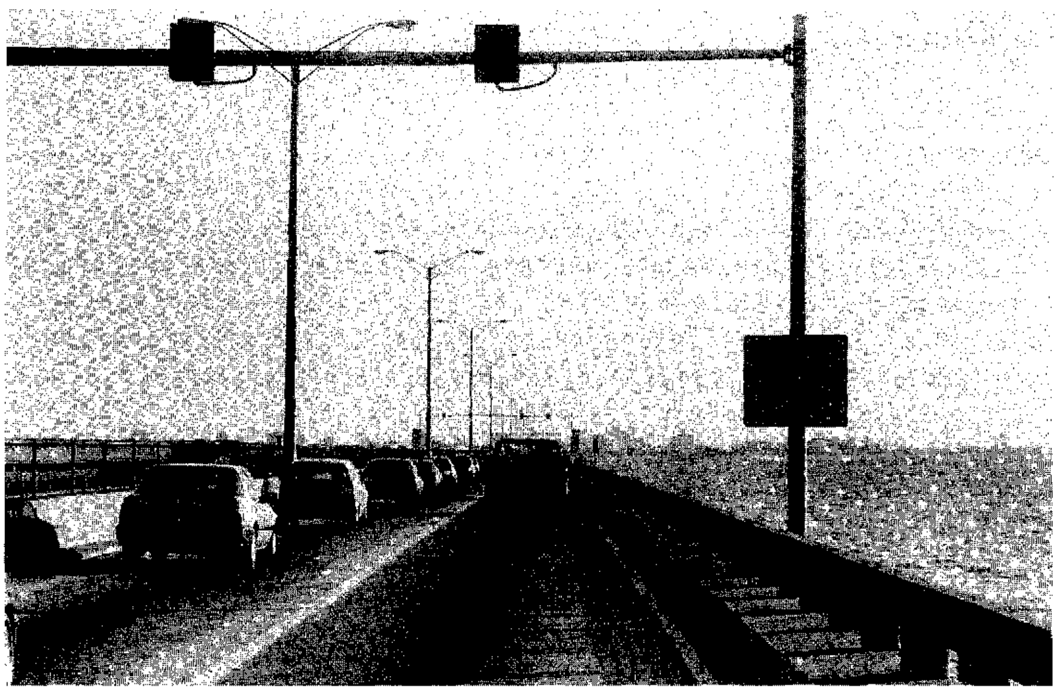


Figure 65. Overhead lane control signals and regulatory sign.

reports it. The other systems are not used as frequently. There are no data to document the frequency of incidents reported by the various communications systems.

Another significant service provided by the courtesy patrol is removing debris from the road. Examples of cleared debris include timber, power tools, camping and picnicking equipment, and sewage sludge. Small items are simply removed, while large loads, such as the sewage sludge, involve the courtesy patrol working with the FDOT maintenance personnel to clean up the bridge.

Effectiveness

According to a regression analysis of accident data performed by FDOT, there is a significant decrease in the slope of nonpatrol accident trend as compared to the accident trend during the courtesy patrol period. The nonpatrol accidents on the bridge are increasing with time (beta of 0.0243) at a slope of 9.70 and R^2 of 0.71. During the patrol period, the analysis shows a slope of 6.10 which is significant (beta on slope of 0.0243) with an R^2 of 0.86. The difference in the slopes of the two periods suggests that the rate of increase in accidents is lower during the period when the courtesy patrol is active as compared to the non patrol period. The analysis concludes that, on the average, the increase in accidents per year is 3.6 accidents less due to the courtesy patrol. It should be noted that this analysis does not compare accident *rates*, because FDOT did not have accurate traffic counts for some time periods during the analysis period.

The contract price for the bridge patrol in 1991 was $141,440 for a period of 12 months. According to FDOT information, this means a cost of $433 per incident cleared by the bridge patrol. No additional start-up or special equipment costs were involved. The benefits of this service are difficult to quantify, but public response to the courtesy patrols is very positive. It is believed to be one of the most effective public relations elements of the Tampa District's operations. To a large degree, this is the result of all the courtesy patrol services being free of charge. This includes furnishing small amounts of fuel to drivers out of gas or assistance in tire changing. Each person assisted by the Courtesy Patrol is given a comment card to fill out and mail back to the Department. The contract contains stiff penalties for contractors who charge for services or even accept a gratuity for services rendered. Response times for a 2-month period for the bridge patrol are shown by figure 66.

The Florida DOT operating personnel indicated that the only deficiency of the system is the short hours of operation. A significant number of incidents occur during the 10 a.m. to 4 p.m. time period. Otherwise, FDOT personnel are very pleased with the patrol.

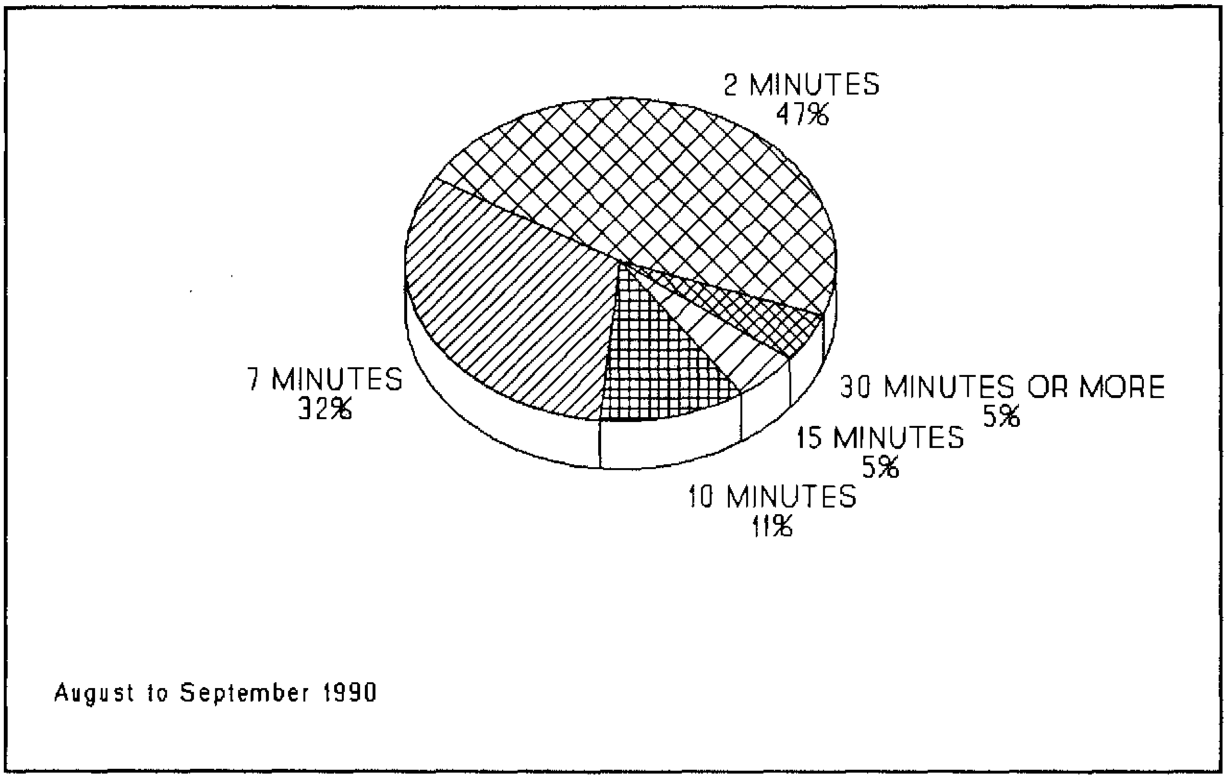


Figure 66. Response time of Howard Frankland Bridge courtesy patrol.

