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16. Abstract

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METRIC CONVERSION FACTORS

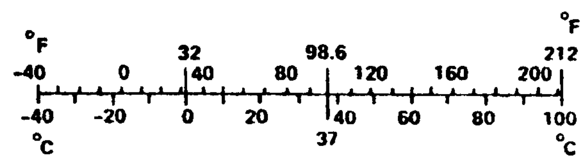
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



The Katy Freeway Authorized Vehicle Lane:
Evaluation of the First Year of Operation

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Research Report 339-6

Improving Urban Mobility Through Application
of High Occupancy Vehicle Priority Treatments
Research Study Number 2-10-84-339

Sponsored by

Texas State Department of Highways and Public Transportation
in Cooperation with the
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Federal Highway Administration

Texas Transportation Institute
The Texas A&M University System
College Station, Texas 77843

September 1986

ABSTRACT

This report presents a first year assessment of the performance of the high-occupancy vehicle facility which was implemented on the Katy Freeway (I-10W) in Houston, Texas. The facility is described, and data from the first year of operation are presented and analyzed. The data presented include park-and-ride demands, travel time changes, vehicle and passenger flow rates, accident experiences, and various transitway operating experiences. Before and after implementation comparisons are evaluated, and projected facility benefits and costs are provided.

SUMMARY

In April 1983, the Texas State Department of Highways and Public Transportation and the Metropolitan Transit Authority of Harris County took the first step towards providing the Houston urban area with an extensive network of barrier-separated high-occupancy vehicle facilities. The two organizations jointly began construction on a transitway located within the median of the Katy Freeway (I-10W), a major interstate highway serving travel demands in the western part of Houston and Harris County.

After a year and a half of construction, construction that resulted in only minimal operating and safety impacts, the first phase of the transitway became operational on October 29, 1984. Operating from near I-610 to near Gessner, a distance of 4.75 miles, this first phase of operation has since been extended an additional 1.7 miles to the west. Within a few weeks after the transitway (or Authorized Vehicle Lane (AVL) as it is locally known) became operational, approximately 78 buses and 160 vanpools were using the transitway each operating day. One year later, volumes have increased to 121 buses and 163 vanpools per day. Carpools initially were not permitted to use the transitway; however, beginning in April 1985, 4+ carpools were allowed to enter the facility on an experimental basis in order to address a problem arising from the facility's perceived underutilization. The 4+ requirement was subsequently reduced to 3+ in June 1985. Starting with only 10 vehicles per day, carpools have since increased to 102 vehicles/day as of October 1985. Overall, by October 1985, the Katy Transitway was carrying almost 390 vehicles and more than 6100 passengers per day. These volumes represent first year growth rates of 62% and 48% for vehicle and passenger volumes, respectively. Accompanying the growth in transitway demand was a growth in park-and-ride utilization. Park-and-ride demand in the corridor increased by 98% in the year after the transitway began operation.

As observed on other high-occupancy vehicle (HOV) projects nationwide, Katy Transitway vehicle volumes peak earlier and more sharply than mainlane traffic volumes. When the transitway first began operation, an interesting phenomenon occurred. Vanpool volumes peaked at two distinct 15-minute time

periods in both the morning and the afternoon operation. Since then, the morning double peaking characteristic has subsided, and the peak 15-minutes on the transitway occurs between 6:30 a.m. and 6:45 a.m. In the afternoon, the double peaking persists with the dominant peak occurring between 4:30 p.m. and 4:45 p.m.

Comparative travel time studies performed on the freeway mainlanes as well as the transitway route have indicated that transitway vehicles are saving, on average, from 4 to 7 minutes in the morning (Gessner access and West Belt access respectively) and from 6 to 8 minutes in the afternoon. Further, these studies indicate that, during a typical two-hour peak period, the average transitway users could save approximately 8 minutes per trip between SH 6 and the S.P.R.R. overpass once the transitway is extended to SH 6 in early 1987.

Despite a few problems, the Katy Transitway has been operating smoothly. Less than 2 vehicles become disabled within the transitway each month, and less than 25% of these vehicles require towing. Overall, only about 15-minutes have been needed to detect and to remove a disabled vehicle. The transitway has been shut down completely only twice in its first year of operation -- both times because of major accidents on the freeway mainlanes.

The automated surveillance, communication and control (SC&C) system for the Katy Transitway is designed to enhance the transitway's operating efficiency and safety. The complete SC&C system will provide traffic control, user communication, and incident management capabilities for the operation of the Katy Transitway. Currently, all signs and lane control signals are controlled manually on the facility at the opening and closing each day. However, by June 1986, all transitway signs and signals are scheduled to be remotely controlled by computer with operator intervention still being possible.

Impacts of the transitway on mainlane freeway operation have been minimal. Geometrically, the widths of the freeway mainlanes have been reduced, and the inside shoulder has been eliminated. Operationally, volumes and travel time have not changed substantially, and accident rates do not appear to have worsened.

On a corridor-wide basis (freeway and transitway), since the transitway began operation, the corridor has been serving 10% more vehicles and almost 20% more person trips during a typical 3-hour peak period. Overall, occupancy rates have also increased from 1.28 to 1.36 passengers per vehicle while mainlane occupancy rates have declined from 1.3 to about 1.1 or 1.2 passengers per vehicle.

Based upon October 1985 transitway volumes, transitway users are realizing a time savings of 627 person-hours per day over parallel freeway mainlane travelers. Over a 20-year period, these travel time benefits, combined with bus operating cost savings, total approximately $29 million. With the present value of construction and annual operating costs totalling $14.3 million, the first phase of the Katy Transitway justifies itself with a benefit-cost ratio in excess of 2.

IMPLEMENTATION STATEMENT

This study was sponsored by the Texas State Department of Highways and Public Transportation as part of an overall effort entitled "Improving Urban Mobility Through Application of High Occupancy Vehicle Priority Treatments" - Research Study Number 2-10-84-339." An objective of this research is to evaluate for the Department the implementation of high occupancy vehicle priority treatment projects. An intent of these evaluations is to develop guidelines for planning, designing, and operating transitways on Texas freeways. This is the first evaluation report on the Katy Transitway.

DISCLAIMER

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INTRODUCTION

The Katy Freeway (I-10W) is a major interstate highway serving travel demands in the western part of Houston and Harris County (Figure 1). Extensive commercial and residential development has occurred as far west as 35 miles from downtown Houston. Traffic congestion within sections of the Katy Freeway corridor restricts peak-hour speeds to less than 20 mph. In an 8-lane section outside of I-610, average daily traffic was 186,000 in 1982. In 1983, a 17-mile bus trip from SH 6 to downtown Houston took 45 minutes.

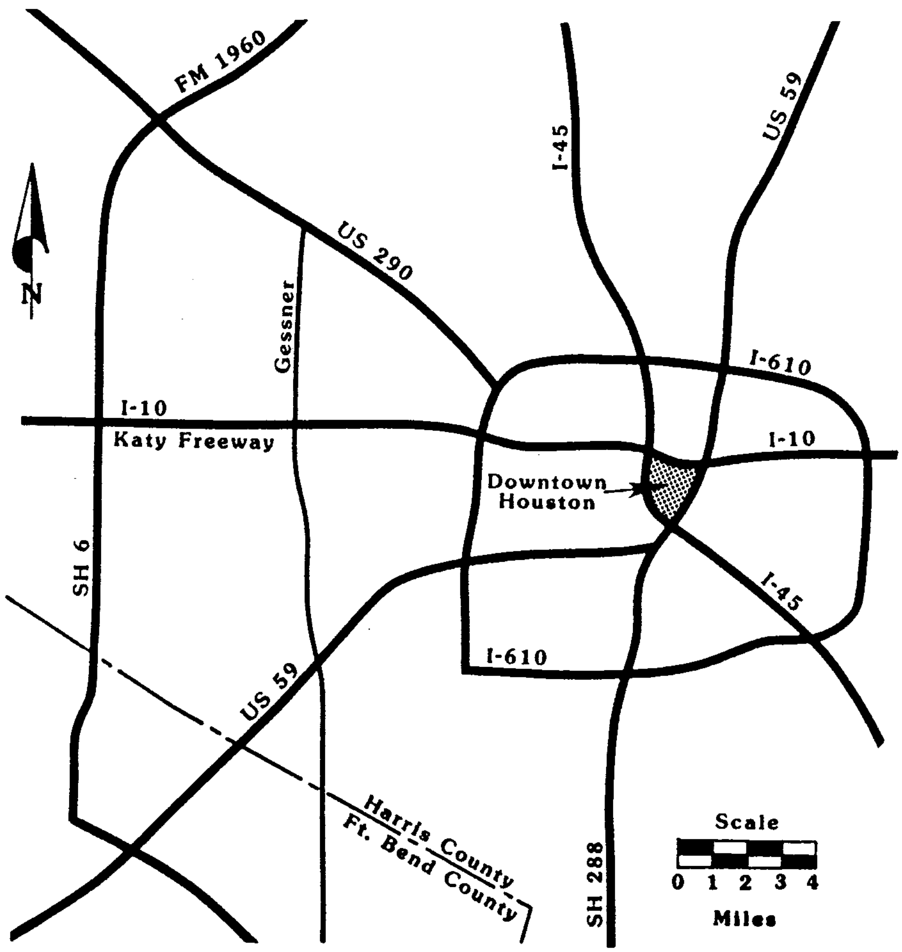


Figure 1. Katy Freeway (I-10W), Harris County

Present and projected freeway traffic volumes as well as the extent of traffic congestion justified the provision of an exclusive transitway on the Katy Freeway. Recognizing this need and the fact that there are no other immediate plans to expand capacity in the corridor, the Texas State Department of Highways and Public Transportation (SDHPT) and the Metropolitan Transit Authority (METRO) of Harris County entered into a cooperative agreement to develop a median transitway on the Katy Freeway. This transitway was developed as part of an already scheduled major pavement rehabilitation project. SDHPT, in conjunction with the Federal Highway Administration, agreed to pay all freeway overlay improvement costs, to award all contracts, and to supervise construction. METRO, using primarily local funds, agreed to pay the additional transitway costs incurred as a part of the project. This concerted effort facilitated the construction and implementation of the Katy Freeway Transitway in a relatively short time period, and thus minimized traffic disruption and combined project cost.

This report details project development and implementation and documents the first year of operation of the Katy Freeway Transitway. Subsequent facility improvements and authorization modifications within this first year are also presented.

KATY FREEWAY TRANSITWAY

Project Description

The Katy Freeway Transitway is being developed in three phases. Phase 1 was constructed between 1-610 and Gessner Drive, a distance of 4.75 miles. Completion of the first phase reduced peak-period travel time for users of the transitway by 4 to 6 minutes (AM vs PM travel time savings). Since the opening of the first phase on October 29, 1984, the interim operation of a western extension of the lane became feasible. Consequently, a 1.7 mile extension of the transitway from Gessner to West Belt was implemented on May 2, 1985. Currently, approximately 86% of the vanpools, 89% of the carpools, and 44% of the buses are taking advantage of this extension to save, on average, an additional 2 to 3 minutes (AM vs PM) in travel time over mainlane vehicles.

Phases 2 and 3 will subsequently extend the transitway from West Belt to beyond SH 6 for a total transitway distance of 11.5 miles (Figure 2). Phase 2 construction (which includes the transitway at grade and the part of the

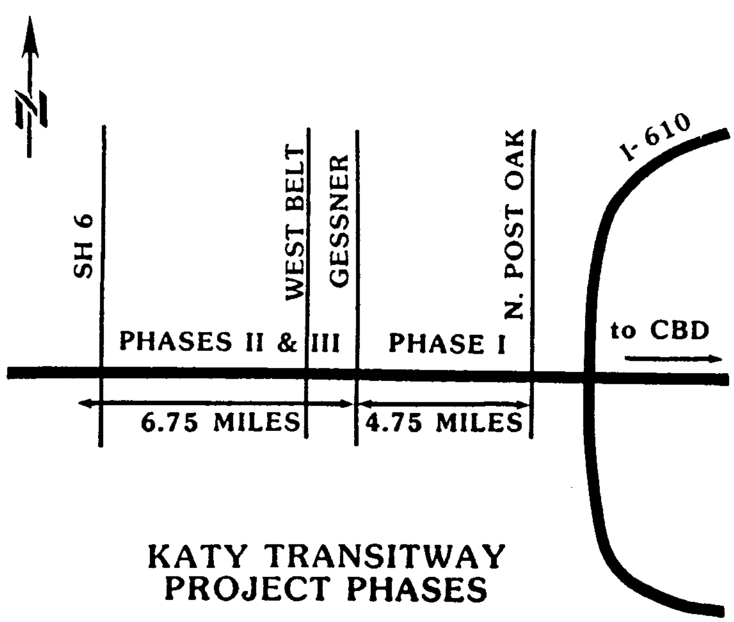


Figure 2. Katy Freeway Transitway Project Phases

elevated transitway interchange at SH 6 lying within the State right-of-way) is currently underway. With approximately one-quarter of the construction already completed, Phase 2 is scheduled to be finished in Spring 1987. Phase 3 provides for the construction of the remainder of the elevated interchange as well as the expansion of, and modifications to, the Addicks Park-and-Ride lot. The contract to construct the north ramp, which will tie into the Addicks Park-and-Ride lot, will be let in Spring 1986 in order to permit operation by the time Phase 2 is completed. Likewise, the park-and-ride expansion and modification will be let so as to be complete by approximately the same time as Phase 2. The construction schedule for the south ramp at Addicks will depend upon the results of METRO's real estate acquisition efforts.

METRO is providing the majority of the funding for the Katy Transitway. As shown in Table 1, METRO is contributing approximately $28 million, the State $3 million, and UMTA $10 million towards the funding of the Katy Transitway.

The Katy Freeway Transitway is being constructed in the median of the freeway, separated from general traffic lanes by concrete median barriers. The facility is reversible (operated inbound in the morning, outbound in the evening), includes an emergency breakdown shoulder along most sections, and is designed to accommodate buses, vanpools and other high occupancy vehicles. Typical "before-and-after" transitway construction cross-sections are illustrated in Figure 3. Actual implementation of the transitway is shown in Figures 4 and 5. The transitway has minimal impacts on the freeway cross-section. The number of mixed flow lanes and the availability of an outside shoulder remain intact. The reduction of lane widths and the elimination of the inside shoulder were necessary to accommodate the placement of the transitway within the freeway median.

Access to the transitway is handled differently at each location. The interim western terminus near West Belt is defined by a combination of

Table 1. Katy Transitway Estimated Funding & Sources*

	Contributing Agencies			
	METRO	SDHPT	UMTA	Total
Phase 1:				
Design	$ 1.2M			
Construction:				
Transitway at-grade	5.3			
Transitway flyover	4.1			
SC&C	1.0		$ 0.4M	
Total, Phase I	11.6	---	$ 0.4M	$12.0M
Phase 2:				
Design	$ 0.6M			
Construction:				
Transitway at-grade	5.5			
Transitway interchange	2.7	$3.0M		
SC&C	1.5			
Total, Phase 2	$10.3M	$3.0M	---	$13.3M
Phase 3:				
Design				$ 0.9M
Land Costs				7.5
Construction:				
Ramps				3.0
Park-and-Ride				2.6
Park Row				2.2
Total, Phase 3	$ 6.4M	---	$ 9.8M	$16.2M
TOTAL	$28.3M	$3.0M	$10.2M	$41.5M

*Source (7)

concrete median barriers and temporary construction barrels with directional traffic signs attached (Figures 6-9). At the intermediate western terminus near Gessner, a series of concrete median barriers create slip ramps to provide access to/egress from the transitway from/to the inside freeway lane