Truck Industry Views

No truck driver interviews were conducted because few truck operators in the immediate area had been directly impacted by the bridge patrol. FDOT personnel who administer the contract stated that the reason for requiring the larger tow trucks was for their capability in handling larger vehicles. However, in some extreme cases, these larger tow trucks are still not large enough. If a large truck is damaged beyond the towing capability of the courtesy patrol, additional specialized equipment is requested.

CHAPTER 16

ANNOTATED BIBLIOGRAPHY

INTRODUCTION

The Annotated Bibliography includes literature sources which specifically address truck accident countermeasures appropriate for use on high volume urban freeways. The format includes the objectives, research approach, research results, and critical analysis. Also, for most of the references, a countermeasure summary table is provided to address the following topics: accident types the countermeasure is designed to reduce, countermeasure benefits, negative results, perceptions of the countermeasure, quality and quantity of data base, information for evaluation, and highway type. Reviewers were careful to show table entries only when the author directly addresses these topics; those which were implied or which were subject to interpretation were excluded.

Cambridge Systematics, Inc., JHK & Associates, Roberts Associates, Inc., and Sydec, Inc., Urban Freeway Gridlock Study: Summary Report. California Department of Transportation, 1988.

Objectives:

- Assess the impacts of large trucks on peak-period freeway congestion.
- Evaluate the effects of freeway and traffic management techniques on congestion reduction.
- Identify the economic impact of freeway and traffic management techniques.

Research Approach:

- Review available data on freeway/truck conditions.
- Review literature on freeway/truck safety and operating characteristics.
- Three areas--Los Angeles, San Francisco, and San Diego--were identified as critically-congested areas and selected for detailed case study.
- Traffic flows at 40 freeway sites in the Los Angeles area, 25 sites in the San Francisco area and 13 sites in the San Diego area were analyzed to determine the volume and type of trucks on the freeways at peak periods.
- Four management techniques were selected for analyses--traffic management, incident management, night shipping and receiving, and peak-period truck bans.
- Legal ramifications concerning implementation of the four selected strategies were reviewed.
- Public officials, industry associations, motor carriers, and shippers and receivers were interviewed to evaluate the impact of congestion on freeway and trucking operations, and the direct economic impact of implementation of the selected strategies.
- Indirect economic impact of the implementation of the strategies on local and state economies was estimated.

Research Results:

- The volume of large trucks on freeways does not have an inordinate impact on peak period congestion, however truck-involved accidents and incidents do have a significant impact on freeway congestion.

- Large trucks comprise 4 percent of all vehicles during the morning peak, 2.5 percent during the evening peak, and 5.5 percent during the midday.

- A traffic management program could reduce freeway congestion, provide air quality benefits and significantly improve safety. The program would require adding continuous-merge lanes at critical interchanges, redesigning high-accident ramps, providing traffic condition information to drivers, regulating speed, and enforcing safe truck operations.

- An incident management program that could reduce congestion and delay from truck-involved accidents and incidents is feasible and should be implemented in conjunction with a traffic management program.

- Night shipping and receiving would modestly reduce peak-period congestion and may improve air quality by reducing truck emissions during daylight hours.

- Peak-period truck bans could reduce congestion on core freeways, however, congestion would increase on parallel arterial routes.

Critical Analysis:

- Large trucks were defined as having 3 or more axles and a gross vehicle weight rating of 11 800 kg (26,000 lb) or more.

Table 34. Countermeasure table for Cambridge Systematics.

Countermeasure	Traffic Management Program	Incident Management Program	Night Shipping and Receiving	Peak-Period Truck Ban
Accident Types that Countermeasure was Designed to Reduce	All	Secondary accidents that occur as a result of an initial accident.	All	All
Countermeasure Benefits (Expected and Actual)	Reduce congestion. Smoother traffic flow and increased volume of peak hour traffic. Modest air quality benefits from smoother traffic flow.	Reduce congestion and delay by significantly reducing the time required to locate and clear truck involved accidents and incidents.	Reduce congestion. Improve air quality by reducing daytime emissions.	Temporary reduction of congestion for 6 weeks to 6 months.
Negative Results			Cost prohibitive for small business owners. Additional cost to carriers and shippers/receivers would increase cost of goods.	Probable increased truck emissions due to lower operating speeds on arterials. Congestion would not be significantly decreased. Additional costs to carriers could increase cost of goods.
Perceptions of the Countermeasure	Would benefit all freeway users.	Addresses public concerns about truck accidents/incidents.	Would only work with industry support. Possible interference with interstate commerce.	Possible interference with interstate commerce. Creates a more homogeneous traffic during peak periods.
Quantity and Quality of Data Base	Surveys and statistical analysis.	Surveys and statistical analysis.	Surveys and statistical analysis.	Surveys and statistical analysis.
Information for Evaluation	Requires funds for additional lane, truck restrictions, and improved entrance and exit ramps. Expansion of existing programs.	Requires funds for equipment and personnel.	Possible legal challenges based on interference with interstate commerce.	Requires safety justification and FHWA approval. Approval of ban by FHWA unlikely.
Highway Type	Freeway	Freeway	Freeway	Freeway

Cambridge Systematics, Inc. in association with JHK & Associates, Transmode Consultants, Inc, and Sydec, Inc., Incident Management Study. Trucking Research Institute of the ATA Foundation, Inc., 1990.

Objectives:

- To provide an overview of the need for incident management in metropolitan areas.
- To present five case studies of metropolitan areas which currently employ incident management procedures.

Research Approach:

- Interview State police, State Departments of Transportation, City police, City Departments of Transportation, Incident Management Program Managers, and the Automobile Association clubs in identified cities.
- Select two established programs -- Chicago and Los Angeles -- and two relatively new programs -- Fort Worth and Minneapolis -- and a program in New York/New Jersey (TRANSCOM) for its innovative organizational structure.

Research Results:

- A comprehensive overview of the need for incident management in metropolitan areas. The cyclic daily congestion already present in these areas is exacerbated by incidents. Incidents are defined as vehicle accidents and breakdowns.
- A profile of the types of reported incidents. For example, 10 percent are accidents and 80 percent are disablements. The location (on shoulder or blocking traffic lanes) and duration (in minutes and vehicle-hours-delay) are also summarized.
- The elements of incident management are described: detection, response, clearance, and recovery. An exhaustive list of existing area-wide incident management systems is provided, including specifics on the means of detection and response.
- Case studies include comprehensive details on the programs in place, including evolution, organization, equipment, personnel training, costs, funding, and benefits.
- Continued funding is dependent on the support of the community.
- Cooperation among local authorities is necessary for a successful program and funding at the State and Federal levels is sometimes required. The TRANSCOM program is an example of a comprehensive system involving 14 member agencies.