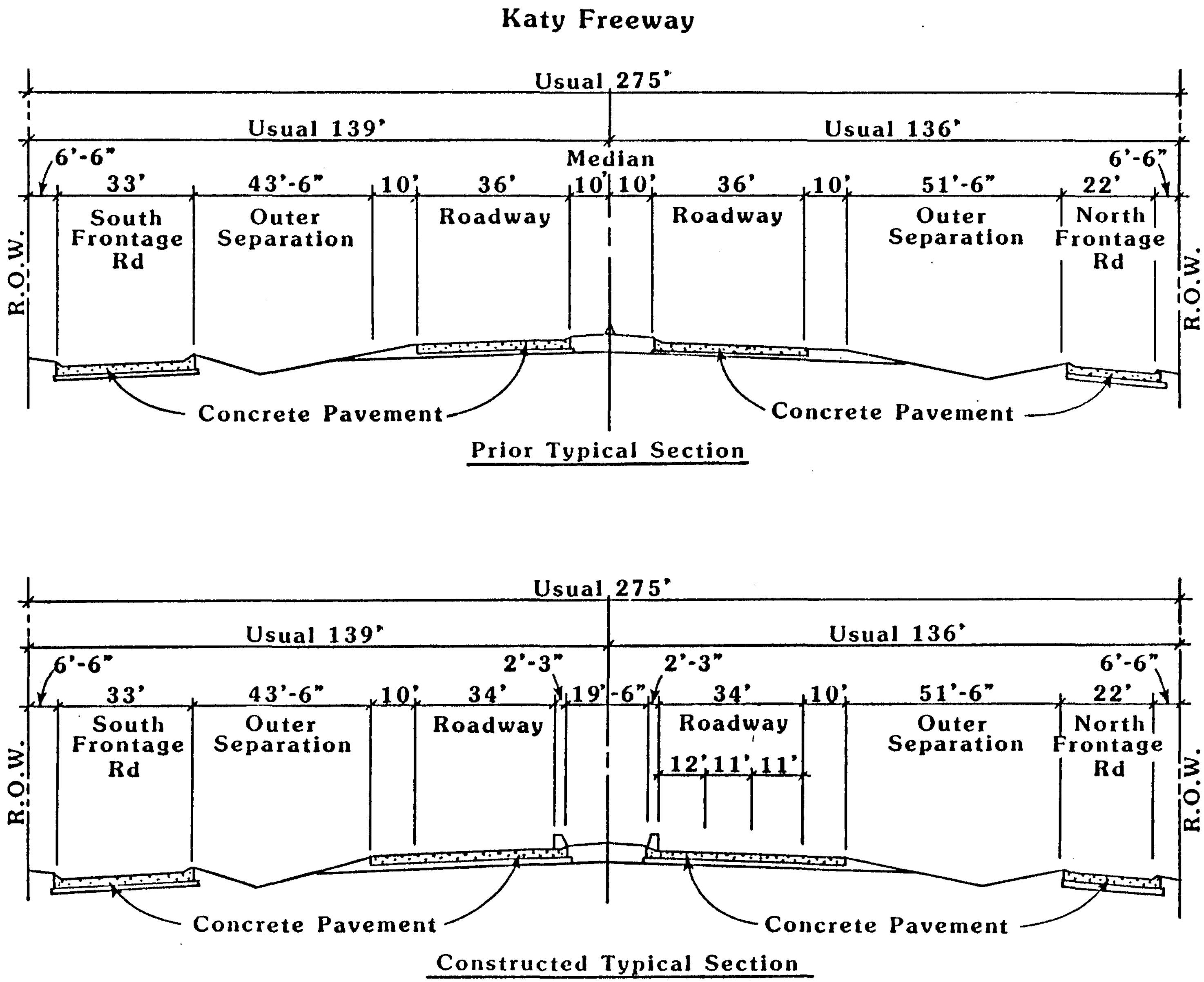


Figure 3. Typical Pre- and Post-Transitway Freeway Cross-Sections

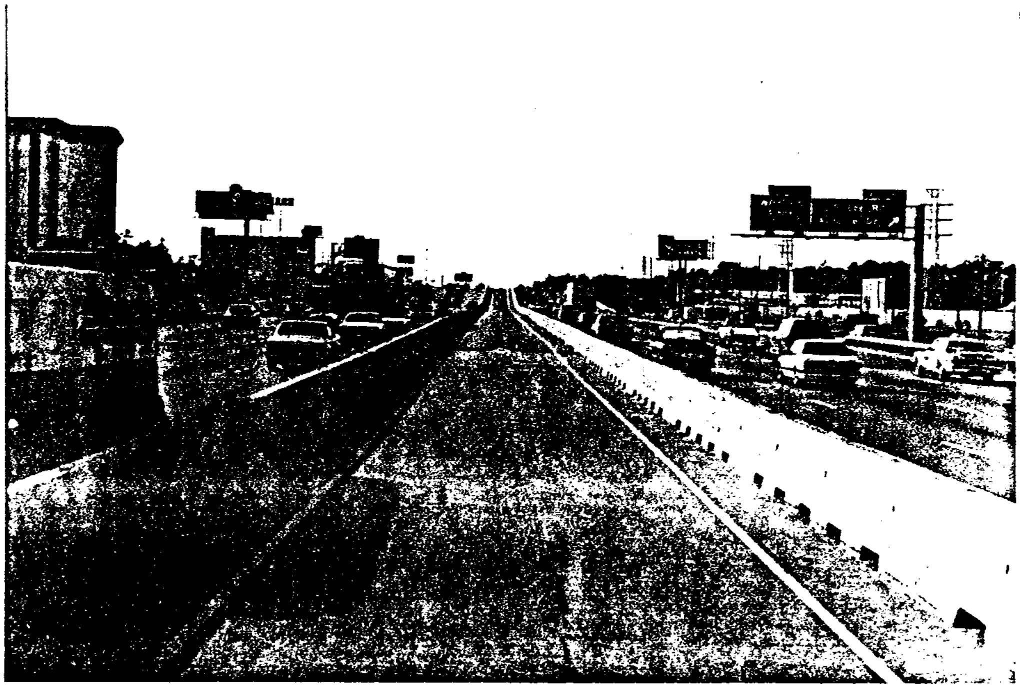


Figure 4. Katy Freeway Transitway Implementation: Straight Section

Figure 5. Katy Freeway Transitway Implementation: Curved Section

Figure 7. Transitway Approaching West Belt Terminus

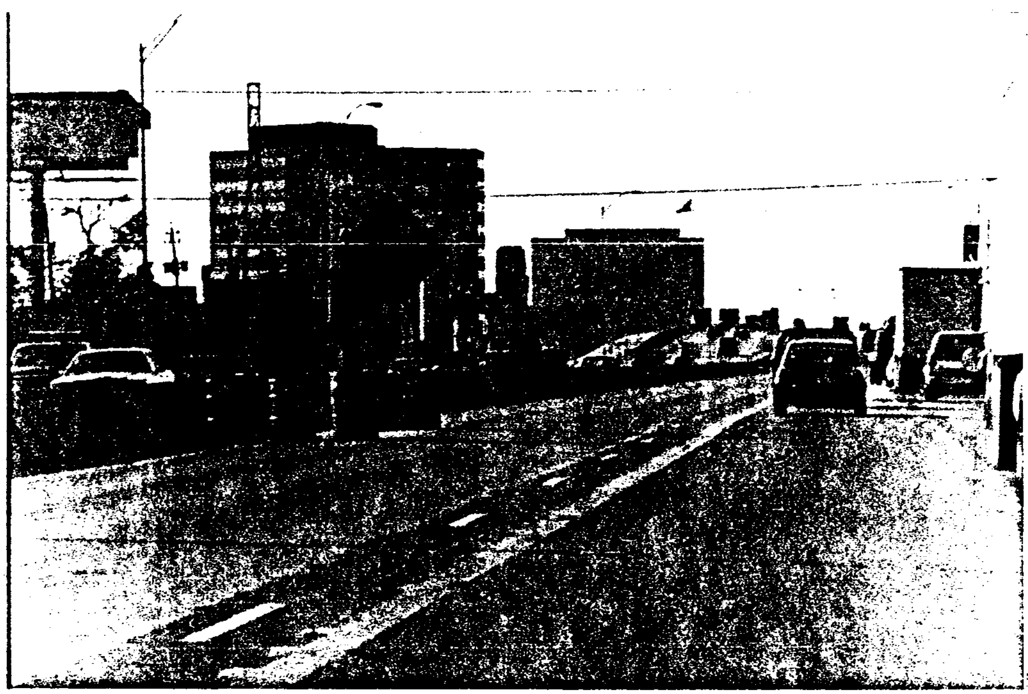


Figure 8. Merge Point Between Transitway and Mainlane Traffic Near West Belt

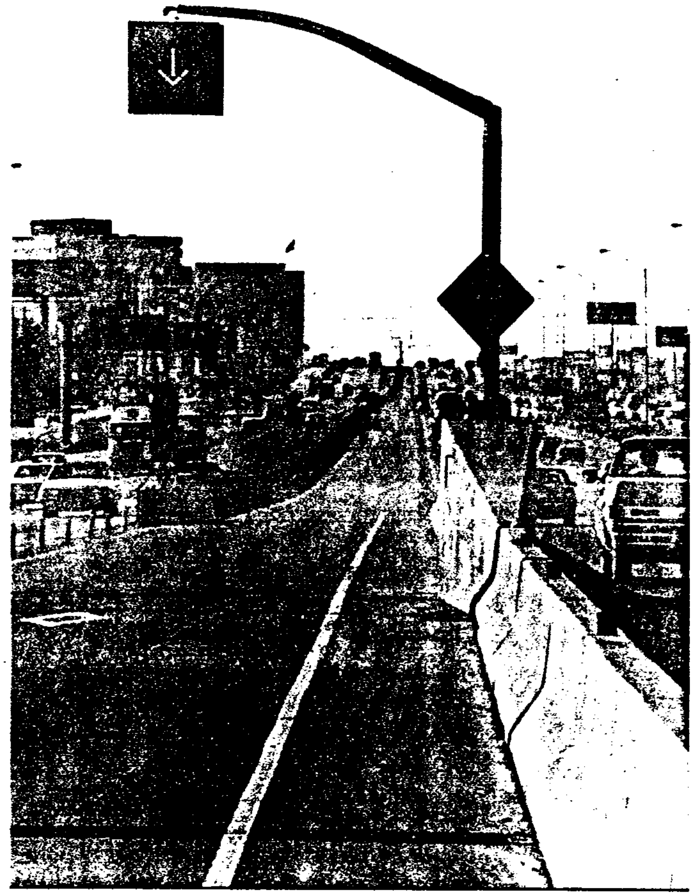


Figure 9. Signing on Transitway Before Merge With Mainlane Traffic

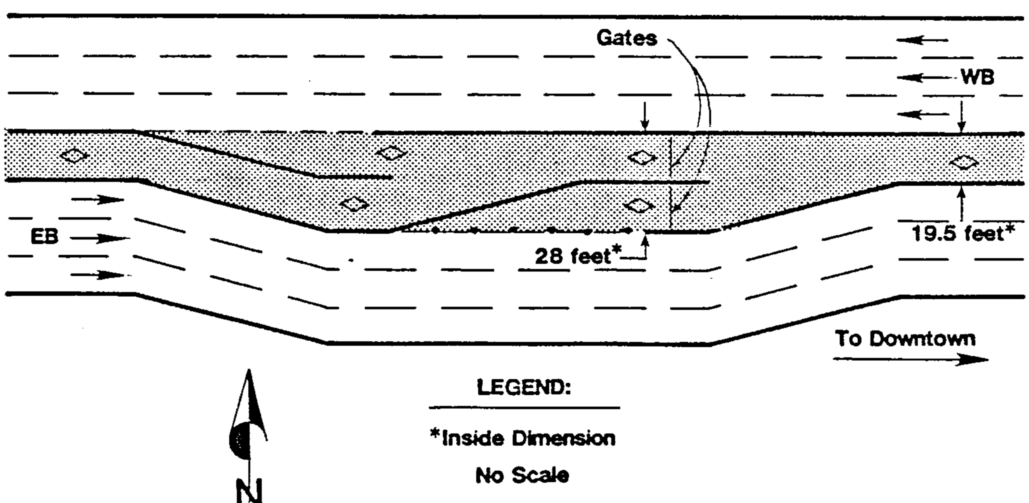


Figure 10. Intermediate Access/Egress Near Gessner, Schematic

(Figures 10-14). During inbound operation, the median shoulder upstream of the transitway entry serves as a short concurrent flow lane. In the afternoon, the outbound vehicles exiting the transitway use the inside shoulder to merge into the mixed flow lanes. At the eastern terminus near I-610, an elevated flyover ramp leaves the median and ties into an arterial street intersection (Figures 15-17). At that intersection (N. Post Oak/Old Katy Rd.), authorized high occupancy vehicles can either travel south to major employment centers or continue east to reenter the Katy Freeway in mixed-flow operation to reach downtown.

Impact Of Construction

Construction on Phase I of the Katy Freeway Transitway began in April 1983. The introduction of a transitway facility into the median required special retrofit construction processes which constrained already congested adjacent freeway sections. Minimizing the adverse traffic impacts associated with this type of construction was a primary concern.

To accomplish the transitway construction, work was sequenced independently within each project segment, with each segment going through four construction sequence steps (Figure 18). The work areas were developed in the median and to the north and the south sides of the freeway mainlane cross-section. Traffic was routed around the work areas through narrow lanes varying from 10 to 11 feet in width with no shoulders on either the inside or the outside. Temporary concrete median barriers protected and separated the work areas from freeway traffic. Figures 18 and 19 summarize the manner in which the retrofit construction was accomplished in order to maintain three traffic lanes in each direction for freeway traffic.

Construction of Phase I of the Katy Transitway was completed in October 1984, approximately four months ahead of the construction schedule. An evaluation of the impacts of the transitway construction indicated that mainlane traffic volumes and speeds were affected only minimally; and, after an initial one month adjustment period, accident rates were not significantly different during transitway construction than one year prior (1).

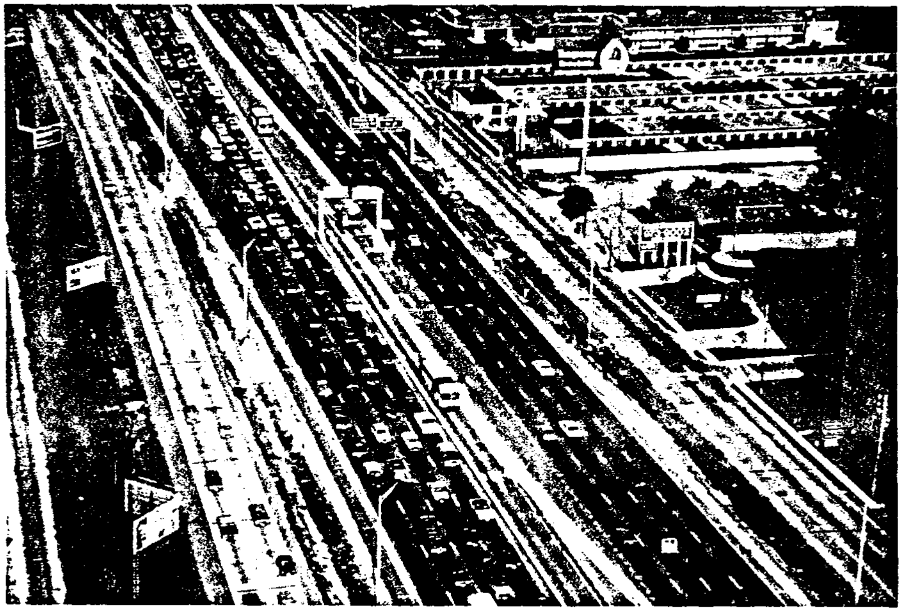


Figure 11. Intermediate Transitway Access/Egress Near Gessner, Aerial

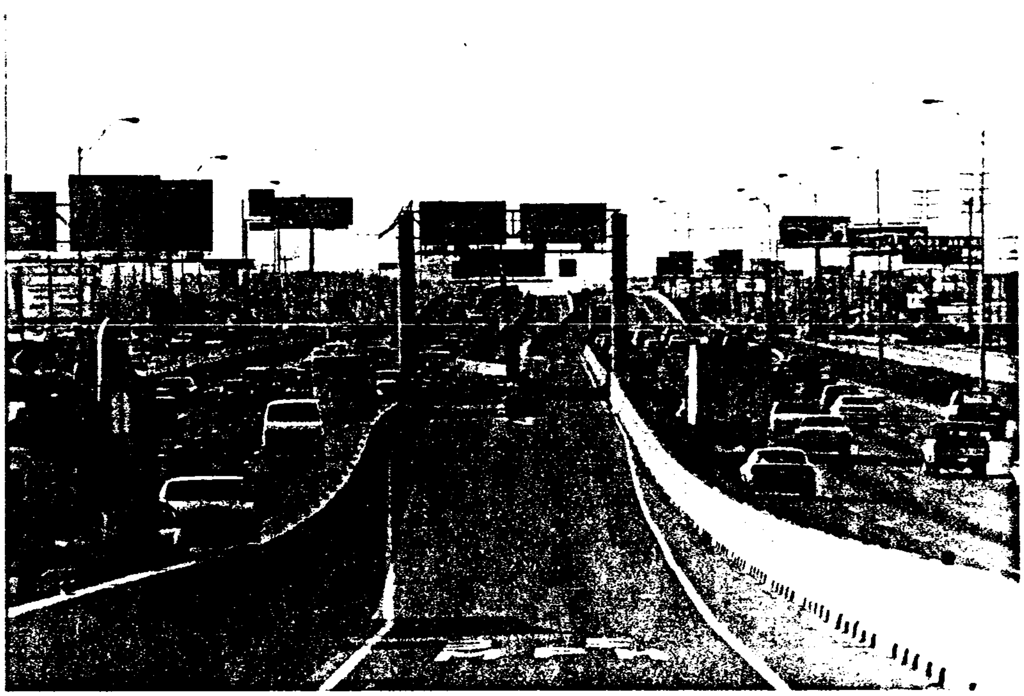


Figure 12. Transitway Approaching Gessner Exit, Outbound

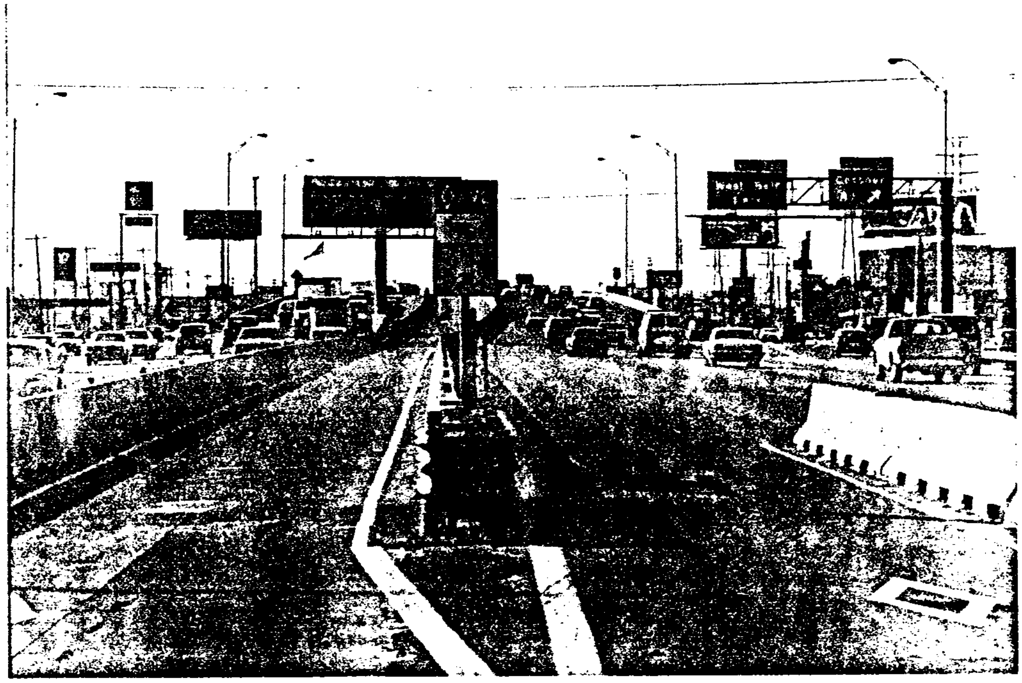


Figure 13. Continuation On/Exit From Transitway Near Gessner

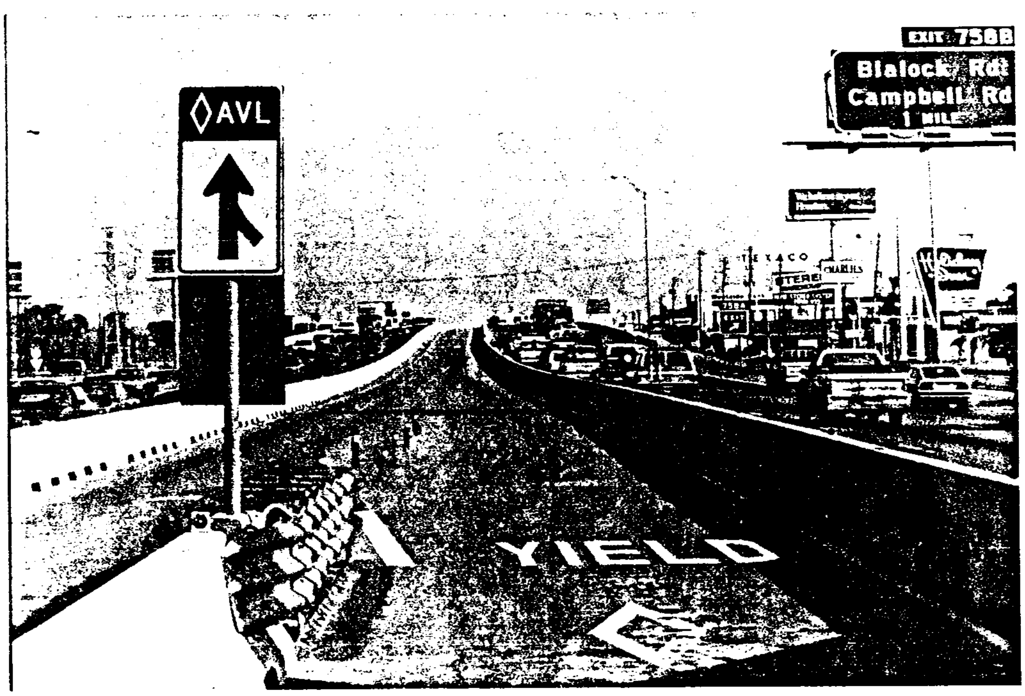


Figure 14. Morning Transitway Access Near Gessner

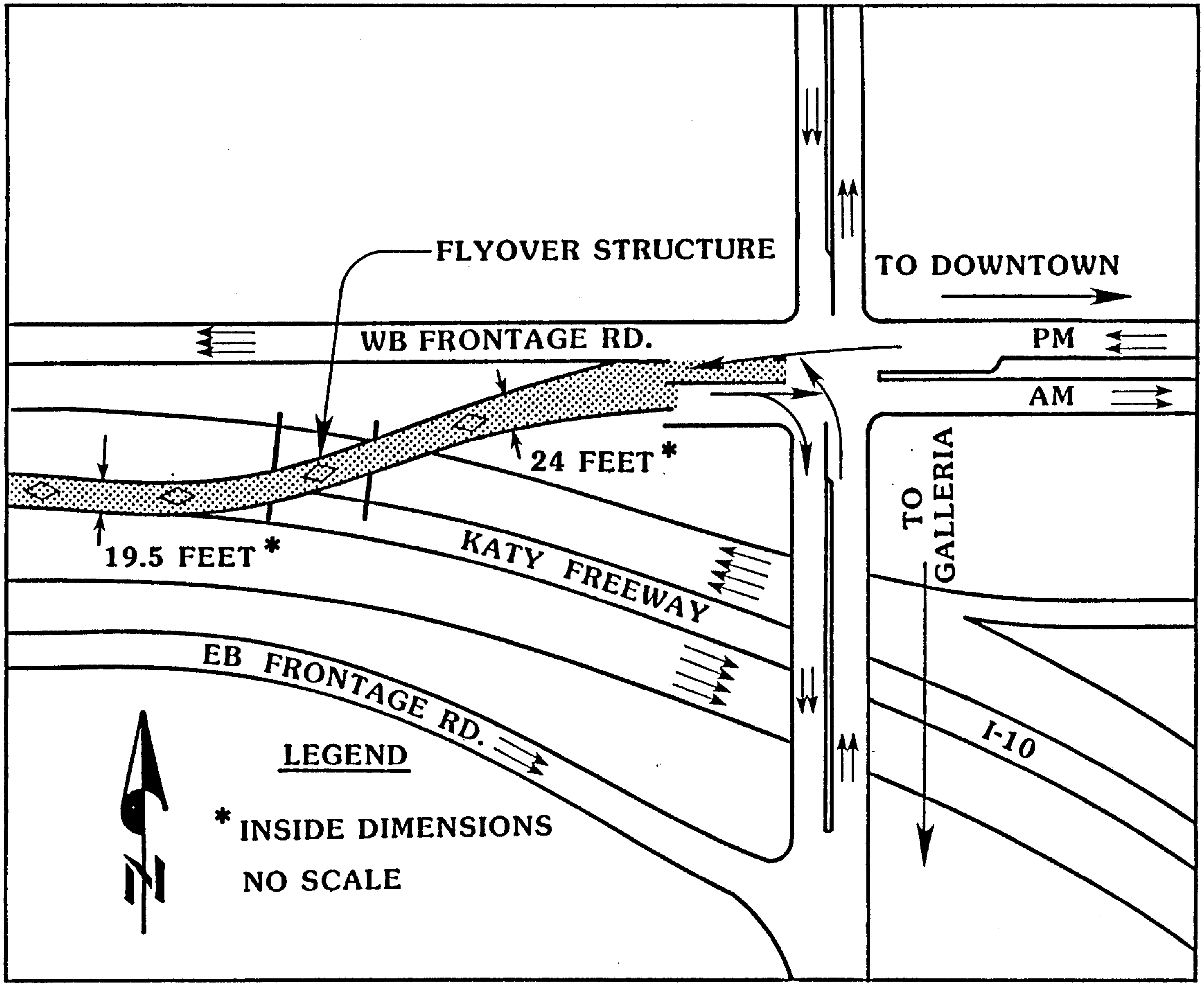


Figure 15. Eastern Terminus at North Post Oak, Schematic

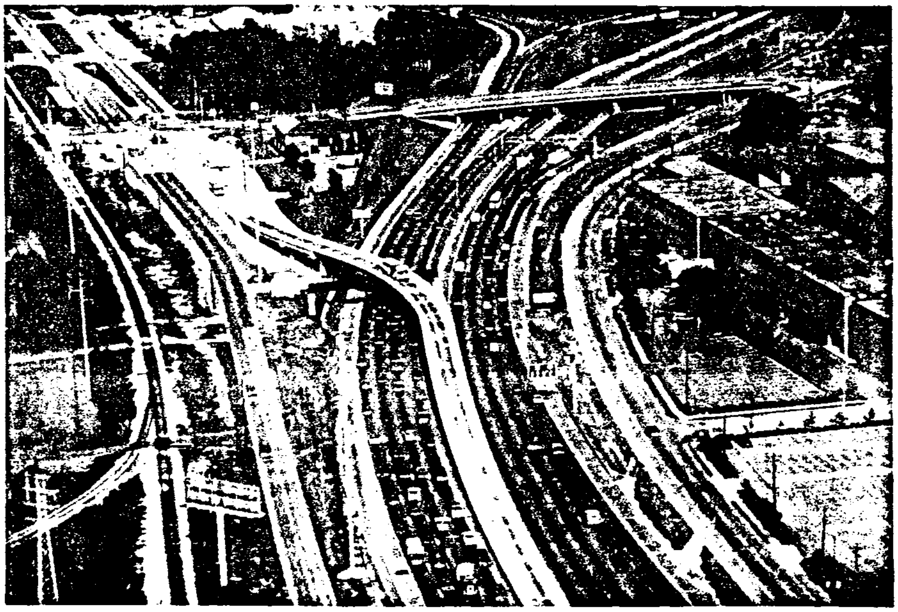


Figure 16. Eastern Terminus At North Post Oak, Aerial

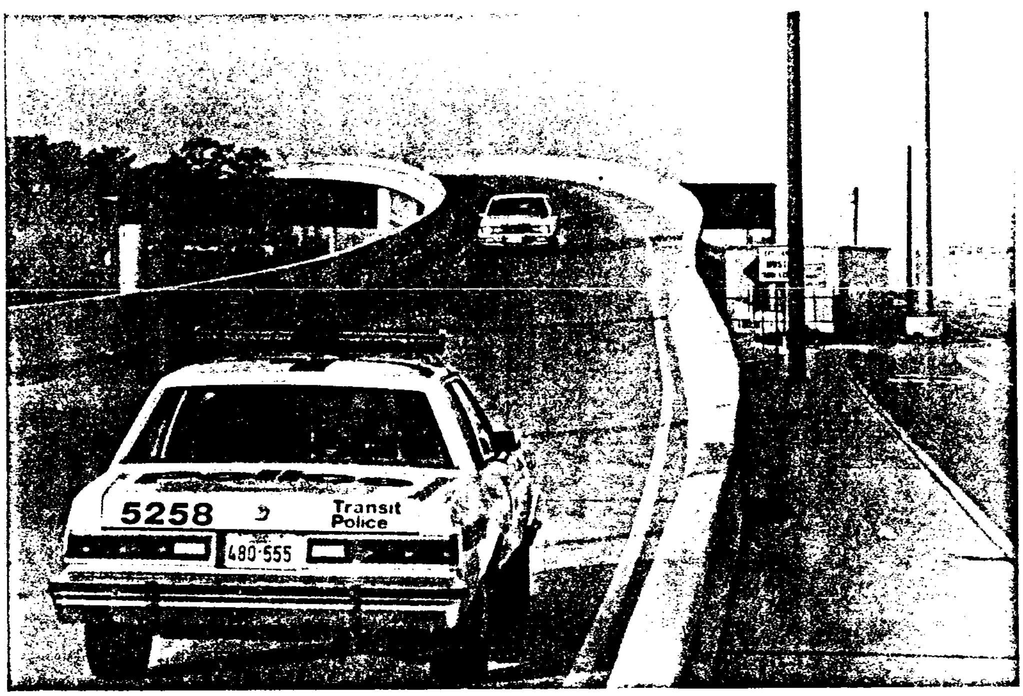


Figure 17. Morning Transitway Enforcement

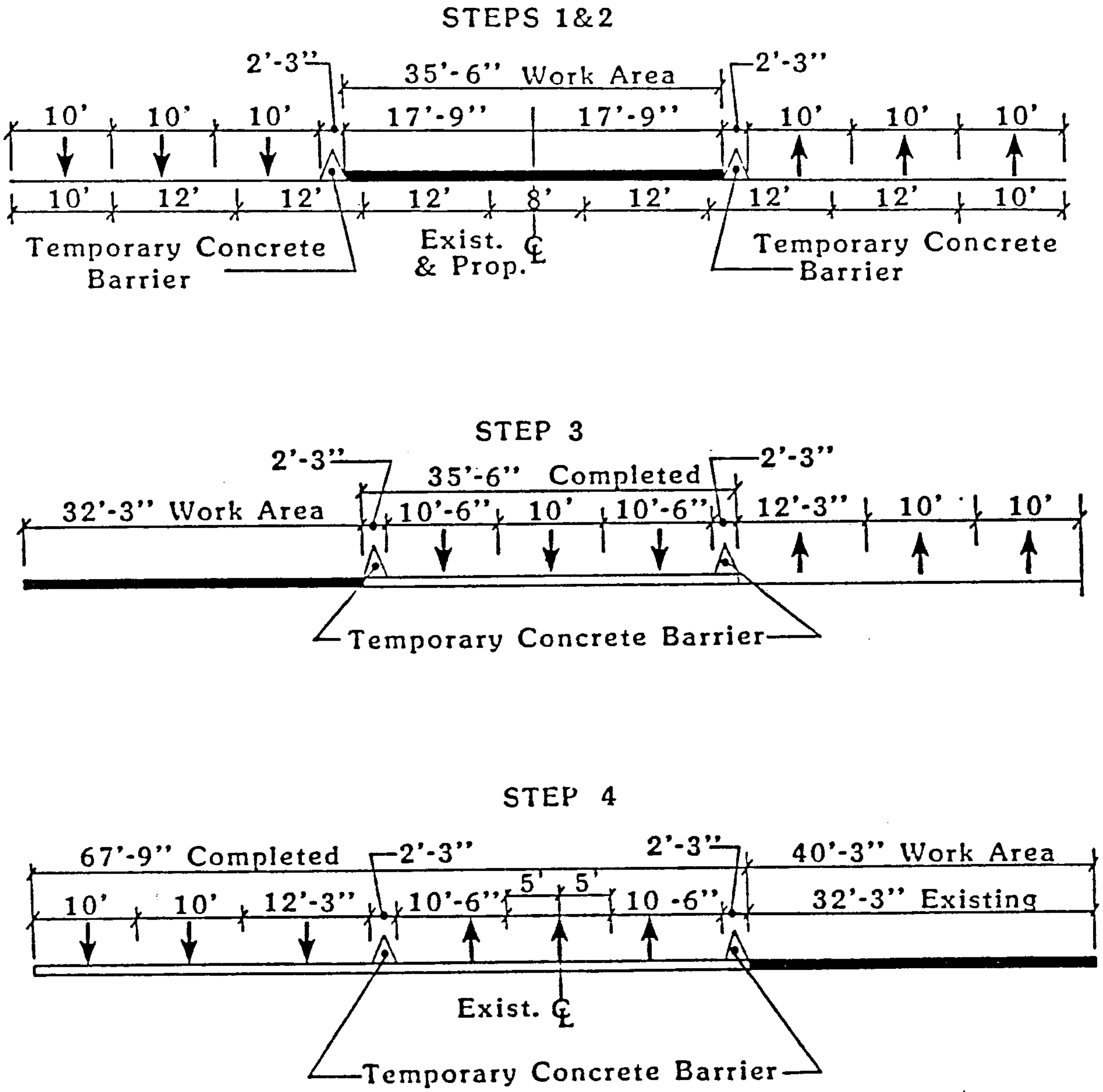


Figure 18. Typical Transitway Construction Cross-Section (looking west)