- Reasons for the difficulty of developing successful incident management programs are: 1) the lack of a clear mandate, 2) conflicting goals of the agencies involved, and 3) costs and benefits are not well understood. Recommendations include State and Federal initiatives to get programs established, as well as full support of the motor carrier industry.

Critical Analysis

- The report is well organized, well presented, and comprehensive.
- Evaluating the benefits of incident management programs is not straightforward. Dollar figures are necessarily gross estimates.
- This report would be very beneficial to a community considering implementing an incident management program.

An Operational Evaluation of Truck Speeds on Interstate Highways. Department of Civil Engineering, University of Maryland, February, 1974.

Objectives:

- To determine the proportion of trucks that are in compliance with existing speed limits.
- To develop and test a procedure for comparing truck speeds on particular sections of highway with accident rates on those highway sections.
- To determine the operational impact of modifying the existing legislation in Maryland which establishes a differential speed limit (DSL) for trucks on Interstates.

Research Approach:

- A literature review was conducted.
- Eighty-four study sites were identified based on posted speed limits, number of accidents at the location, geometric design, and operational characteristics.
- Four sets of data--speed, traffic volume, accidents, and existing geometrics -- were collected for each study site.
- Traffic volume, design plans for selected routes, and accident data were obtained from the Maryland State Highway Administration. Accident data for 1970 and 1971 were used.
- Speed data for sites were obtained from speed samples collected at each site. The sample size was 200 vehicles at each site; only "free flow" conditions were evaluated.
- Study sites were chosen to include locations with and without a truck differential speed limit and a broad scope of geometric features commonly found on Interstate facilities.
- No sites were chosen on toll facilities or near major construction sites.
- Sites with high truck accident rates were chosen if they met other site criteria.

Research Results:

- There is poor compliance with posted speed limits on limited access highways.
- The level of compliance for trucks depends on the geometric design of the road and the existence of a DSL.
- No consistent relationship could be found among speed parameters and accident rates.

- A decrease in trucks involved in rear-end collisions was noted at locations with higher operating speeds. Increasing truck speeds and effectively removing the DSL would reduce the truck accident rate.

- Excessive speed or speed too fast for conditions was cited as a probable cause in approximately 20 percent of the truck-involved accidents, this is slightly less than the value reported for all accidents.

- Accidents which occur at higher speeds are more severe.

- Highway design and operational features should be considered in the establishment of a speed limit.

Table 35. Countermeasure table for the University of Maryland.

Countermeasure	Differential Speed Limit (DSL) DSL attempts to compensate for trucks needing greater stopping distances.
Accident Types that Countermeasure was Designed to Reduce	Trucks rear-ending other vehicles.
Countermeasure Benefits (Expected and Actual)	No consistent relationship could be found among speed parameters, accidents, and accident rates.
Negative Results	Rate of truck accident involvement decreased with higher truck speeds. Increased percentage of trucks exceeded the posted speed limit.
Perceptions of the Countermeasure	Truck drivers will travel at a perceived reasonable speed that is frequently in excess of the posted speed limit.
Quantity and Quality of the Data Base	Study based on 84 sites with a speed sample size of 200 vehicles at each site. Accident data was based on a 2-year period.
Information for Evaluation	Nighttime driving hazards were not considered in recommendations.
Highway Type	Interstate

Ervin, R., Barnes, M., MacAdam, C. and Scott, R., Impact of Specific Geometric Features on Truck Operations and Safety at Interchanges. Volume I - Technical Report, Report Number FHWA/RD-86/057, Federal Highway Administration, Washington, DC, 1986.

Firestine, M., McGee, H. and Toeg, P., Improving Truck Safety at Iuterchanges. Research Report FHWA-IP-89-024, Federal Highway Administration, Washington, DC, 1989.

Objectives:

The objectives of the UMTRI (Ervin et al.) study were:

- Identify a number of individual ramps that were appropriate for the simulation of truck dynamic response.
- Identify the causes of truck accidents on ramps through the study of the ramp accident data.

The objectives of Firestine et al., study were:

- Provide highway engineers guidance in designing interchanges to reduce the likelihood of truck accidents.
- Improve highway safety.

Research Approach:

UMTRI used the following approach for their study:

- Reviewed accident report forms from all States, including their instructions and coding protocols to determine which States might have the capability of providing the needed information.
- Over 800 accident reports were reviewed and evaluated.
- Fifteen ramps with a history of accidents were selected for study. The ramps were located at 11 interchanges in 5 different States.
- Reviewed 52 (29 irrelevant to project) in-depth accident investigation reports of truck accidents that occurred at the selected ramps.
- Reviewed the conformance of the selected ramps with AASHTO design policies.

- Computer simulation (Phase IV model) was used to study truck dynamic response on the selected ramps.

Firestine et al. developed countermeasures based on the research conducted by UMTRI.
<u>Research Results:</u>

UMTRI research results concluded:

- Truck loss-of-control accidents on interchange ramps are predominately rollover and jackknife events (as opposed to collisions with off-road fixed objects).

- Jackknife accidents predominate at sites where inadequate pavement friction levels prevail during wet weather. Jackknife accidents also occur ahead of curves that appear to pose a threat of rollover to vehicles traveling near or above the advisory speed. Apparently, truck drivers apply excessive braking in an attempt to reduce speed before entering the curve, resulting in wheel lockup and jackknifing before the curve is reached.

- Rollover accidents occur at sites having high levels of friction demand, particularly if: (a) superelevation is largely undeveloped at the point of curvature; (b) there is an outside curb, close to the edge of the traveled way, on a curve; (c) a relatively demanding curve is placed at the bottom of a substantial downgrade; (d) the curve appears early in a ramp which is preceded by a short deceleration lane, or; (e) the curve is placed late in a compound curve which entails a sharp-flat-sharp sequence of curve radii.

- AASHTO policy for the geometric design of curves provides for virtually no margin of safety against rollover for some trucks.

- AASHTO policy for the length of deceleration lanes does not provide for the deceleration of truck combinations the same as treatment for passenger cars.

- The mismatch between the provided lengths of acceleration lanes and the acceleration length demands of loaded trucks may be prompting the truck driver to speed in the later portions of many interchange ramps in order to mitigate conflicts in merging. A final sharp curve before the exit terminal of a ramp may cause loss of control if this strategy is used.

- AASHTO's policy of accepting ramp downgrades as high as 8 percent may be ill-advised at sites on which a relatively sharp curve remains to be negotiated toward the bottom of the grade.

- Curve warning signs that are improperly selected or placed at an insufficient distance ahead of the curve, may be more critical for trucks than for cars.

Using the UMTRI research results, Firestine recommended the following countermeasures:

- Poor transition to superelevation creates high levels of side friction demand that increases the threat of rollover. A greater safety margin should be incorporated into formulations for side friction factors. Posted speed limits and advisory speeds should be reviewed for adequacy and signing at interchanges improved.

- Abrupt changes in compound curves place excessive demands on drivers while pushing the side friction factor to the point of rollover. Adequate signing is needed to alert drivers to changing curve conditions.

- Short deceleration lanes preceding a tight-radius exit do not allow drivers enough deceleration time to negotiate short-radius curves. Increasing deceleration lane length will accommodate truck drivers and reduce the hazard.

- Curbs placed on the outside of a ramp curve may be the tripping mechanism for rollover accidents. Removing the curb can eliminate the problem.

- Substantial downgrades before a tight ramp curve can lead to rollovers. Redesigning sites where accidents are common and placing special signs at these sites may alleviate the problem.

- Friction levels on a high-speed ramp may be dangerously lowered in certain conditions. Resurfacing ramps with high-friction overlays should reduce the hazards.

- Recognizing differences in margins of safety between cars and trucks is fundamental to safety.

Critical Analysis:

- The computer simulation model (Phase IV) developed by UMTRI represents the dynamic response of tractor-semitrailers along the selected ramps.

Table 36. Countermeasure table for Ervin et al.

Countermeasure	Speed Restrictions or Speed Advisories	Improved Signing	Longer Deceleration Lanes	Removal of Outside Curbs from Ramps
Accident Types that Countermeasure was Designed to Reduce	Rollovers, jackknifes, and loss of control accidents.	All	Rollovers and jackknifes	Rollovers
Countermeasure Benefits (Expected and Actual)	Reduces excessive lateral force acting on vehicle negotiating the curve. Allows driver more control of vehicle.	Provides drivers with warning of potential hazards, recommended speeds and actions.	Allows truck drivers time to safely decelerate to ramp speed. Eliminate overbraking.	Eliminates curb contact due to "high-speed offtracking" which may act as tripping mechanism for rollover.
Negative Results	Drivers may fail to heed posted advisories.			
Perceptions of the Countermeasure	Posted advisory speeds on loop-type connections are often too low and not realistic.	Signs must be properly placed and of sufficient quantity to be effective.	Current design guidelines on length of deceleration lanes do not consider truck capabilities.	
Quantity and Quality of the Data Base	Simulation based on 15 sites.	Simulation based on 15 sites.	Simulation based on 15 sites.	Simulation based on 15 sites.
Information for Evaluation	Study based on simulation.	Study based on simulation.	Study based on simulation.	Study based on simulation.
Highway Type	Freeway Interchanges	Freeway Interchanges	Freeway Interchanges	Freeway Interchanges

Table 36. Countermeasure table for Ervin et al. (Continued)

Countermeasure	Redesigning Substantial Downgrades Leading to Tight Ramp Curves	Increasing Friction Levels on High-Speed Ramps	Redesigning Ramps with High Truck Accident Rates	Incorporating Greater Safety Margins into Formulations for Side Friction Factors
Accident Types that Countermeasure was Designed to Reduce	All	All	All	Rollovers
Countermeasure Benefits (Expected and Actual)	Reduces naturally developed excessive speed that leads to rollovers or loss of control	Reduces hydroplaning-like loss of tire/pavement friction. Water drainage can be improved.	Reduces accidents due to shortcomings in design guidelines. Increased highway safety.	Better transition to superelevation. Increase safety margins for trucks on curves. Curves are less sharp.
Negative Results		Lightly loaded trucks may have control problems where pavement friction quality is deficient.		Increases cost of ramps substantially.
Perceptions of the Countermeasure	Downgrades should be limited to 3 to 4 percent where truck and bus traffic is high.	Use of an independent measure of pavement texture depth to estimate friction levels on ramps is advisable.		
Quantity and Quality of the Data Base	Simulation based on 15 sites.	Simulation based on 15 sites.	Simulation based on 15 sites.	Simulation based on 15 sites.
Information for Evaluation	Study based on simulation.	Study based on simulation.	Study based on simulation.	Study based on simulation.
Highway Type	Freeway Interchanges	Freeway Interchanges	Freeway Interchanges	Freeway interchanges

Federal Highway Administration and Bureau of Motor Carrier Safety, Special Study: Commercial Vehicles in Collisions Involving Vehicles Parked or Stopped on Highway Shoulders. Department of Transportation, Washington, D.C., 1977.

Objectives:

- Evaluate the causes and results of vehicles colliding with vehicles parked on shoulders of Interstate and other highways.

- To assess the danger of nonemergency and negligent parking on highway and Interstate shoulders.

Research Approach:

- In depth accident investigation of 58 accidents of commercial motor carriers that involved shoulder parking.

Results:

- Of the 58 accidents investigated involving vehicles parked on shoulders, 47 of the accidents were on Interstate highways.

- Negligent and nonemergency parking by both commercial and noncommercial drivers were contributing factors in 21 percent of the accidents. Of the 58 vehicles parked on the shoulder 43 percent were commercial vehicles. The primary cause of the accident was driver fatigue, with 52 percent of the accidents occurring between 11:31 p.m. and 5:30 a.m. The primary accident type was rearend collision.

- Highway shoulders should be used for emergency situations only, and for minimal periods of time.

- There is a need for contrasts in the texture of highway shoulders from that of the traveled portion of the highway to the point of producing a "rumble effect" to alert dozing drivers. The contrasts would also induce safe recovery for reentry onto the traveled portion of the highway.

- Drivers should be made aware of rest areas and be encouraged to use their facilities.

- Pedestrians who alight from disabled vehicles and are not engaged in the repair of the vehicle should stand away from the traveled portion of the highway and shoulder.

Critical Analysis:

- There is no discussion of how accidents were selected. However, it appears that the selection was nonrandom, with the more serious accidents being more likely for investigation.
- The value of the information on the reason for the vehicle parking on the shoulder is limited due to unknown data.

Garber, Nicholas J. and Gadiraju, Ravi, The Effect of Truck Traffic Control Strategies on Traffic Flow and Safety on Multilane Highways. Report Number UVA/537363/CE90/101, School of Engineering and Applied Science, Department of Civil Engineering, University of Virginia, Charlottesville, VA, September 1989.

Objectives:

- To determine the speed-flow relationships for different traffic lanes at different locations.
- To investigate the relationship between congestion and accident rates on multilane highways.
- To determine the effect of truck speed and lane-use restrictions on speed distributions on different lanes and locations, as well as the flow distributions for different lanes.
- To determine the impact, if any, of certain speed and lane-use restrictions on the time headway of vehicles in different lanes and on accident characteristics.

Research Approach:

- A literature search was conducted.
- Nine test sites in Virginia were selected using the following criteria: ease of collecting traffic data; truck percentages within the range of 5 to 40 percent; a good representation of multilane highways; and availability of accident data.
- Traffic data, including individual vehicle spot speeds and volume counts, were collected at the test sites.
- Data on accidents for each site were obtained from the Virginia DOT and the Virginia Department of Motor Vehicles from 1985 to 1987.
- Using collected data, traffic flow relationships were developed. Vehicle behavior for each highway lane was modelled using SIMAN, a simulation software package.
- SIMAN was used to study the effects of implementing different strategies on multilane highways.

Research Results:

- Lower speed limits for trucks had no significant effect on the volume distribution of trucks and non-trucks among the different lanes of the multilane highway.