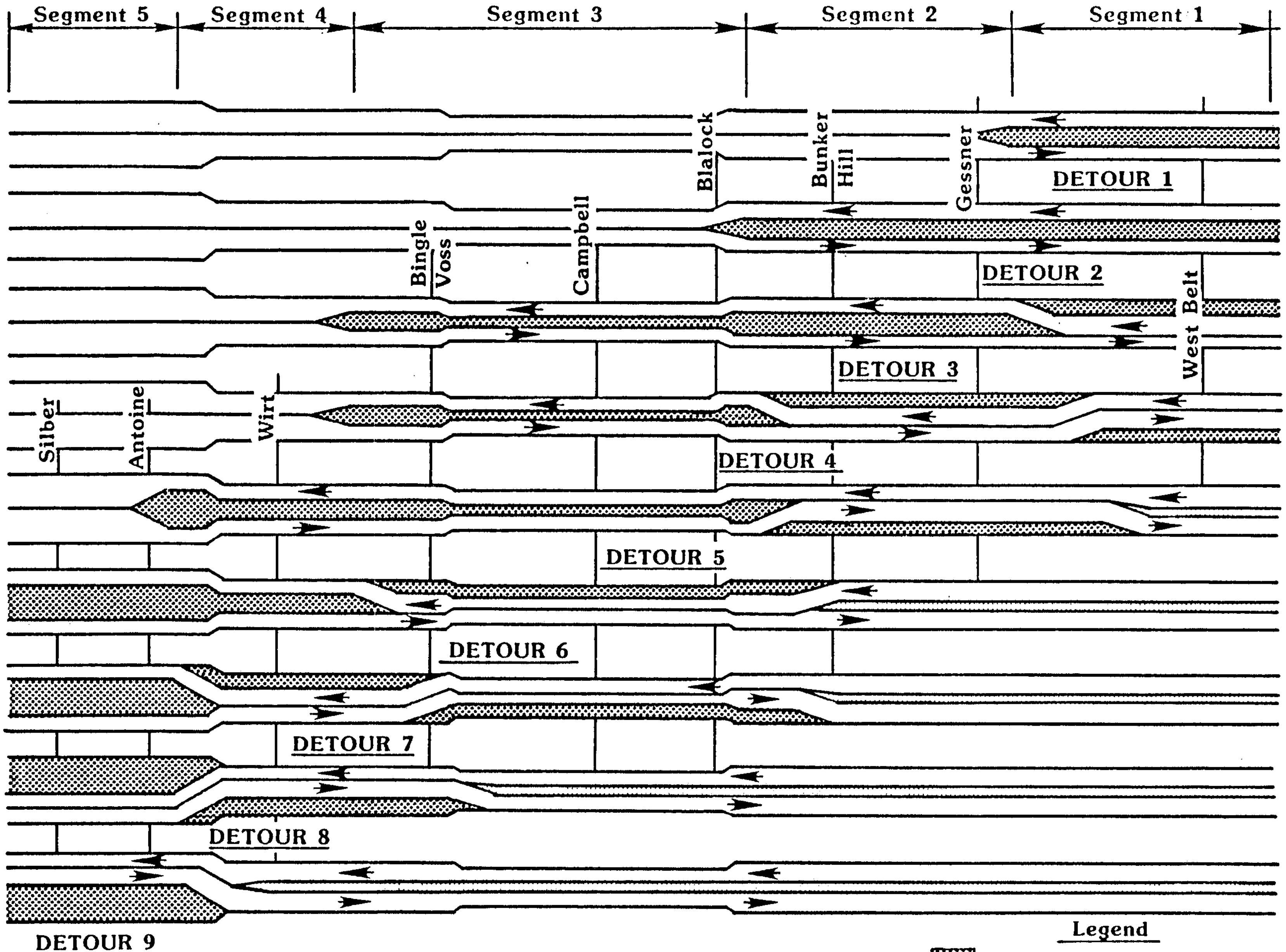


Figure 19. Transitway Construction & Detour Sequence

Legend

Construction Work Area

Completed AVL

FIRST YEAR OPERATIONS

Transitway

The Katy Freeway Transitway was opened on October 29, 1984 as a median, barrier-separated, one-way, reversible, single lane priority facility for use by authorized high-occupancy vehicles (HOVs). The approach of permitting only authorized vehicles to use the Katy Transitway was based upon METRO's experience with the North Freeway (I-45N) Contraflow Lane. Primarily for safety reasons, only buses and vanpools authorized by METRO and the State were allowed to use the contraflow lane. Eligibility for authorization on the contraflow lane was limited to buses and vanpools in order to maximize vehicle occupancy levels, and to make it easier to detect unauthorized vehicles. In order to become authorized, eligible HOV's first had to meet a number of vehicle maintenance, inspection, and insurance requirements, and they had to maintain a minimum number of registered riders. Additionally, only certified transitway drivers who had participated in the METRO Transitway Driver Training course were permitted to operate a vehicle within the contraflow lane. As this approach had worked well on the North Freeway (sustaining a high level of utilization), it was decided initially to use the same approach in operating the Katy Transitway. In addition to providing a level of operational control, the authorization process was considered desirable in that it required driver training before a driver was permitted to operate a vehicle within the restricted geometrics of the transitway. Consequently, when the Katy Transitway first opened on October 29, 1984, only authorized transit authorized buses and vanpools were permitted to use the priority lane.

Carpool Authorization

After the first five months of operation, despite sustained growth, combined bus and vanpool vehicle volumes on the transitway were still relatively low. This resulted in a perception that the lane was underutilized (2). As a means of overcoming this perception (and following the example set by most other freeway HOV projects elsewhere in the United States), the

Metropolitan Transit Authority and the Texas State Department of Highways and Public Transportation decided to approve a trial carpool experiment on the Katy Freeway Transitway beginning April 1, 1985 (3, 4).

Transitway carpool utilization was originally restricted to authorized automobiles carrying four or more persons. In order to become authorized, carpools had to have: 1) certified drivers; 2) valid Texas inspection stickers no more than 6 months old; 3) the minimum state insurance coverage; 4) some familiarity with the transitway geometrics before actually driving in the facility; and 5) the vehicle had to pass a visual inspection by METRO. If an authorized carpool had fewer than four persons on any day due to carpool member work schedule, travel, illness, or vacation, it was not permitted into the transitway that day. This carpool definition was structured to ensure maximum passenger occupancy of vehicles travelling within the Katy Transitway. The concern that a 3+ designation could possibly exceed the capacity of the transitway and create unacceptable operating conditions also contributed to the decision to initially restrict authorization to 4+ carpools.

Approximately 30 carpools were authorized to use the transitway in April 1985. However, as shown in Table 2, of these 30 carpools, an average of only 5 carpools actually chose to use the lane during a typical peak period. By July, 1985, the number of carpools observed using the transitway had doubled, but absolute demand levels remained low. Consequently, effective July 29, 1985, carpools were permitted to enter the transitway with a minimum of three passengers, although four or more registered passengers were still required to obtain authorization. Less than a month after occupancy requirements were reduced for carpools, carpool volumes increased by more than 30% (carpool passenger volumes increased by 20%). However, in absolute numbers, the increase was not substantial; only nine more carpool trips were being made on the transitway each day. Consequently, further consideration was given to reducing the authorization requirement to a minimum of only three registered occupants. Officially, the authorization of 3+ carpools was not to commence until November 4, 1985. However, as early as September, 1985, 3+ carpools had begun to be authorized by METRO to travel through the Katy Transitway. As a result, carpool volumes increased by 138% between August and September,

Table 2. Carpool Demand on Katy Freeway Transitway

Month	Morning		Afternoon		Daily	
	Vehicles	Passengers	Vehicles	Passengers	Vehicles	Passengers
04/85	6	24	4	16	10	40
05/85	6	26	6	24	12	50
06/85	8	32	5	18	13	50
07/85	13	52	15	59	28	111
08/85	20	67	17	63	37	130
09/85	46	171	42	156	88	327
10/85	54	203	48	167	102	370
11/85	82	299	73	258	155	557
12/85	92	337	83	295	175	632

1985, and then by another 16% between September and October 1985. Since official 3+ authorization began in November, carpool volumes increased by 52% in the first month and by another 13% in the second month. Figure 20 plots the carpool volumes associated with the various authorization levels.

A concern associated with allowing carpools onto the transitway had been that a mode shift from transit and vanpools towards carpools would occur. This could result in the transitway moving more vehicles but not necessarily more people. However, based upon a TTI survey of Katy Transitway carpoolers in October 1985, this concern has not yet been realized. Nearly 75% of the carpoolers responding had previously driven alone or had been members of other carpools; only 5% of the carpoolers had switched from either the transitway bus or the vanpool modes (5).

Permitting carpools to use the Katy Transitway has had a positive impact on carpool occupancy rates. More than 40% of the carpools using the transitway increased the number of people in their carpool in order to be able to be eligible to use the transitway. Overall, median carpool occupancy rates for those carpools using the transitway increased from 2.1 to 3.5 persons per vehicle (5).

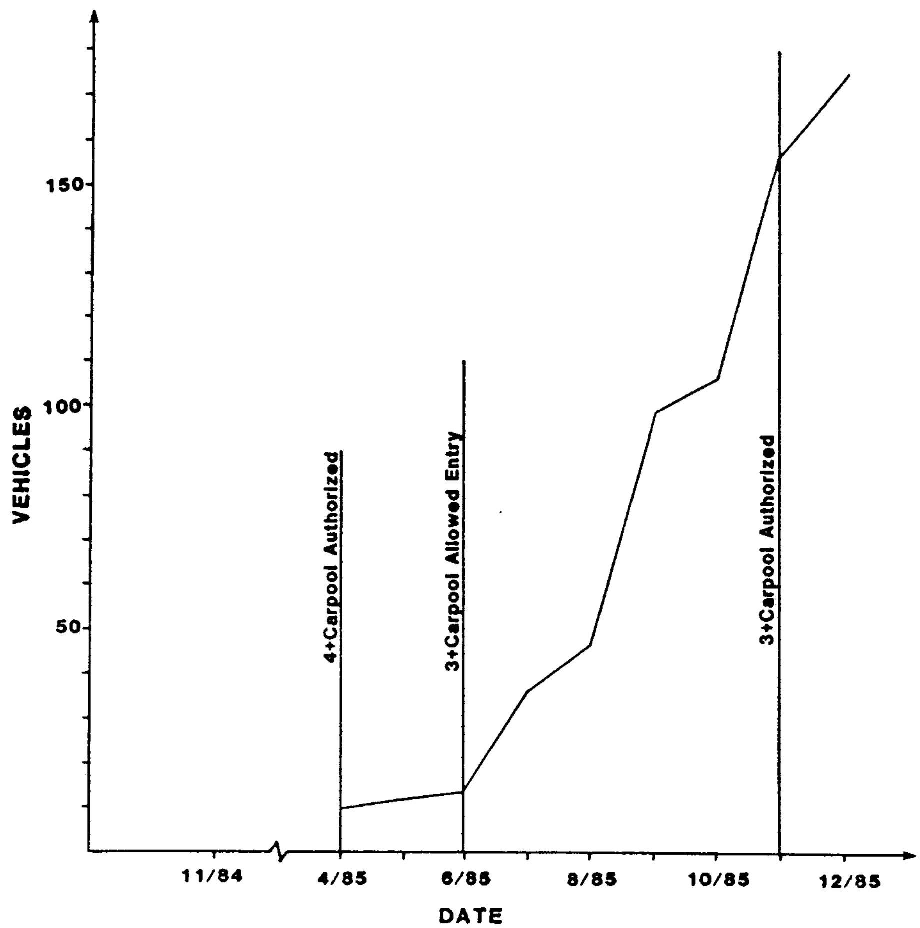


Figure 20. Daily Carpool Demand On Katy Freeway Transitway

As shown in Table 3, the carpoolers are very similar to the other transitway users in many respects (age, sex, education, and occupation); however, an important difference appears in trip destinations. Whereas transit and vanpool trips are predominantly destined for downtown Houston (96% of the transit trips and 70% of the vanpool trips), a much smaller proportion of carpoolers are destined for downtown Houston (29%). A substantial proportion of carpool trips have destinations within the Galleria/City Post Oak area (13%) and the Greenway Plaza area (13%). The introduction of carpools into the transitway has accommodated trips to destinations not well served by bus or vanpool (5).

Table 3. Personal and Trip Characteristics of Survey Respondents*

Characteristic	Transitway Users			Non Transitway Users
	Transit	Vanpool	Carpool	Motorists
Age, years (50th percentile)	33	36	41	40
Sex, % male	49%	52%	71%	64%
Education, years (average)	15.6	15.4	15	15.7
Occupation				
% Professional	56%	55%	58%	51%
% Managerial	13%	21%	20%	19%
% Clerical	21%	20%	11%	9%
% Sales	4%	2%	2%	12%
Trip Purpose, Percent Work	99%	100%	N.A.	94%
Trip Frequency (5 or more days/week)	91%	95%	100%	84%
Trip Destination				
Downtwon	96%	70%	29%	38%
Galleria/City Post Oak	0%	11%	13%	24%
Texas Medical Center	1%	5%	3%	9%
Greenway Plaza	0%	3%	13%	8%
University of Houston	3%	0%	3%	2%
Percent of Home Zip Codes (origin) in 77079, 77084, or 77449	46%	44%	58%	31%

*Source (5)

Transitway Demand

Tables 4 and 5 present monthly transitway vehicle and passenger demands from opening to October 1985. The cumulative increases in demand categories are also given. These values are depicted graphically in Figures 21 and 22. Initially, daily vehicle and passenger volumes totaled 78 buses and 160 vanpools carrying 2,860 and 1,303 passengers, respectively. As can be seen, vehicle utilization of the transitway has increased from 238 to 386 vehicle trips per day, and person movement has increased from 4,163 to 6,147 passenger trips per day. This represents an approximate 62% increase in vehicle volumes and a 48% increase in passenger volumes. Currently, although

Table 4: Daily Transitway Vehicle Demand

	Daily Vehicles				Change	
Month	Buses	Vanpools	Carpools	Total	Per Month	Cum
Nov. 84	78	160	--	238	--	--
Dec. 84	81	162	--	243	2%	2%
Jan. 85	90	172	--	262	8%	10%
Feb. 85	97	166	--	263	0%	11%
Mar. 85	101	170	--	271	3%	14%
Apr. 85	104	166	10	280	3%	18%
May 85	106	168	12	286	2%	20%
Jun. 85	121	158	13	292	2%	23%
Jul. 85	116	153	28	297	2%	25%
Aug. 85	122	145	37	304	2%	28%
Sep. 85	124	161	88	373	23%	57%
Oct. 85	121*	163	102	386	3%	62%

*Includes 14 articulated buses with maximum capacity of approximately 70 passengers seated.

Table 5: Daily Transitway Passenger Demand

	Daily Passenger Trips				Change	
Month	Buses	Vanpools	Carpools	Total	Per Month	Cum
Nov. 84	2,860	1,303	--	4,163	--	--
Dec. 84	3,020	1,426	--	4,446	7%	7%
Jan. 85	3,180	1,636	--	4,816	8%	16%
Feb. 85	3,520	1,640	--	5,160	7%	24%
Mar. 85	3,450	1,596	--	5,046	-2%	21%
Apr. 85	3,490	1,601	40	5,131	2%	23%
May 85	3,300	1,557	50	4,907	-4%	18%
Jun. 85	3,780	1,271	50	5,101	4%	23%
Jul. 85	3,880	1,236	111	5,227	2%	26%
Aug. 85	4,100	1,203	130	5,443	4%	31%
Sep. 85	3,980	1,334	327	5,641	4%	36%
Oct. 85	4,410	1,367	370	6,147	9%	48%

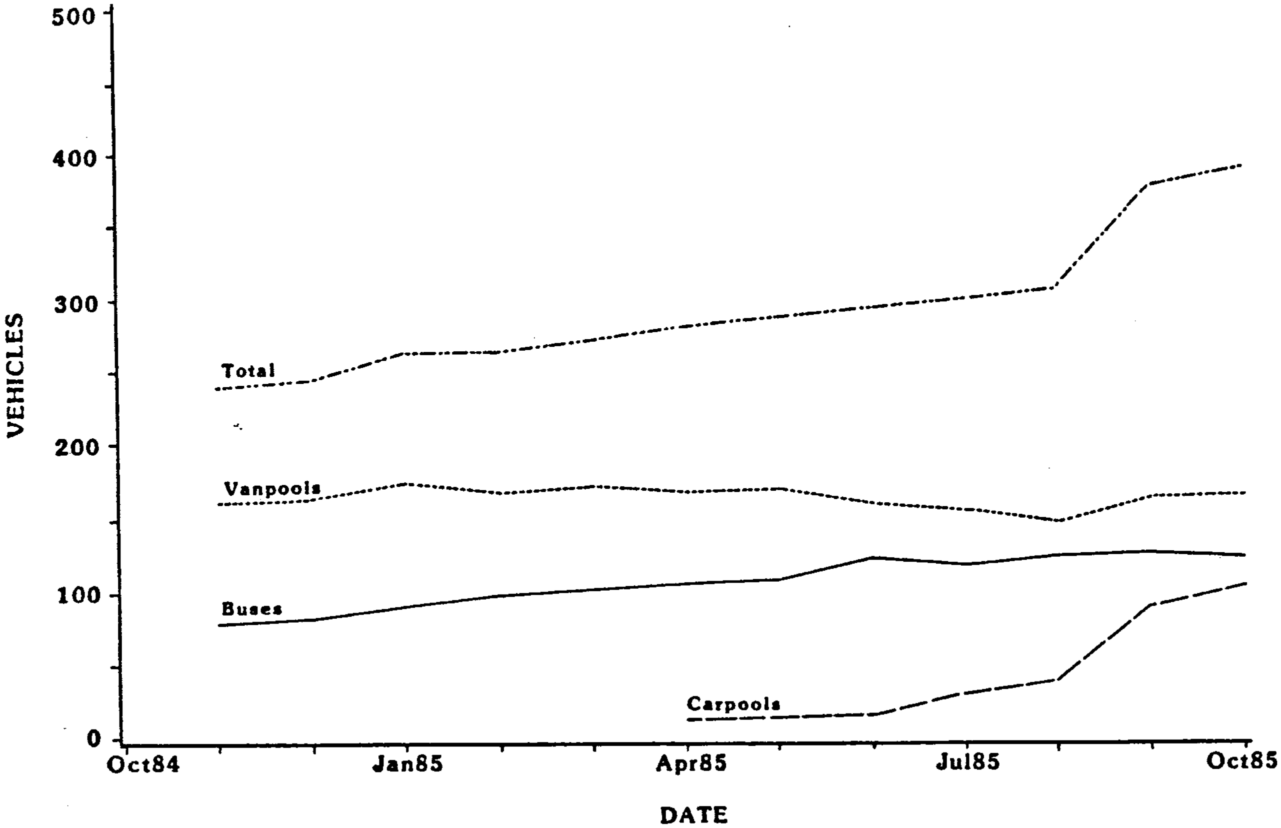


Figure 21. Katy Transitway, Daily Vehicle Volumes

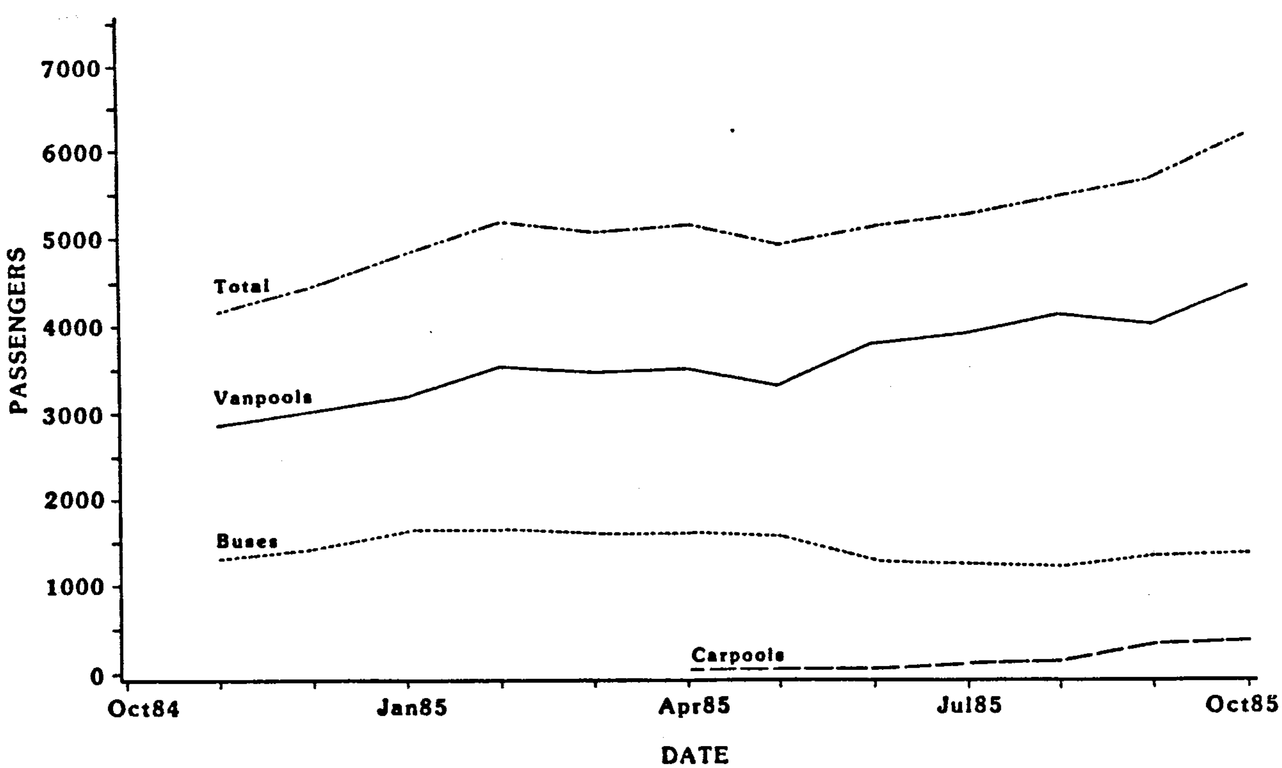


Figure 22. Katy Transitway, Daily Passenger Volumes

the number of vehicles utilizing the transitway in a peak hour of operation is typically less than 5% of the vehicle volume that may be observed on an adjacent freeway mainlane, the number of passengers served in these few vehicles is roughly equivalent to that on an adjacent freeway lane.