- 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 accidents.

- Restriction of trucks to the right lane decreased the vehicular headway in this lane.

- 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 accidents on the right lane.

Critical Analysis:

- Data required for a before-and-after analysis of sites at which one or more truck strategies had been implemented was not available and thus, simulation techniques were used.

- The simulation software package SIMAN was used to model vehicle behavior for each lane, and the model logic was tested using the collected speed and volume data.

Table 37. Countermeasure table for Garber et al.

Countermeasure	Differential Speed Limit (DSL) DSL Attempts to Compensate for Trucks Needing Greater Stopping Distances.	Truck Lane-use Restriction Restriction of Trucks to Specific Lanes to Reduce Interaction Between Trucks and Other Vehicles.	Combination of DSL and Lane-use Restriction This Countermeasure Combines the Objectives of DSL and Lane Restriction.
Accident Types that Countermeasure was Designed to Reduce	Trucks rear-ending other vehicles.	All	All
Countermeasure Benefits (Expected and Actual)			
Negative Results	Increases the propensity for certain accidents, such as passenger cars rear-ending trucks.	Slight increase in right lane accidents. Decreased vehicular headway identified in right lane. A "barrier effect" created increasing the difficulty for entering and exiting the highway.	Results are the same as those for truck lane-use restriction and DSL.
Perceptions of the Countermeasure	Does not alter the distribution of trucks. Does not alter the congestion level on multilane highways. Affects the operation of trucks.	Congestion level in right lane increased. Does not alter the speed distribution in other lanes.	Vehicle speeds do not follow normal distribution.
Quantity and Quality of Data Base	Simulation based on 9 test sites.	Simulation based on 9 test sites.	Simulation based on 9 test sites.
Information for Evaluation	Study based on simulation.	Study based on simulation.	Study based on simulation.
Highway Type	Interstate and associated arterials.	Interstate and associated arterials.	Interstate and associated arterials.

Hanscom, Fred R., "Operational Effectiveness of Three Truck Lane Restrictions," Presented at the 69th Annual Meeting of the Transportation Research Board, Washington, D.C., 1990.

Objectives:

- Address the operational effectiveness of restricting trucks from designated lanes on a multilane roadway.

- The lane restriction effectiveness is primarily evaluated by the voluntary truck compliance to the imposed restrictions.

- Additional effectiveness measures include: traffic congestion as determined from speeds and platooning behaviors for vehicles following trucks, and deferential speeds between the restricted and adjacent traffic lanes.

Research Approach:

- The applied study approach used was a before-after study (with matched control sites) of three locations. Two of these sites had three lanes and the remaining site had two lanes.

- Restricted sites were paired with geometrically-matched, non-restricted sections of the same highway.

- Data collection was conducted on weekdays and was controlled for time-of-day match between "before"and "after" conditions.

- The following measures of operational effectiveness were used to evaluate the truck lane restrictions: truck lane occupancy, delay to following vehicles, proportion of trucks impeding followers, and adjacent lane speed differential.

Research Results:

- Favorable truck compliance effects were evident at all three locations.

- Violation rates were higher at the two-lane site (10.2 percent as opposed to 0.9 and 5.7 percent at the three-lane sites), as a result of increased truck concentrations due to restricting trucks to a single lane.

- The restriction at the three-lane sites achieved the intended goal of reducing overall congestion.

- An adverse flow effect of reduced speeds of impeded vehicles following trucks was observed at the two-lane restriction site.

- No speed changes were observed in all-vehicle speed comparisons, to indicate increased differential speeds occurring between the restricted and adjacent lanes.

Critical Analysis:

- The study sites all had an AADT of less than 100,000 vehicles per day. One study site had an AADT of only 4,478 vehicles per day.
- Two of the study sites were fringe-area urban sites near Chicago, and the remaining site was in rural Wisconsin.
- Large volume differences existed at the two three-lane locations, both between the before and after periods and between the test and control sites, causing difficulty evaluating reasons for observed differences.
- Observed traffic parameters although statistically significant were not practically significant.

Table 38. Countermeasure table for Hanscom

Countermeasure	Truck Lane Use Restrictions
Accident Types that Countermeasure was Designed to Reduce	All
Countermeasure Benefits (Expected and Actual)	Reduced traffic congestion resulting from fewer trucks impeding vehicles and shorter following queue lengths. No increases of differential speeds between the restricted and adjacent lanes were observed.
Negative Results	Reduced speeds of impeded vehicles following trucks at the two-lane site.
Perceptions of the Countermeasure	
Quality and Quantity of the Data Base	Study sites had AADT's of less than 100,000 and were located in urban fringe and rural areas.
Information for Evaluation	Study sites had AADT's of less than 100,000. Compliance of lane restriction was voluntary.
Highway Type	Interstate, urban and rural mix.

Holder, R.W., Christiansen, D.L., Fuhs, C.A. and Dresser, G.B., Truck Utilization of the I-45N Contraflow Lane in Houston--A Feasibility Study. Research Report 205-6, Texas Transportation Institute, College Station, TX, 1986.

Objectives:

- To investigate the possibility of trucks as a potential user of a proposed contraflow lane on the North Freeway (I-45) in Houston.
- Determine the capacity of the contraflow lane.
- Determine the impact truck usage of the lane would have on the mixed-flow lanes and the contraflow lane.
- Investigate the safety aspects of truck usage of a contraflow lane.

Research Approach:

- Interviews with managers of nine major truck terminals in Houston.
- Collection of data pertaining to peak period traffic operations on the North Freeway to determine amount and type of truck traffic. Data collected included traffic volumes, traffic speeds, vehicle occupancy, and classification counts.

Research Results:

- Vehicular capacity of the contraflow lane is more than adequate to accommodate trucks.
- Although capacity in the lane would be available, very few trucks would choose to use the lane.
- Improved safety could only be achieved if all trucks using the North Freeway were to use the contraflow lane.
- Tractor-trailer trucks constitute only about 2 percent of the total traffic stream inside Loop I-610 and less than 3 percent of the total traffic outside the loop for a total of approximately 4 percent of all traffic during peak periods. Therefore, little benefit would accrue to general traffic through their removal from normal peak-period lanes.

Table 39. Countermeasure table for Holder et al.

Countermeasure	Truck Usage of Contraflow Lane
Accident Types that Countermeasure was Designed to Reduce	All
Countermeasure Benefits (Expected and Actual)	Reduce congestion of mixed-flow lanes by removal of trucks. Trucks are highly visible thus allowing opposing traffic to keep on-coming contraflow vehicles in sight at all times. The percentage of vehicles in the peak period traffic flow is low (4 percent of total traffic).
Negative Results	Few trucks would choose to use the contraflow lane. Trucks comprise approximately 4 percent of total traffic during peak-periods, therefore, their removal from normal peak-period lanes would be of little benefit to general traffic.
Perceptions of the Countermeasure	
Quantity and Quality of the Data Base	Scope of study limited to North Freeway (I-45) in Houston.
Information for Evaluation	
Highway Type	Freeway

Stokes, R.W. and Albert S., Preliminary Assessment of the Feasibility of an Exclusive Truck Facility for Beaumont-Houston Corridor. Research Report FHWA/TX-86/393-2, Texas Transportation Institute, College Station, TX, 1986.