Occupancy Rates

Average peak-period bus occupancies on the transitway have varied from 30 to 37 passengers per bus in the past year (Not included in the above average are the articulated buses introduced in October 1985 which averaged approximately 65 passenger per bus in the peak period) (Figure 23). Vanpool occupancies continue to hover between 8 and 10 passengers per van, and carpools have been carrying between 3 and 4 passenger per car in the past 7 months since they have been permitted to use the transitway. Meanwhile, mainlane occupancy rates, after dropping from about 1.3 passengers per vehicle before the opening of the transitway, have remained fairly constant, varying slightly between 1.1 and 1.2 passengers per vehicle (Figure 24).

Park-and-Ride Demand

There have been corresponding increases in demand for transitway support facilities such as park-and-ride lots and vanpool staging areas. The geographic locations of these facilities within the Katy Freeway corridor and their current capacities are shown in Figure 25. Demand totals for each of these transitway support facilities are given in Table 6. As illustrated in Figure 26, total corridor demand for park-and-ride has increased by 98% within the 1 year period since the transitway began operation.

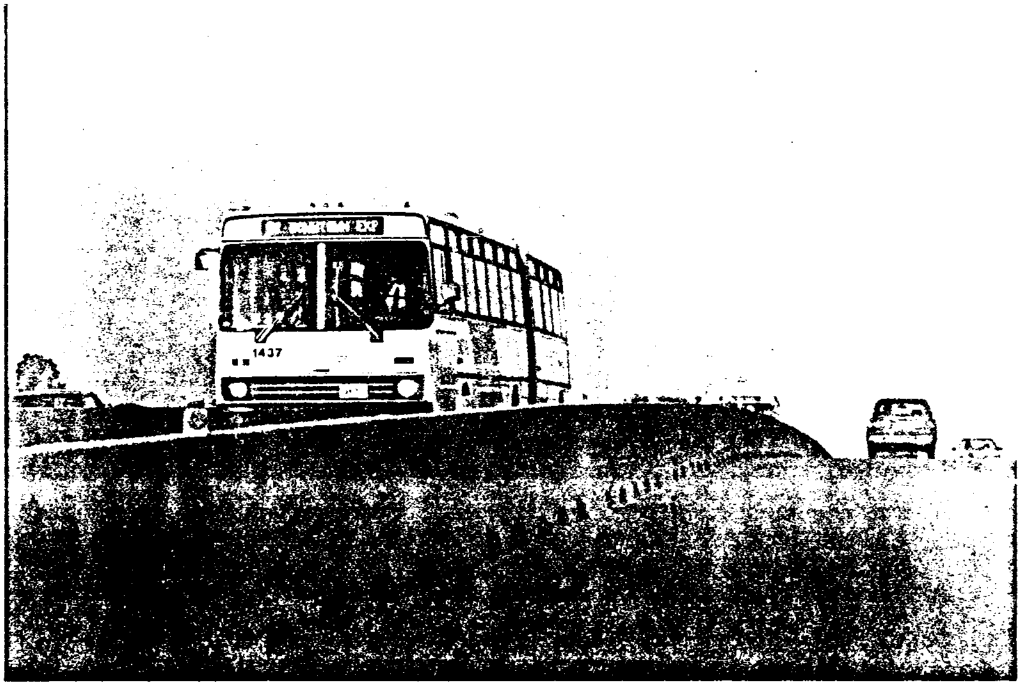


Figure 23. Articulated Bus in Katy Freeway Transitway

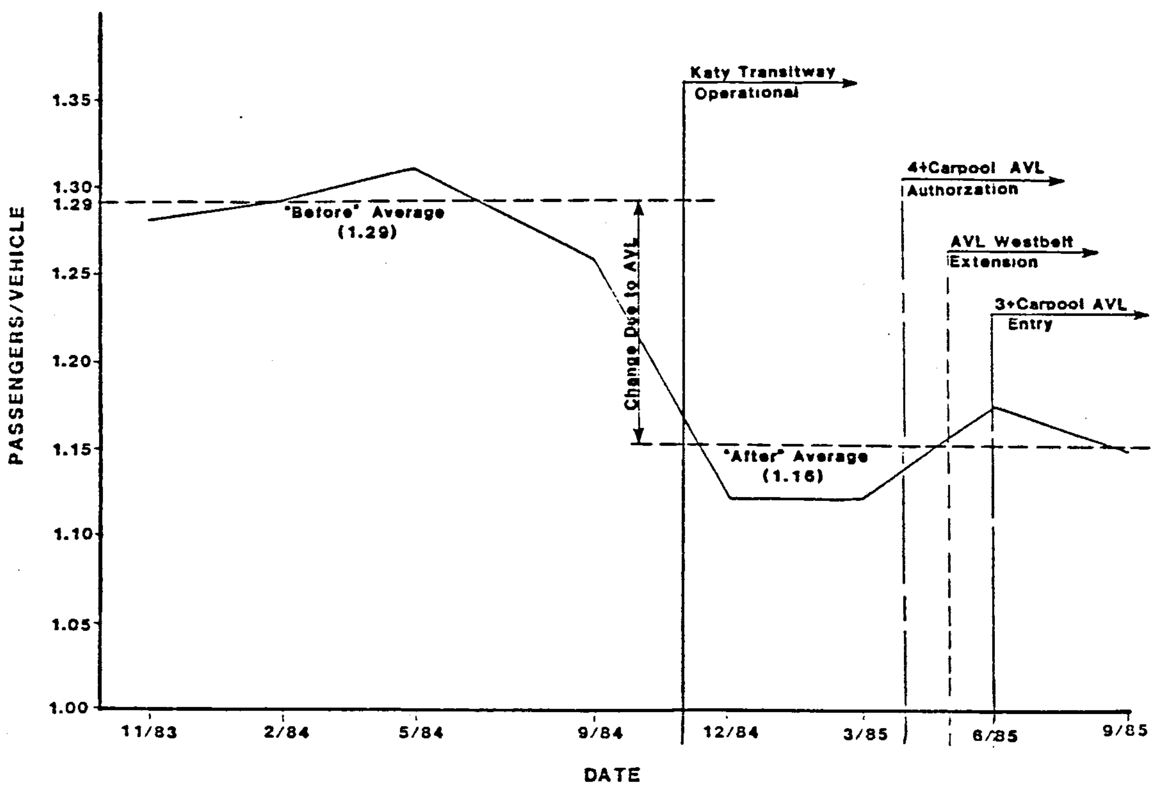
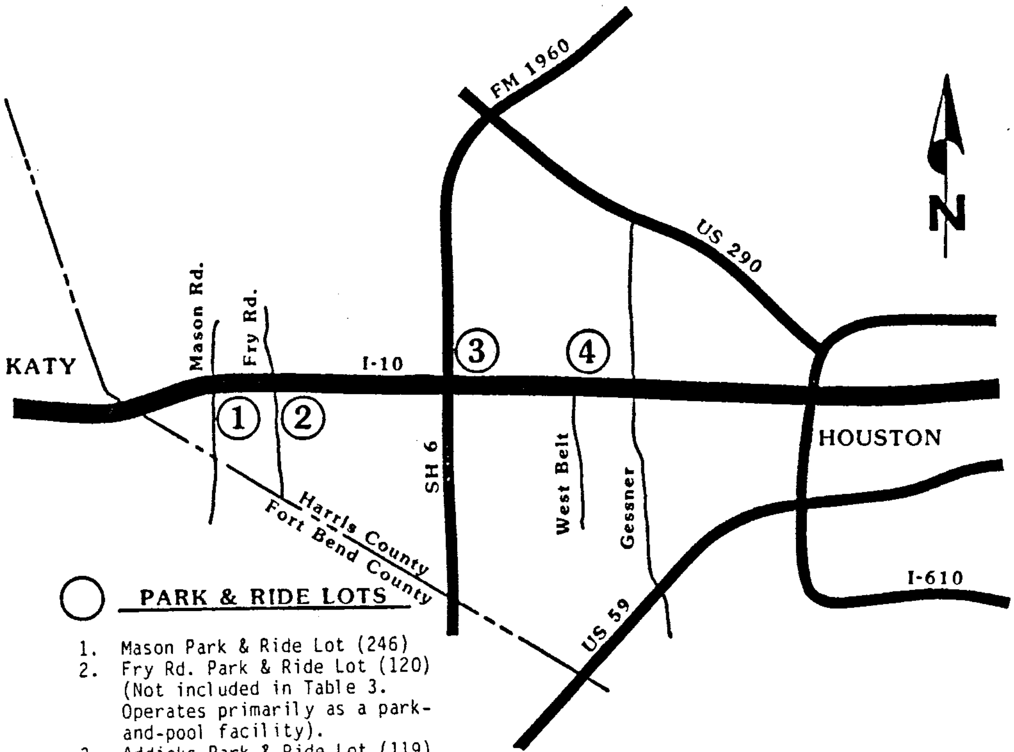


Figure 24. Mainlane Occupancy Rates



1. Mason Park & Ride Lot (246)
2. Fry Rd. Park & Ride Lot (120) (Not included in Table 3. Operates primarily as a park-and-pool facility).
3. Addicks Park & Ride Lot (119)
4. West Belt Park & Ride Lot (1196)

Figure 25. Katy Freeway Corridor Park-and-Ride Facilities

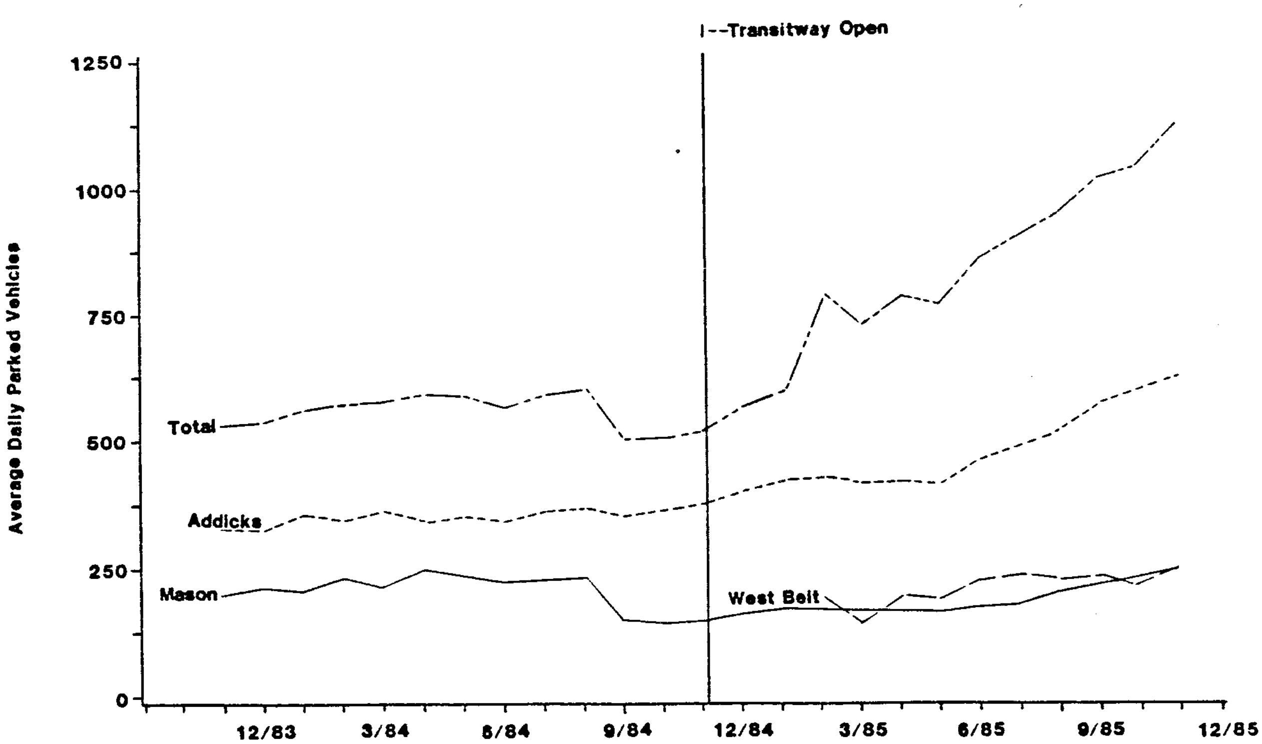


Figure 26. Park-and-Ride Demand

Table 6. Katy Freeway Park-and-Ride Demand Totals

Total Parked Vehicles					
	Park-and-Ride Lot				
Month	Mason	Addicks	W. Belt*	Total	Cum. % Change
Nov. 84	147	378	--	525	--
Dec. 84	162	335	--	497	-5%
Jan. 85	173	425	--	598	14%
Feb. 85	171	430	191	792	51%
Mar. 85	170	420	144	734	40%
Apr. 85	167	423	197	787	50%
May 85	165	417	189	771	47%
Jun. 85	175	461	226	862	64%
Jul. 85	180	492	237	909	73%
Aug. 85	203	522	228	953	82%
Sep. 85	216	573	231	1,020	94%
Oct. 85	226	600	215	1,041	98%

*Operational January 28, 1985

A major park-and-ride lot was opened by METRO near the West Belt cross street to I-10W in late January, 1985 to support the Katy Transitway. This facility has a capacity of 1,111 parked vehicles. After seven months of operation, approximately 230 vehicles were utilizing the lot, with an average of 12 buses per peak period accessing the transitway from the lot (Table 6). This represents a growth rate for the West Belt lot of approximately 20% in the seven months following the initial opening of the lot (as compared to the first month's utilization rate). Since this initial growth phase, however, West Belt park-and-ride lot utilization (as measured by parked vehicles) has remained stable at the level recorded seven months after operation of the lot commenced.

Transitway Peaking Characteristics

Transitway vehicle demand has exhibited peaking characteristics which have gradually changed as the year progressed. In the first month of operation, both the morning and the afternoon distribution patterns were similar (Figures 27 and 28). Bus volumes showed only slight peaking, with the highest volumes being observed between 7:00 and 7:15 in the morning the between 4:45 and 5:00 in the afternoon. Unlike the bus volumes, vanpool volumes peaked more sharply and at two distinct times. The double peaking effect was even more pronounced in the afternoon than in the morning. In the morning, the two peaks occurred between 6:30 and 6:45 A.M. and then between 7:00 and 7:15 A.M. In the afternoon, the two peaks occurred between 4:30 and 4:45 P.M. and then again between 5:15 and 5:30 P.M. Overall, approximately 70% of the morning and 60% of the afternoon peak period volume was recorded in the peak hour of operation. Further, about 30% of the peak hour volume was recorded within the peak 15-minutes. This percentage had increased 40% before the introduction of carpools into the transitway. Since the introduction of carpools, the peak 15-minute volume has declined back to the 30% level previously observed, and peak hour volumes have decreased to 60% of peak period volumes in the morning and 50% in the afternoon, although absolute volumes have increased in both the peak 15-minute and the peak hour. Demand has simply increased more uniformly across the entire peak period as opposed to over the peak 15-minute or the peak hour.

Since the first month of operation, peaking patterns have gradually shifted. Within five months after the transitway began operating, the double peaking of morning vanpool volumes ceased. The later peak subsided, and the earlier peak, between 6:30 and 6:45 A.M., maintained its prominence. As shown in Figure 29, regardless of the introduction of carpools, the morning vanpool volumes continue to peak between 6:30 and 6:45 A.M., bus volumes continue to peak between 7:00 and 7:15 A.M., and carpool volumes are gently peaking between 7:15 and 7:30 A.M.

Afternoon peaking patterns have also changed, but in a different manner from the morning distribution patterns (Figure 30). Unlike the morning vanpool volumes, the afternoon vanpool volumes continue to peak at two distinct times. The main difference appears to be that the times when these peaks occur have shifted 15 minutes earlier. The vanpool peaks are now occurring between 4:15 and 4:30 P.M. and between 5:00 and 5:15 P.M. Carpools distribution patterns have changed from month to month in the afternoons.

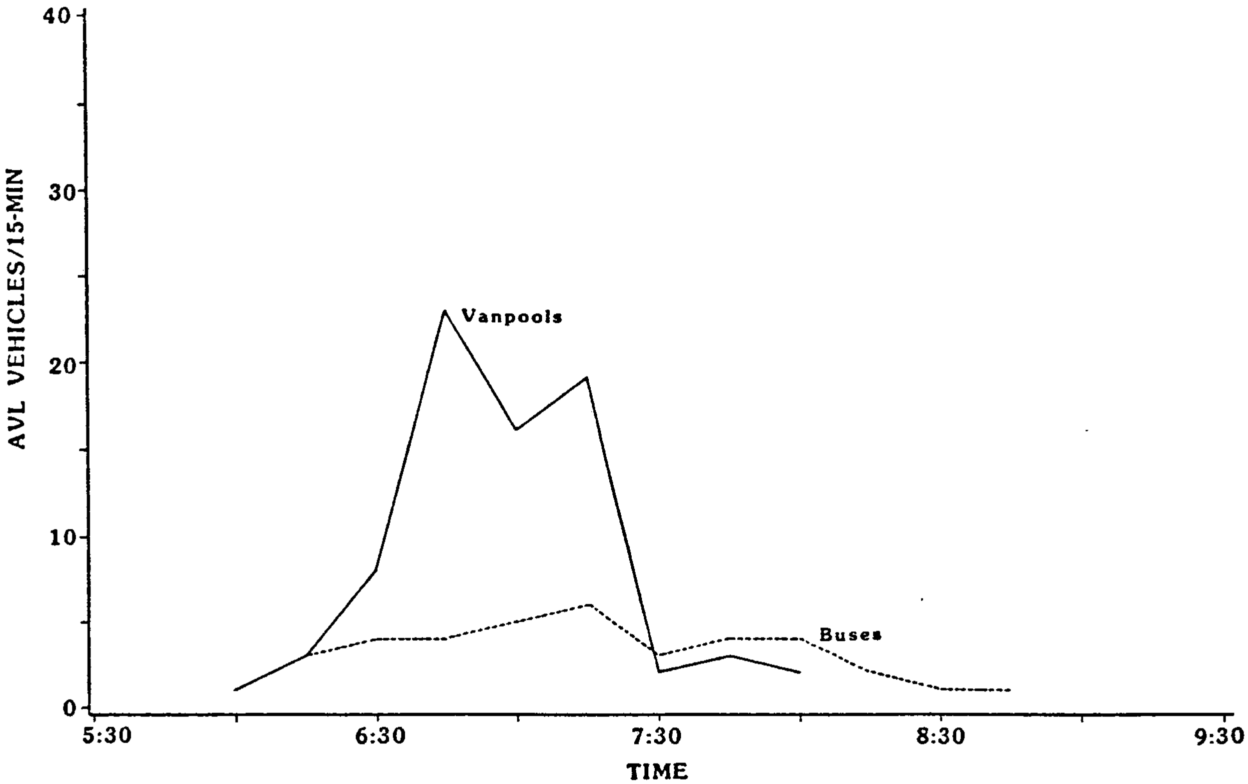


Figure 27. Morning Transitway Volumes by 15-Minute Increments, November 1984

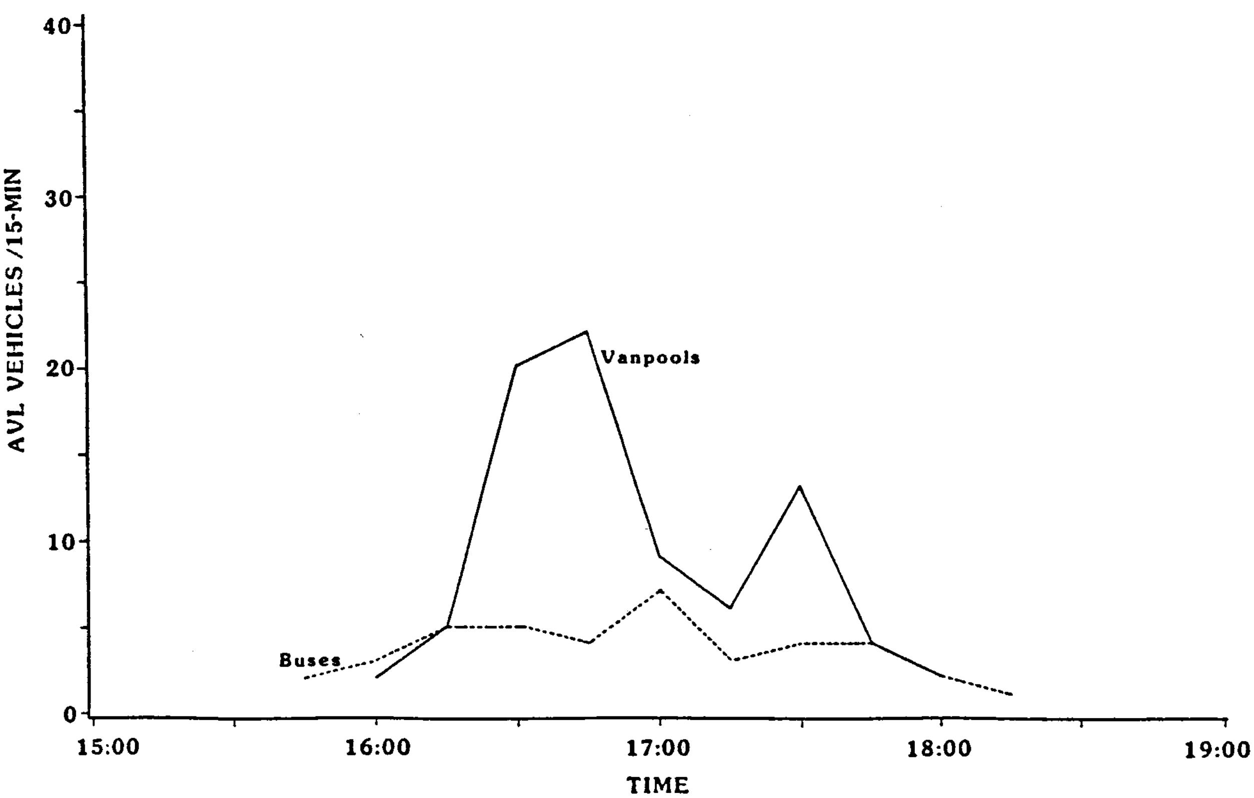


Figure 28. Afternoon Transitway Volumes by 15-Minute Increments, November 1984

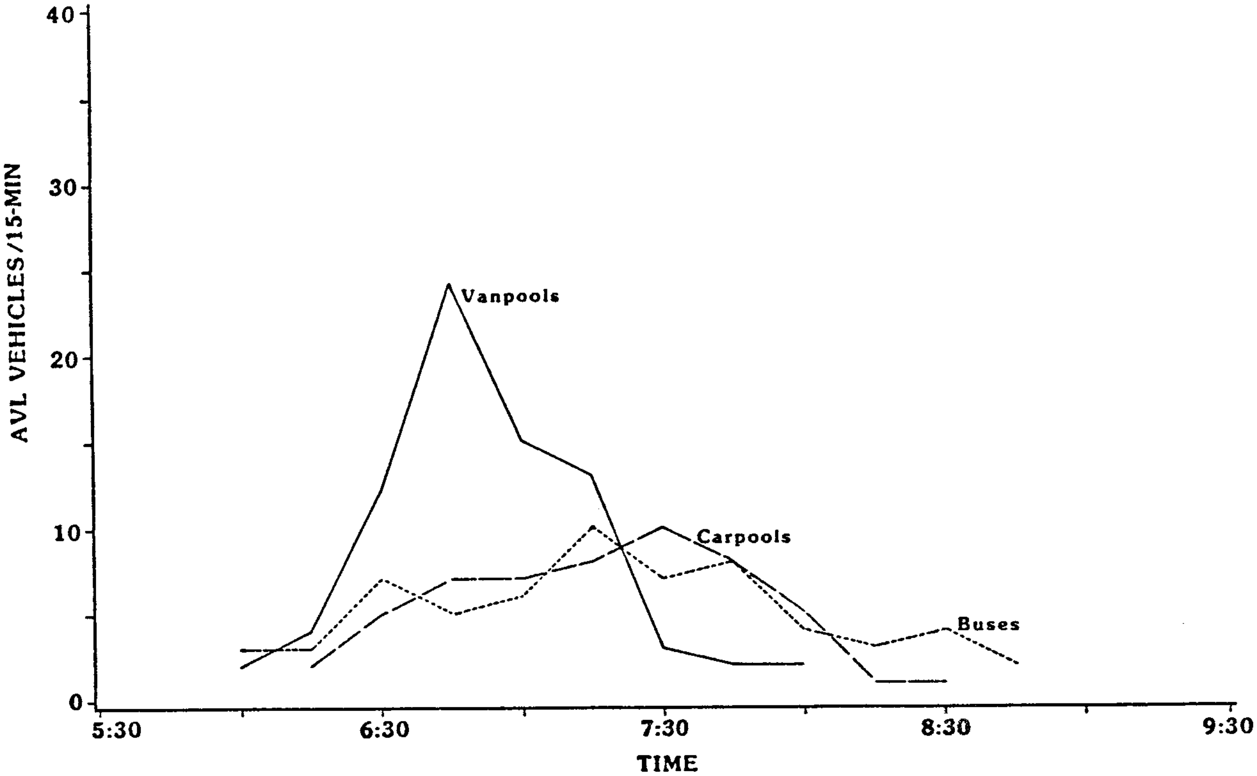


Figure 29. Morning Transitway Volumes by 15-Minute Increments, April 1985

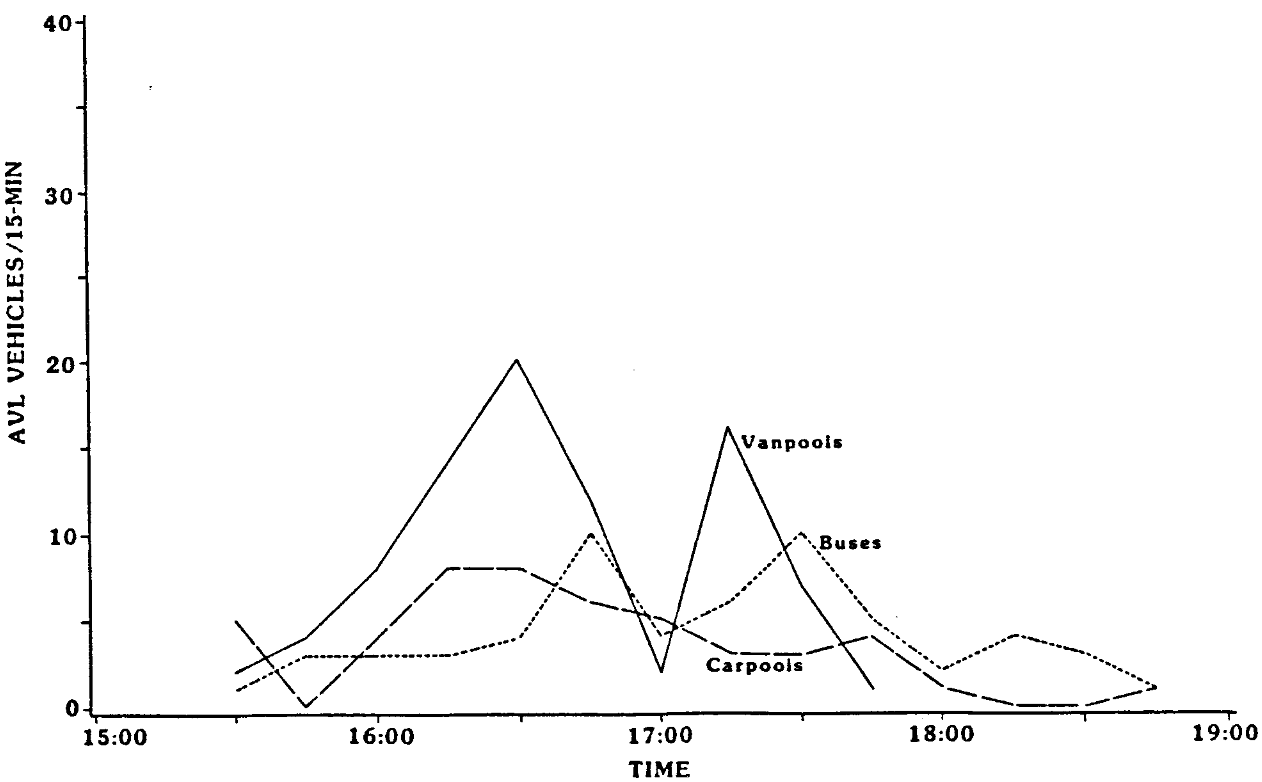


Figure 30. Afternoon Transitway Volumes by 15-Minute Increments, April 1985

Most recently, carpool volumes have been peaking between 4:00 and 4:30 P.M., although just the month before they were peaking between 4:30 and 4:45 P.M. Afternoon bus volume distribution patterns have been shifting irregularly in this first year of operation. The latest month's observations have indicated a possible double peaking of bus volumes. It is likely, however, that these peaks are more attributable to daily variations in bus schedule adherence due to traffic conditions encountered before entering the transitway (i.e. traffic congestion on the Katy Freeway outbound in the afternoon could result in a platooning of buses on the freeway). The stronger peak appears to be occurring between 5:15 and 5:30 P.M.

Comparative Travel Times

In February and March of 1985, travel time studies were conducted to measure the effect of the opening of the Katy AVL from Gessner to Post Oak. Additional studies were also made after the AVL was extended to West Belt on May 2, 1985. The results of these studies were published in "The Impacts of Carpool Utilization on the Katy Freeway Authorized Vehicle Lane 'Before' Data" in July 1985 and are summarized in the following discussion (5).

The study length of 13.2 miles extended from SH 6 to the S.P.R.R. overpass east of Washington Avenue. It was divided into 4 sections and numbered in the direction of travel as shown in Table 7 and Figure 31. Travel time runs were made at 15 minute intervals on the freeway mainlanes and at more frequent intervals on the AVL and Katy Road/Washington Avenue route.

Table 7. Section Limits for Travel Time Runs*

Section Number		Limits of Section
AM Designation	PM Designation	
1	4	SH 6 to the West Belt Access Ramps to the AVL (4.6 mi.)
2	3	West Belt Access Ramps to the Gessner Access Ramps (1.7 mi.)
3	2	Gessner Access Ramps to the east terminus of the AVL at Post Oak (4.7 mi.)
4	1	Post Oak to the S.P.R.R. overpass of I-10 (2.2 mi.)

*Source (5)

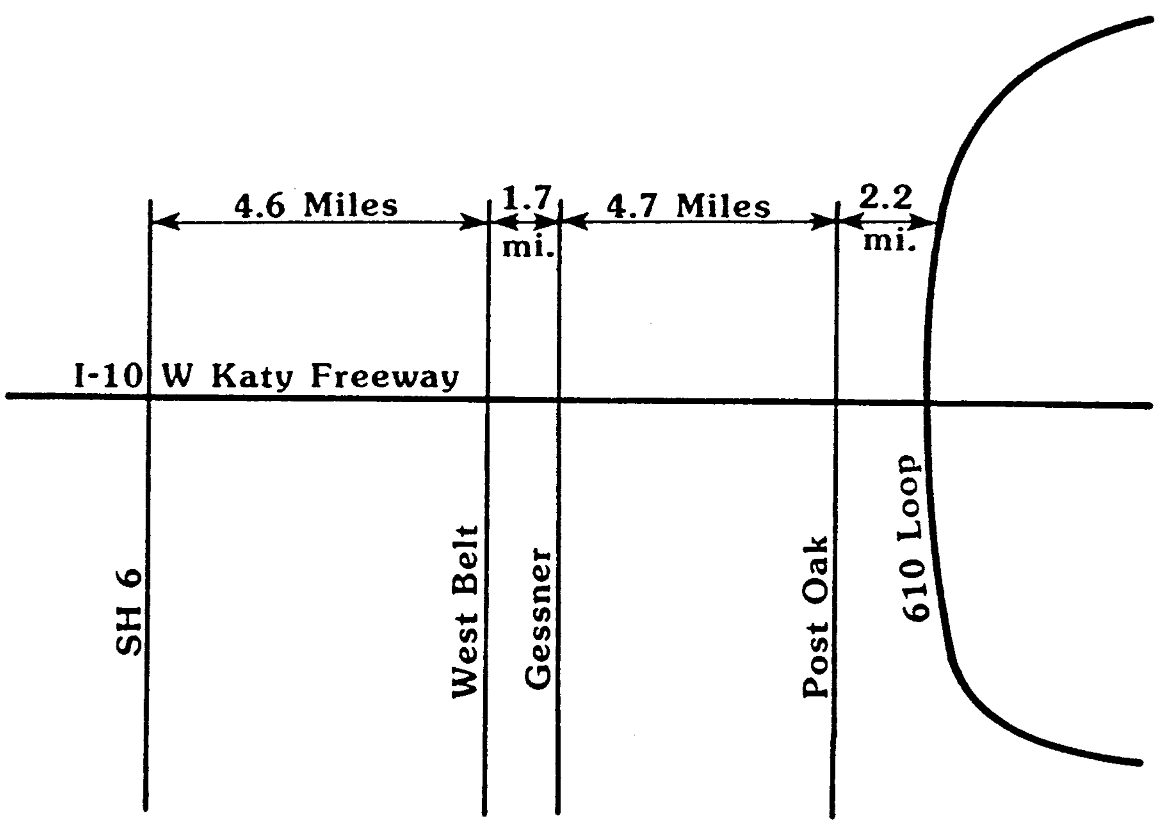


Figure 31. Section Limits for Travel Time Runs

AM Peak Period

As illustrated in Figure 32, morning travel times vary by time of day as traffic congestion develops on the freeway lanes within the study sections. Overall, for the three hour peak period, travel times for non-AVL traffic averaged approximately 26.5 minutes (30 mph) from SH 6 to the S.P.R.R. overpass. The corresponding travel times for AVL traffic averaged approximately 23.6 minutes (33.6 mph) with the AVL operating from Gessner, and 21.1 minutes (36.5 mph) with the AVL operating as far as West Belt.