Lamkin, J.T., and McCasland, W.R., The Feasibility of Exclusive Truck Lanes for the Houston-Beaumont Corridor. Research Report 393-3F, Texas Transportation Institute, College Station, TX, 1986.

Objectives:

Stokes and Albert's objective was:

- To examine the following general truck facility options for the Beaumont-Houston corridor, including: construction of an exclusive truck facility within the existing I-10E right-of-way; construction of an exclusive truck facility immediately adjacent to the I-10E freeway outside the existing right-of-way; or construction of an exclusive truck facility on, or immediately adjacent to, an existing roadway which parallels I-10E (e.g., US 90).

Lamkin and McCasland's objectives were:

- To determine the economic feasibility, safety aspects and design criteria for providing separate facilities for trucks.

- To investigate the legal aspects, motor carrier issues and State agency issues concerning exclusive truck facilities.

Research Approach:

The Stokes and Albert research approach:

- Reviewed related research.

- All options were evaluated in terms of the following issues: physical and design requirements for upgrading existing facilities and/or constructing new facilities to accommodate high truck volumes; implementation issues such as costs, lead times, regulatory/legal problems; and impacts of the options on users and non-users of the facilities.

- Traffic volumes, accident data, median widths and proposed improvements for the selected study corridor (extending from I-610 in Houston to Beaumont) were collected and assessed.

The Lamkin and McCasland research approach included:

- Literature and related research review.
- Traffic volume, accident data, land use characteristics, and truck support facilities for the selected study corridor (extending from I-610 in Houston to Beaumont) were collected and assessed.
- Options for exclusive truck facilities (within the median of the freeway, within the right-of-way of the freeway, on a new right-of-way, and within the right-of-way of an adjacent roadway) were assessed.
- A "moving analysis" computer program was used to analyze individual segments of the study corridor.

Research Results:

Stokes and Albert's results were as follows:

- Measures directed toward improving truck operations and safety should be considered for implementation.
- The potential for an exclusive truck lane on I-10E to divert truck traffic from US90 should be investigated, and the legal and operational issues of such a diversion should be addressed.
- The most feasible alternative considered is an outside at-grade truck lane within the I-10E right-of-way. A number of physical, operational, legal, and economic issues however, must be investigated prior to making a final determination of what, if any, improvements should be considered for implementation.

Lamkin and McCasland's research results were:

- Although short sections of the I-10 right-of-way can geometrically accommodate an exclusive truck facility, major structures would be required to obtain continuous facilities.
- The preferred alternative is the construction of the exclusive truck facility within the freeway median.
- Traffic volumes (existing and future trends) do not warrant construction of an exclusive truck facility.

Table 40. Countermeasure table for Stokes et al.

Countermeasure	Exclusive Truck Lanes
Accident Types that Countermeasure was Designed to Reduce	All
Countermeasure Benefits (Expected and Actual)	Improving traffic safety and reducing conflicts by separating trucks from cars. Reduce maintenance costs. Smoother operation of traffic and reduction of overall weaving.
Negative Results	Possible legal problems by requiring trucks to use a separate facility. Potential operational problems (enforcement, interchanges and treatments).
Perceptions of the Countermeasure	
Quantity and Quality of the Data Base	
Information for Evaluation	Possible legal challenges. Expensive. Environmental impacts to nonusers.
Highway Type	Interstate

McCasland, William R. and Stokes, Robert W., "Truck Operations and Regulations on Urban Freeways." Research Report FHWA/TX-85/28+1F, Texas Transportation Institute, College Station, TX, 1984.

Objectives:

- Identify truck traffic characteristics and problems on urban freeways in Texas.
- Survey existing truck regulations being imposed by Federal, State, and local governments.
- Develop a comprehensive list of alternative truck regulations.
- Assess the impacts of these truck regulations on traffic operations, safety, the environment, and commerce.
- Evaluate driver-related factors influencing truck operations and safety.
- Identify possible test regulations for evaluation of one or more urban freeways in Texas.

Research Approach:

- A literature review was conducted for truck related problems and truck restrictions/regulations on urban freeways.
- A survey of State policies relating to truck restrictions/regulations on urban freeways was conducted.
- Six truck restrictions and regulatory practices were examined using information obtained from the literature review and survey of State policies.
- Truck usage of urban freeways was based on two truck studies conducted by TTI in 1983 on urban freeways in the Houston, San Antonio, and Dallas/Fort Worth areas.
- Truck operating speeds were based on a 1984 TTI study of off-peak period speeds conducted in Houston, and the 1982-1983 Houston Area Transportation Safety Association safety patrol and observation reports.
- Accident statistics were obtained from the State of Texas.

Research Results:

- Restriction of truck traffic to one mixed-flow lane would probably not improve freeway safety or operations based on associated constraints and limitations. Prohibition of truck traffic from the left lane would be acceptable for roadways of three or more lanes.

Trucks may be restricted to the two right lanes, except to pass on roadways with four or more lanes.

- Restriction of truck traffic based on time-of-day or peak periods would not contribute to improved safety, because truck traffic peaks do not coincide with typical commuter peaks.

- Speed restrictions of all vehicles or trucks only on urban freeways could improve safety and operations.

- Route restrictions would have little or no effect on freeway safety or operations, however, route restrictions could be beneficial in controlling transport of hazardous materials.

- Revisions in 1984 to the Texas driving statute affecting truck drivers, requiring that driving skill examinations be taken in the class of vehicle for which the license is being obtained, could substantially improve the safety of truck operations on urban freeways.

- Restrictions evaluated in this study would be difficult to enforce, with the possible exception of existing speed limits.

Critical Analysis:

- Forty-three States responded to the State policy survey. Comments on enforceability or effectiveness of truck restrictions and regulations were generally subjective opinions and were not based on quantitative analysis.

- All assessments and recommendations are based on findings of the literature review and State policy survey.

Table 41. Countermeasure table for McCasland et al.

Countermeasure	Lane Restrictions Separation of Trucks from all Other Vehicles on a Freeway	Time-of-day Restrictions Prohibiting Truck Traffic During Certain Critical Peak Periods	Speed Restrictions (Trucks and/or all Vehicles)
Accident Types that Countermeasure was Designed to Reduce	All	All	All
Countermeasure Benefits (Expected and Actual)			Lower speeds could improve safety and operations on freeways.
Negative Results	Freeway segments with lane drops would concentrate lane changes to a short section of freeway. Could accelerate pavement deterioration. Increase merging conflicts (if trucks are restricted to outside lane). Could reduce visibility of overhead signing (if trucks are restricted to outside lane).	Increase truck travel. Encourage truck use of roadways with lower design standards. Create a truck storage (parking) problem. Impact trucks that must travel during restricted periods.	
Perceptions of the Countermeasure	Congestion level in right lane could increase. Overall effects of lane-use restriction on freeway operations and safety are negligible.	Negligible impact on operating speeds and congestion because truck traffic peaks do not coincide with typical commuter peaks. Possible legal challenge as alleged interference with interstate commerce.	
Quantity and Quality of Data Base	Based on literature review and State policy survey.	Based on literature review and State policy survey.	Based on literature review and State policy survey.
Information for Evaluation	Difficult to enforce. Could accelerate pavement deterioration. Require establishment of transition areas before and after lane drops.	Difficult to enforce. Truck storage problems. Possible legal challenges.	Would require an extensive enforcement program. Would require the use of innovative detection, apprehension, and citation strategies.
Highway Type	Urban freeways	Urban freeways	Urban freeways