Since the majority of the AVL traffic uses the lane during the 2 hours when traffic congestion peaks, travel times and speed impacts of the AVL are more substantial during this time period (Table 8). For the non-AVL user,

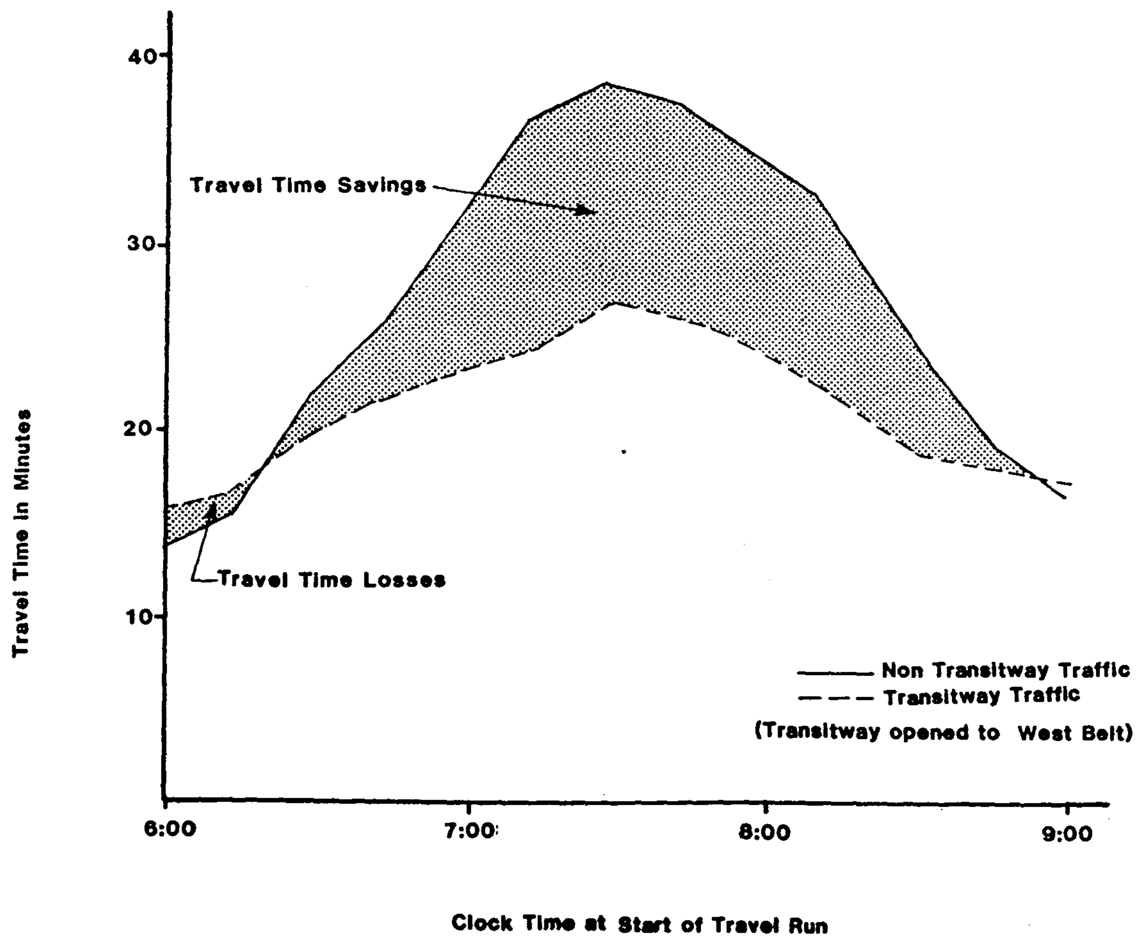


Figure 32. Katy Corridor Travel Times, A.M. Eastbound, SH 6 to S.P.R.R.

the average travel time is 30.6 minutes (26 mph). The corresponding measures of travel time and speed for the transitway traffic during the 2-hour peak are 26.5 minutes with the AVL open to Gessner and 23.5 minutes with the AVL open to West Belt. This translates into an average savings of 4.1 minutes with the AVL open to Gessner and 7.1 minutes with the AVL open to West Belt. A disaggregate analysis of travel times in the individual sections provides additional information.

Table 8. Eastbound A.M. Travel Times and Average Speeds, Freeway Mainlanes and Katy Transitway, Katy Freeway, SH 6 to S.P.R.R. (13.2 miles)*

Traffic and Time Period	Average Travel Time (minutes)	Average Speed (MPH)
3-hour Period, 6-9 a.m.		
Non AVL Traffic	26.5	30
AVL Traffic-Gessner Entrance	23.6	34
AVL Traffic-West Belt Entrance	21.2	37
2-Hour Period, 6:30-8:30 a.m.		
Non AVL Traffic	30.6	26
AVL Traffic-Gessner Entrance	26.5	30
AVL Traffic-West Belt Entrance	23.5	34

*Source (5)

The travel times in section 1 (from the 4.5 miles SH 6 to the West Belt access to the AVL) have the greatest variability. This variability is the result of the fluctuating traffic flow rates that load the freeway from the west. The length of congestion varies from zero to the entire 4.6 mile length of the section. AVL, as well as non-AVL, traffic operates in this section under mixed flow conditions. Overall, however, travel times average approximately 10.2 minutes (27 mph) over the three-hour peak-period and approximately 12.6 minutes (22 mph) over the two hour peak period (Table 9).

Table 9. Eastbound A.M. Average Travel Times and Speeds (By Section)*

Section	Time Period	Average Travel Time		Average Speed	
		Non-AVL	AVL	Non-AVL	AVL
1	6-9 a.m.	10.2	10.2	27	27
	6:30-8:30 a.m.	12.6	12.6	22	22
2	6-9 a.m.	4.3	1.9	24	55
	6:30-8:30 a.m.	4.9	1.9	21	55
3	6-9 a.m.	9.1	5.1	29	55
	6:30-8:30 a.m.	10.9	5.1	26	55
4	6-9 a.m.	2.4	4.0	55	33
	6:30-8:30 a.m.	2.4	4.0	55	33

*Source (5)

Travel times in this section indicate that an additional potential average time savings of 7.6 minutes in travel times in this section alone may be realized by AVL traffic once the AVL is extended to SH 6.

The 1.7 mile section (section 2) from West Belt to Gessner was included in the first phase of construction but was not opened to AVL traffic until May 2, 1985. As shown in Table 9, travel time savings in this short section average 3 minutes for AVL traffic.

Section 3 (4.7 miles, from Gessner access ramp to eastern terminus at Post Oak) has a directional freeway cross section of 3 lanes to the Wirt freeway entrance ramp (3.5 miles) and then 4 lanes for the remaining 1.2 miles. Traffic congestion normally extends only to the Wirt entrance ramp and, thus, the average speeds on the freeway increase after the Wirt entrance. Average travel time savings of 6 minutes accrue to AVL traffic in this section (Table 9).

The last section covers the 2.2 mile distance from Post Oak to the S.P.R.R. overpass. The AVL traffic uses Old Katy Road to Washington Avenue, where it enters the I-10 eastbound lanes. Freeway travel speeds during the A.M. peak period are high in this section, except for traffic exiting at the I-610 interchange. The average freeway travel time and speeds are 2.4

minutes and 55 mph throughout the peak period. Because of a combination of lower speed limits and traffic signal delays at both Post Oak and Washington, the average travel times and speeds for AVL traffic in this section are 4 minutes and 33 mph. Consequently, AVL traffic loses about 1.6 minutes in this section (Table 9).

PM Peak Period

Afternoon travel times exhibit a variability similar to morning travel times (Figure 33). Congestion normally extends beyond Gessner (into section 3) during the peak hour, and speeds from the S.P.R.R. overpass to Post Oak vary according to the loading flow rates from the downtown CBD. Over the three hour afternoon peak period, travel times on the freeway mainlanes averaged about 21.3 minutes (37 mph) from the S.P.R.R. overpass to SH 6. The comparable travel times for AVL traffic averaged about 18.8 minutes (42 mph) with the AVL operational to Gessner and 16.3 minutes (49 mph) with the AVL

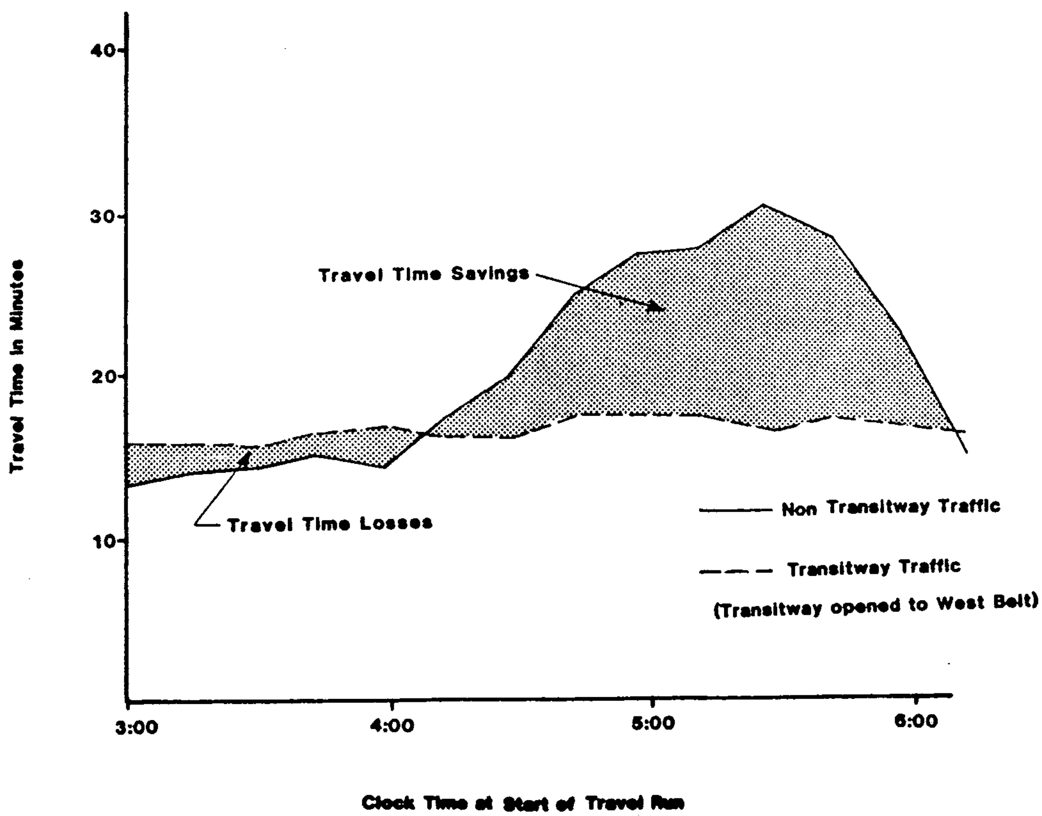


Figure 33. Katy Corridor Travel Times, P.M. Westbound, S.P.R.R. to SH 6

operational to West Belt. Over the two-hour peak period, freeway mainlane travel times increased to an average of 24.7 minutes (32 mph). Meanwhile, AVL travel times increased only to 19.1 minutes (41 mph) as far as the Gessner terminus and to 16.6 minutes (48 mph) as far as the West Belt terminus (Table 10). These two hour peak period travel times translate into average time savings of 5.6 minutes for AVL traffic using the Gessner exit and of 8.1 minutes with the West Belt terminus.

Travel times within the first section, the 2.2 miles between the S.P.R.R. overpass and Post Oak, vary. Although the average speed was measured at 40 mph, speeds in this section often drop into the 20-30 mph range. This wide variation in speeds results from the fact that traffic from Washington approaches I-610 in 5 lanes, but only 2 lanes continue west on I-10. Consequently, this section can become overloaded in the peak period and, thus, lower speeds can result. In contrast, the travel times for AVL traffic fluctuate only slightly due to variable delays experienced at traffic signals with an average speed of approximately 33 mph (Table 11).

Table 10. Westbound P.M. Travel Times and Average Speeds, Freeway Mainlanes and Katy AVL, Katy Freeway, S.P.R.R. Overpass to SH 6 (13.2 mi.)*

Traffic and Time Period	Average Travel Time (Minutes)	Average Speed (MPH)
3-hour period, 3:15-6:15 p.m.		
Non AVL Traffic	21.3	37
AVL Traffic-Gessner Exit	18.8	42
AVL Traffic-West Belt Exit	16.3	49
2-hour period, 4:15-6:15 p.m.		
Non AVL Traffic	24.7	32
AVL Traffic-Gessner Exit	19.1	41
AVL Traffic-West Belt Exit	16.6	48

*Source (5)

Table 11. Westbound P.M. Average Travel Times and Speeds (By Section)*

Section	Time Period	Average Travel Time		Average Speed	
		Non-AVL	AVL	Non-AVL	AVL
1	3:15-6:15 pm	3.0	4.0	44	33
	4:15-6:15 pm	3.3	4.0	40	33
2	3:15-6:15 pm	8.6	5.1	33	55
	4:15-6:15 pm	11.4	5.1	25	55
3	3:15-6:15 pm	3.4	1.9	30	55
	4:15-6:16 pm	3.3	1.9	26	55
4	3:15-6:15 pm	5.6	5.6	49	49
	4:15-6:15 pm	5.9	5.9	47	47

*Source (5)

From Post Oak to Gessner, section 2, severe congestion causes average speeds to drop to less than 30 mph on the mainlanes and results in a travel time savings of approximately 6.3 minutes for AVL traffic. The same congestion that exists in section 2 extends into section 3, Gessner to West Belt. As a result, mainlane speeds average 26 mph, and travel time savings of 2 minutes may be realized by AVL traffic. In the fourth and last section, from West Belt to SH 6, AVL traffic must reenter mixed flow operation. Since the last bottleneck occurs at Westview, approximately 1 mile west of the AVL exit, average speeds are relatively high in this section (approximately 49 mph). These average travel times and speeds are summarized in Table 11.

Despite the travel time losses that are incurred within the Post Oak to S.P.R.R. section during both the morning and the afternoon peak periods, overall, AVL traffic saves approximately 4 minutes if travelling only to Gessner and seven minutes if traveling through to West Belt in the morning. In the afternoon, the travel time savings are even more substantial with 6 minutes saved if using the AVL to Gessner and 8 minutes saved, if using the AVL to the West Belt terminus. Direct comparisons of AVL and non-AVL travel time runs indicate an average two-hour peak-period travel time savings of approximately 8 minutes per person per trip between SH 6 and the S.P.R.R. overpass. As shown in Figures 32 and 33, the maximum time savings of approximately 10 minutes in the morning and 12 minutes in the afternoon may be realized at 7:30 A.M. and at 4:30 P.M.

Transitway Operations

Operation of the transitway, at this time, is controlled manually by an on-site Metro crew. This crew consists of a transit police officer, a wrecker driver, and a traffic control worker. These persons open the inbound transitway by 5:45 a.m. and close the transitway by 9:15 a.m.. In the afternoon, the transitway is open for out bound traffic from 3:30 to 7:00 p.m.

The transit police officer is on duty at the eastern terminus to handle emergencies and to warn or to ticket unauthorized patrons using the transitway lane. The wrecker and driver are situated at the western transitway entrance to handle emergencies and to remove immobile vehicles stranded on the facility. In order to improve maneuverability within the transitway cross-section, the wrecker was specially designed with a shorter than normal wheel base (thus allowing a tighter turning radius). A photograph of this wrecker is provided in Figure 34.

Figure 34. Transitway Wrecker

A few problems have arisen since the transitway became operational. These problems involve various aspects of the maintenance, signing, enforcement, geometrics, and lighting of the transitway. First, the wording currently displayed on METRO ("3 passenger carpools may use transitway") and State ("authorized 3 passenger carpools may use transitway") message signs appear to be misleading to the public (Figure 35). Apparently, some non-users are interpreting the signs to be saying that anyone with 3 passengers/vehicle is "authorized" to use the transitway. Second, the apprehension of unauthorized vehicles entering the transitway has been difficult because enforcement vehicles are positioned at only one end of the transitway. Although violations occur at an average rate of 12 vehicles per month, only 2 to 3 citations (with a maximum fine of $200) per month have been issued over the first year of operation (6). Fourth, of the few accidents that have occurred involving the transitway since the transitway became operational (an average of approximately 1 every 2 months), a great majority have involved speeding, out of control vehicles on the mainlanes that have hit transitway signs and crash barriers (especially at the Gessner access/egress location) (6). Fifth, although the transitway has a design width of 19.5 feet over most of its length, the width is reduced to 17.5 feet within those segments where lane control signals and changeable message signs are located. This width reduction becomes a problem when vehicles become disabled within these sections. The facility is more easily blocked since there is less room for passing, and the wrecker is even more constrained in its maneuverability, thus inhibiting the swift clearance of the incident. Lastly, some transitway users have expressed concern over the headlight glare from on coming traffic in the mainlanes as well as the desirability of having high mast lighting or lights on the concrete median barriers in order to enhance visibility within the transitway.