Table 41. Countermeasure table for McCasland et al. (Continued)

Countermeasure	Route Restrictions	Driver Licensing/Certification	Increased Enforcement of Existing Regulations
Accident Types that Countermeasure was Designed to Reduce	All	All	All
Countermeasure Benefits (Expected and Actual)	Applied to hazardous cargo carriers, the restriction minimizes risk to persons and property.	Driving skill more representative of class of license.	Would lead to increased compliance with existing traffic laws.
Negative Results	Efficient routing plan could not exclude freeways.	Short-term impacts are minimal. Dependent on application and enforcement of regulations.	Proof that increased compliance reduces accidents is inconclusive.
Perceptions of the Countermeasure	Increased cost to carrier operating in urban areas due to circuitous routes and service travel patterns. Negligible impact on safety and operations.	Long-term impacts could significantly impact safety and operations on freeways.	Could improve freeway safety and have a positive effect on traffic flow.
Quantity and Quality of the Data Base	Based on literature review and State policy survey.	Based on literature review and State policy survey.	Based on literature review and State policy survey.
Information for Evaluation	Increased carrier costs. Positive impact if applied to hazardous cargo carriers.	Requires strict application and enforcement of regulation.	Would require additional law enforcement personnel. Could require incorporation of enforcement requirements in design/redesign of freeways
Highway Type	Urban freeway	Urban freeway	Urban freeway

Reilly, W. F. and Haven, J., Large Truck Incidents on Freeways, ITE 1989 Compendium of Technical Papers.

Objectives:

- To assess the importance and possible impact of incident-management programs.
- Summarize the magnitude of traffic accidents and incidents in the major metropolitan areas of California.
- Identify the amount of delay being incurred by motorists as a result of incidents and accidents involving large trucks.
- Measure the amount of large truck traffic in California.

Research Approach:

- Traffic volumes, truck traffic volumes, peak period traffic flow and composition, and truck incidents were provided by Cambridge Systematics, Inc., based on data from the CALTRANS Urban Freeway Gridlock Study, and an Institute of Transportation Study by Recker et al., (1988).
- The San Diego area district of CALTRANS was selected for study, and incidents which occurred in a 24 month period were reviewed.

Research Results:

- Large trucks were defined as those with three or more axles and having 10 or more tires on the ground. For the three metropolitan areas (Los Angeles, San Francisco, and San Diego), a general pattern of large truck volumes occurs with 17 percent being the highest proportion of trucks at any of the freeway sites measured. The proportion of large trucks increases substantially during midday hours and is lowest during the evening peak period.
- Major incidents involving trucks (incidents that block two or more freeway lanes for longer than 2 hours) comprise 5 to 10 percent of all incidents and accidents. Eighty percent of all truck involved incidents occur during the daytime, and approximately 50 percent occur during the midday off-peak period. The average duration of a major incident is about 3 hours and 40 minutes (other incidents have a duration of about 1 hour).
- The annual economic cost of large truck incidents for CALTRANS districts (Los Angeles, Orange County, San Francisco, and San Diego) is estimated to be $200 million per year. Therefore, a 10 to 20 percent improvement in the response times and the time it takes to clear incidents from freeways could represent a $20 million annual savings in direct economic costs.

- Incident response teams for large truck incidents on freeways can have a positive impact on the consequences of incidents.

- Improvements in the following areas should be made: better interdistrict decision making to resolve incidents near boundaries; acquisition of equipment more suited to the field environment; more experienced personnel; more frequent coordination with the California Highway Patrol (CHP); involvement in educating local agencies and local response teams; use of aerial photos at the scene; improving tow truck operations and response time; and reviewing CHP policies concerning salvaging of loads.

Table 42. Countermeasure table for Reilly et al.

Countermeasure	Incident Response and Management Teams
Accident Types that Countermeasure was Designed to Reduce	Secondary accidents which result from congestion caused by the large truck incident.
Countermeasure Benefits (Expected and Actual)	Large annual savings from reducing direct economic costs caused by delays. Reduction of congestion and secondary accidents. Improve safety. Minimize road user costs.
Negative Results	
Perceptions of the Countermeasure	General public perception that the program may not be totally cost effective.
Quality and Quantity of the Data Base	Study based solely on CALTRANS program.
Information for Evaluation	Initial start up costs for program and equipment.
Highway Type	Urban Freeway

Sirisoponsilp, S., and Schonfeld, P., Impacts and Effectiveness of Freeway Truck Lane Restrictions. Transportation Studies Center, Maryland State Highway Administration, Baltimore, MD, 1988.

Objectives:

- Examine strategies used by various State highway agencies to restrict trucks from certain lanes, and the impact these restrictions have on traffic operation and safety.
- Assess the objectives and effectiveness of the restrictions, current restriction methods, enforcement practices, and procedures for evaluating restrictions.
- Predict the impact of lane restrictions.

Research Approach:

- Literature review
- Survey State highway agencies about their experience with truck lane restrictions.
- Evaluate the findings from the literature review and the survey using the following issues: purpose and effectiveness of truck lane restrictions, strategies used to restrict trucks, enforcement and compliance with the restrictions, and evaluation of the effectiveness of the restrictions.

Research Results:

- Although truck lane restrictions have been imposed in a number of States for many years, the effects on traffic operation and safety are still not well known, and their cost effectiveness is still in doubt until comprehensive studies are made.
- The goal of restricting the trucks' lane usage appears to have shifted from traffic operation to traffic safety. This stems from public perceptions of increased truck-related accidents.
- Truck lane restrictions have not been accepted as a potential solution to the congestion and accident problem on urban freeways.
- Additional research on truck lane restrictions is needed to understand the benefits and impacts of the restrictions.

Critical Analysis:

- State highway agency comments were based on judgement. Objective studies have not been conducted to evaluate the impact of truck lane restrictions.

- Many of the studies done are before and after studies that include all truck accidents, not just those expected to be influenced by the restrictions.

Virginia Department of Transportation, Assessment of Accidents on I-95 from Petersburg to the Woodrow Wilson Bridge with Truck Accident Update. Traffic Engineering Division, Unpublished Report, February 1989.

Objectives:

- Identify and compare traffic volume trends and accident histories of three segments of I-95, each with a different restriction against a control segment.
- Establish a baseline against which the safety impact of truck restrictions could be measured.
- Assess the safety of truck restrictions along the entire length of roadway encompassed by the study.

Research Approach:

- The case/control approach was used because of multiple determinants affecting the operational and safety aspects of I-95. Three segments consisting of a toll road, an HOV/shoulder travel lane operation, and a truck restriction segment, were compared with a control segment of roadway. The period of evaluation extended from 1985 to 1987.
- Traffic volumes and accident histories for each segment were obtained and analyzed.

Research Results:

- Truck accident rates have increased where restrictions have been enacted, and that rate tends to be lower where there are fewer restrictions.
- The severity of accidents in terms of fatalities and injuries did not change, although the total number of accidents increased.
- The majority of truck accidents occur on the right side of the road.
- Initial accident rate reductions on a truck restriction section may have been due to attentiveness to increased police enforcement during the early stages of the restriction.
- Truck restrictions for the three segments currently without truck lane restrictions (HOV operation, control area, and toll road sections of I-95) are not recommended.
- Present restrictions on the Beltway should be removed.

Table 43. Countermeasure table for VA DOT.

Countermeasure	Truck Lane Restrictions
Accident Types that Countermeasure was Designed to Reduce	All
Countermeasure Benefits (Expected and Actual)	Expected to reduce congestion and accidents.
Negative Results	Truck accident rates increased where travel was restricted. Majority of truck accidents occur on the right side of the road.
Perceptions of the Countermeasure	Political and public perception is that restricting trucks to right lanes make the highway safer.
Quantity and Quality of Data Base	Evaluation period 1985-1987. Updated through June 1988.
Information for Evaluation	Study was conducted on a freeway with a speed limit of 88 km/h (55 mi/h).
Highway Type	Interstate (6 and 8 lanes)

Virginia DOT, Traffic Engineering Division, Capital Beltway Safety Study with Truck Accident Update for 1988. Virginia DOT, Richmond, VA, June 1989.

Objectives:

- Describe and compare the frequency of truck accidents versus other vehicle accidents including selected accident characteristics of the Capital Beltway ramps and loops from 1985 to 1989.

- Provide information on the feasibility of existing incident management systems.

- Provide an update for the evaluation of the volumes, accident frequencies, and accident rates from 1985 to 1988 for the Capital Beltway study (014).

Research Approach:

- Conduct a field study of interchange ramp and loop geometrics to determine if these locations were properly posted with a maximum safe speed limit for the existing superelevation.

- Analyze accident frequency and characteristics to determine the interface between drivers, vehicle, and roadway conditions.

- Perform an exploratory evaluation of the Northern Virginia (NOVA) Freeway Management Team.

Research Results:

- For the period 1985 to 1987, 23 percent of the accidents on the Capital Beltway involved trucks, except for southbound I-95 where 37 percent of the accidents involved trucks. Accident rates increased for two consecutive years on southbound I-95 which has a truck lane restriction; it was recommended that the lane restriction be lifted.

- The four most prevalent factors in accidents 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 rearend collisions.

- Rearend collisions during the evening peak accounted for 19 percent of all accidents. Over half the accidents during the evening (51 percent) and morning (53 percent) peaks were rearend collisions while over 20 percent (27 and 21 percent, respectively) were sideswipes.

- Left hand entrances and exits on I-495 preclude the restriction of trucks from the median lane until appropriate roadway signing and geometrics are installed.

- Some of the posted maximum speeds for ramps and loops on the beltway exceeded the maximum safe speed determined from a ball-bank indicator. A field review was recommended for ramps and loops with posted maximum speeds which exceed a ball-bank reading of 10 degrees.

- The maximum safe speed for "unposted" ramps and loops should be determined and posted.

- A review of the length of weaving lanes between entrance and exit loops should be reviewed. While in most cases it is not feasible to lengthen these lanes, posting advanced reduction speed signs for exit vehicles is suggested.

- Accident prone areas of the Beltway should be skid-tested for tractor-trailers to determine whether special signing is needed.

- Vegetation should be selectively trimmed or removed to improve motorists' line of vision to other vehicles and to posted speed limit signs.

- Existing signs should be reviewed for proper placement relative to interchange approaches. A review of accident reports also indicated rearend collisions occurring due to queues related to inadequate signalization on adjoining thoroughfares. Existing signal phasing should be reviewed and/or adjusted to reduce queuing on ramps, loops, and weaving lanes.

- An operational plan for incident management is necessary to provide an efficient tool so that all agencies will know their roles should an incident occur. A working plan should be developed to set guidelines and objectives for those agencies that will be involved in incident management.

Virginia Department of Transportation, Traffic Engineering Division, Capital Beltway Truck/Tractor Trailer Restriction Study. Richmond, VA, February, 1987.

Objectives:

- Assess the impact of the truck restriction on the I-95 section of the Capital Beltway between I-395 and west of the Woodrow Wilson Bridge by comparing traffic volume, speed, and accident data prior to and during the restriction.

Research Approach:

- The following data were collected for 24 months prior to and periodically during the restriction: traffic volume and vehicle classification, accident history experience, and vehicle speeds.

- Each issue area (such as speed, road geometry, and accident data) was analyzed and then considered for its effect on operation and safety on the Beltway.

Research Results:

- The accident rate increased 13.8 percent during the restriction, with no change in fatal and injury accident severity. Traffic volume increased nearly 8 percent. The only significant change for the segment was the lane restriction.

- The accident rate for the section consisting of the I-95, I-495, and I-395 interchange was the primary contributor to the overall accident rate increase. The accident rate increase for the study section of roadway approaching the interchange was 75.9 percent and 16 percent for the study section leaving the interchange. It was found that accidents were redistributed by lane of occurrence, type of maneuver, and collision type during the restriction.

- The maintenance of the accident severity level along with various intangible benefits such as favorable public perception and continuity of the lane restriction with Maryland warrant the retention of the restriction.

Critical Analysis:

- The authors state that with a traffic volume increase, the normal expectation would be an increase in accident frequency, and severity would occur as the exposure increases if all other variables remain constant. Accident severity is not a function of volume.

Virginia Department of Highways and Transportation. "Capital Beltway Truck Trailer Restriction Study Final Report." Highway and Traffic Safety Division, Richmond, VA, 1985.

Objectives:

- Assess the impact of the truck lane restriction imposed on the I-95 section of Beltway between I-395 and west of the Woodrow Wilson Bridge by comparing traffic volume, speed, and accident data prior to and during the restriction.

Research Approach:

- Identify and evaluate the following data for the study area: traffic volumes, vehicle classifications, accident history, and speeds.

- Each variable was analyzed and evaluated for its effect on traffic safety and operations on the Beltway. These variables are: speed, road geometry, and accident data.

Research Results:

- The lane restriction resulted in a redistribution of trucks in the nonrestricted lanes while passenger vehicles using the left lanes increased slightly.

- The majority of users of the Beltway have indicated support of a truck-free lane.

- The specific findings of the study do not indicate significant reductions in the number of accidents along the restricted section of the Capital Beltway. The accident rate declined slightly with the restriction, and there was a 20-percent reduction in injury accident severity. It was thus recommended that the truck lane restriction be maintained.

Critical Analysis:

- The analysis was based on only 1 year of data prior to and during the restriction.

- The 20-percent reduction in accident severity is actually only a reduction of injury accidents by eight (41 versus 33). Property-damage only accidents increased during that time by nine accidents (60 versus 69). Therefore, the reduction is probably insignificant.

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