Overall, despite the problems described above, the Katy Transitway has been operating smoothly. An average of less than two disabled vehicle incidents occur per month, and of these disabled vehicles, less than 25% need to be towed out of the facility (6). For those disabled vehicles not requiring towing, a METRO pickup truck is dispatched either to push the vehicle out of the facility or to offer short term remedies (e.g., temporarily reinflating low tires). Only twice has the transitway been completely closed due to

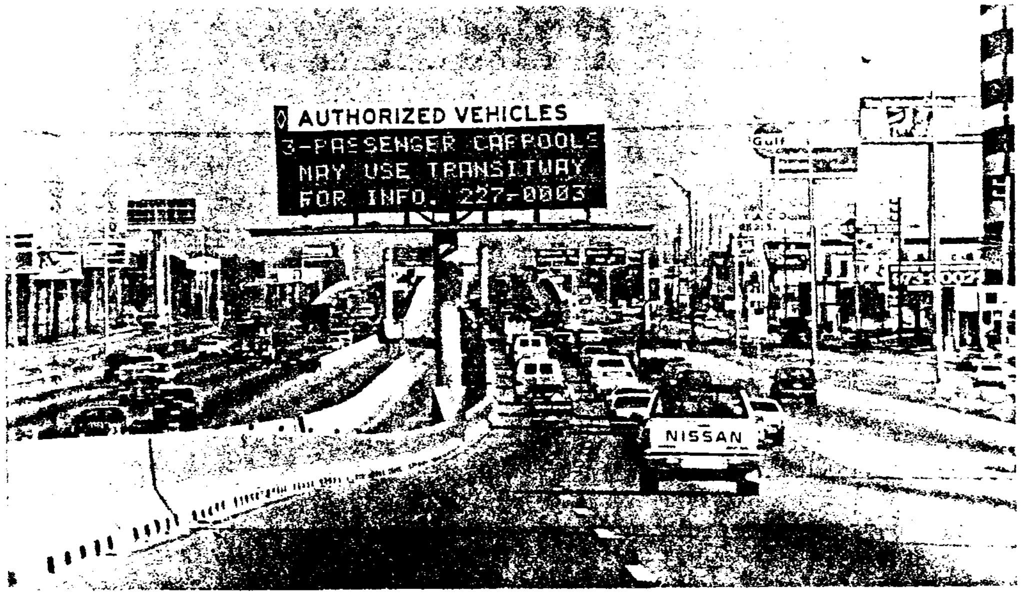


Figure 35. Carpool Signing

accidents on the mainlanes, and the transitway has been blocked only five times three incidents of which lasted longer than 20 minutes since it began operation at the end of October 1985 (6).

Surveillance, Communication, and Control

Currently, a number of signs and lane control signals are used to direct transitway traffic through the facility (Figures 36-47). Changeable message signs are used at each end of the transitway to inform vehicles and the public about the facility. Lane control signals, displaying a red "X" or a green or yellow arrow, verify the direction and conditions of transitway operation. Finally, traffic guide signs direct vehicles from connecting arterials to the transitway entrance. Currently, all signs and lane control signals within the transitway are controlled manually on the facility at opening and closing each day. Within the next few months, all transitway signs and signals are scheduled to be remotely controlled by computer with operator intervention.

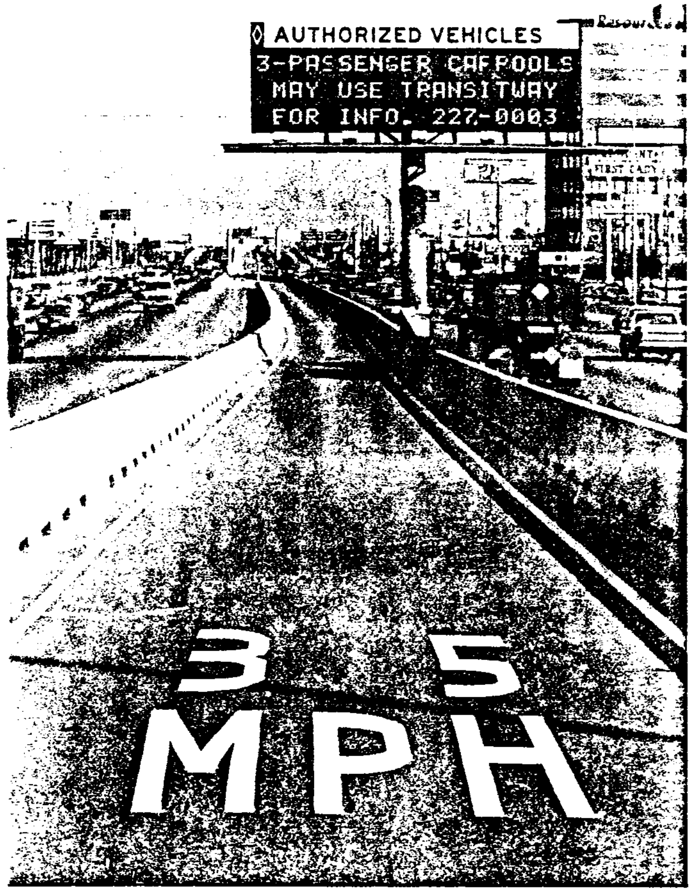


Figure 38. Speed Zones Near Access/Egress Locations

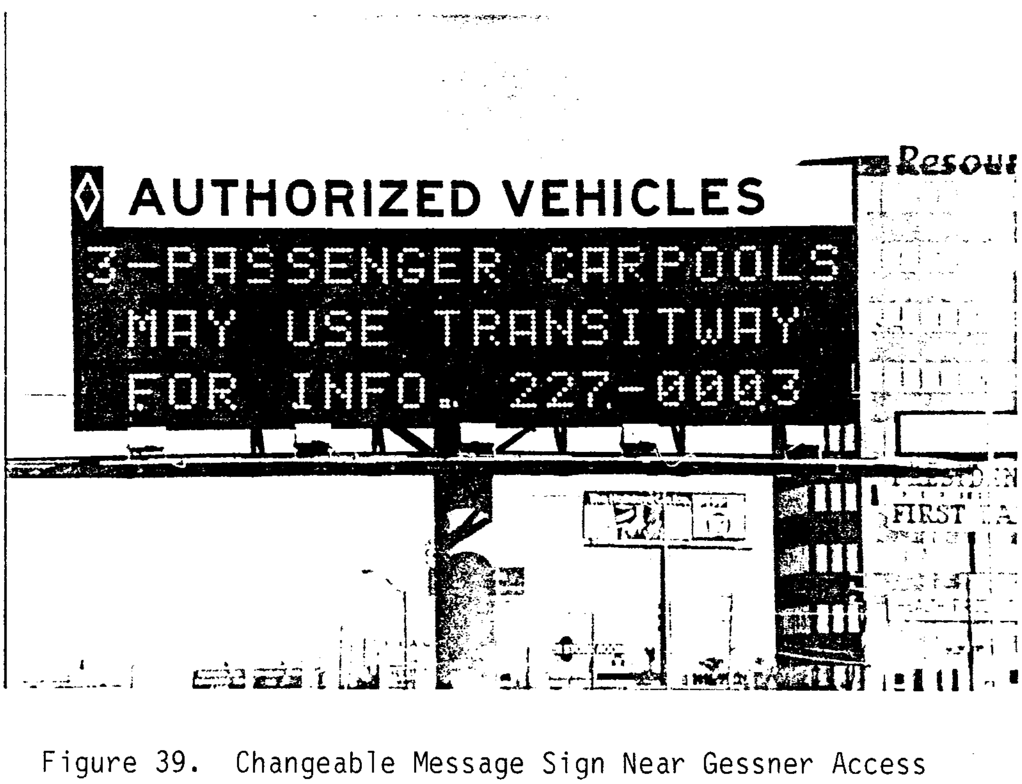


Figure 39. Changeable Message Sign Near Gessner Access

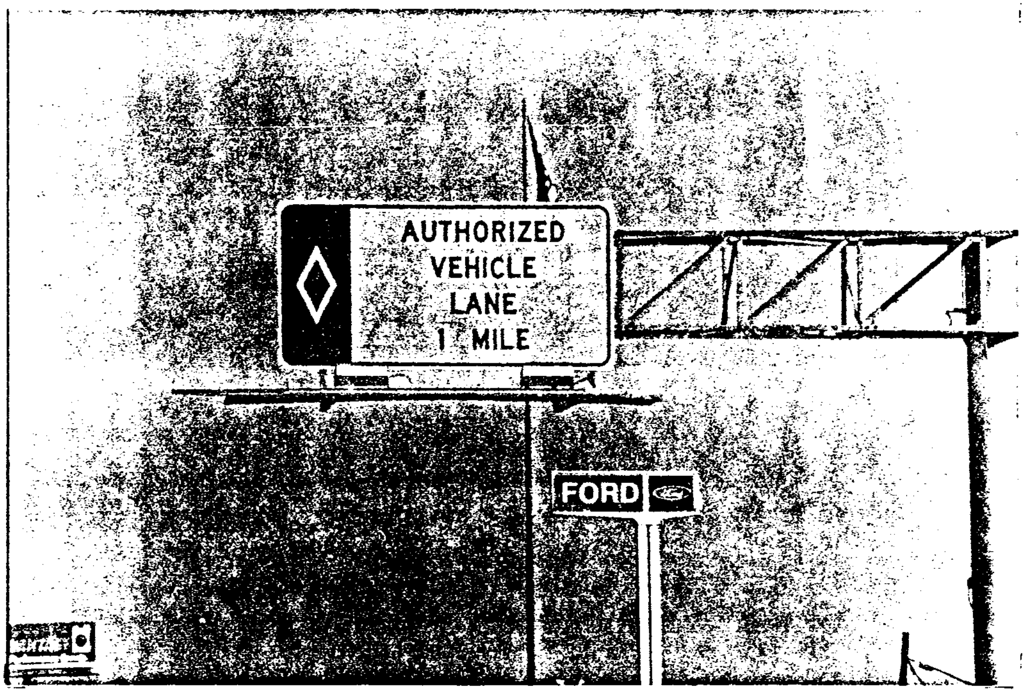


Figure 40. Freeway Traffic Guide Sign

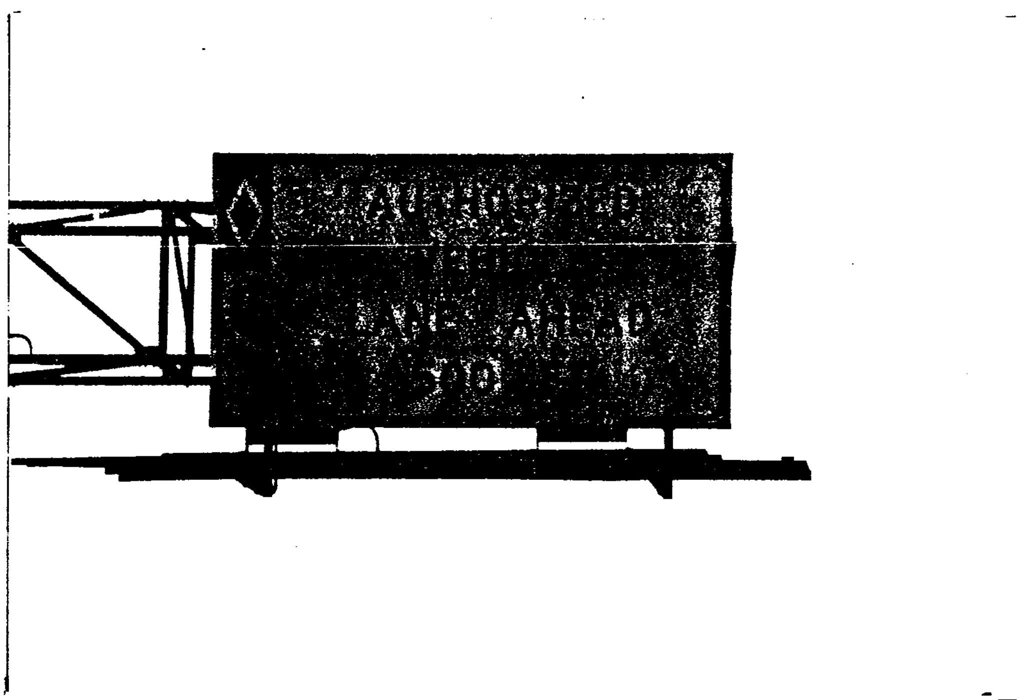


Figure 41. Surface Street Traffic Guide Sign

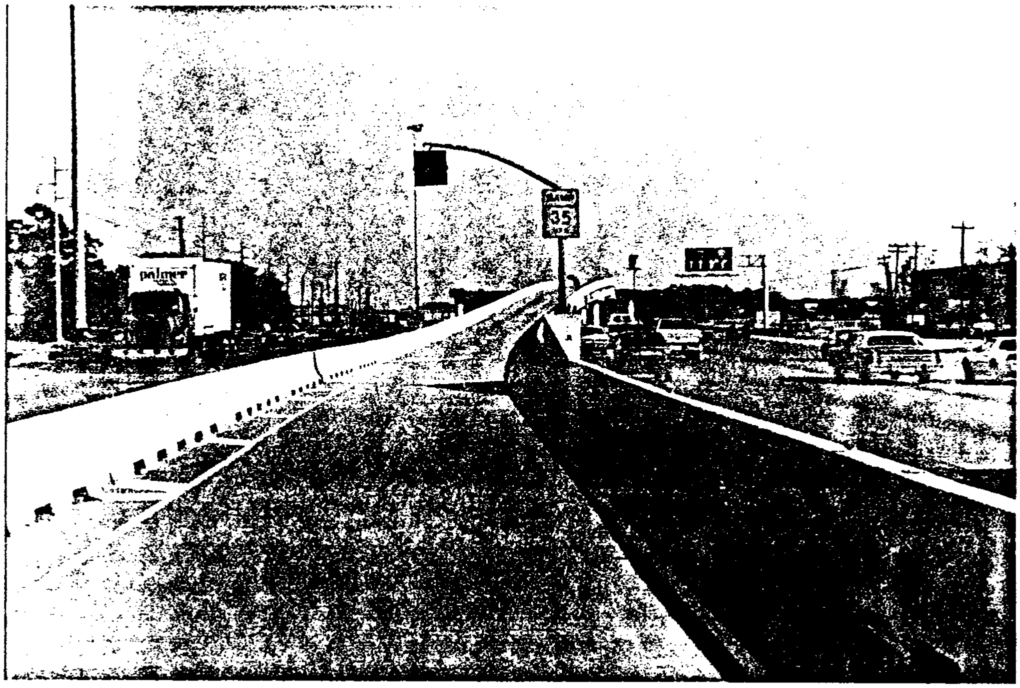


Figure 42. Speed Zone At Flyover Ramp At Eastern Terminus

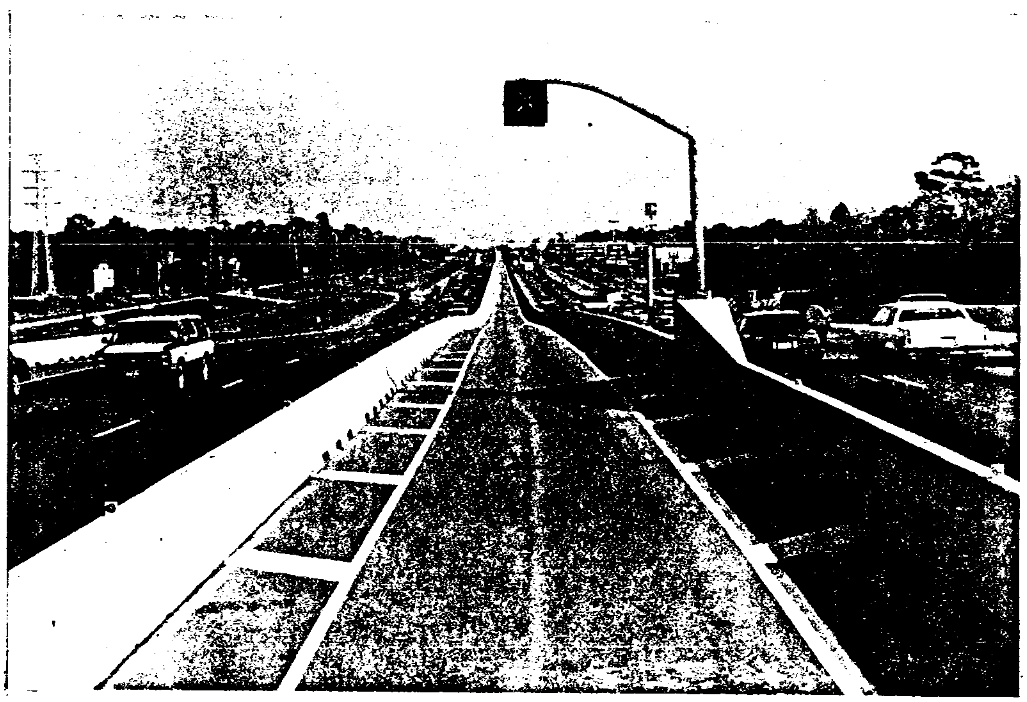


Figure 43. Lane Control Signal

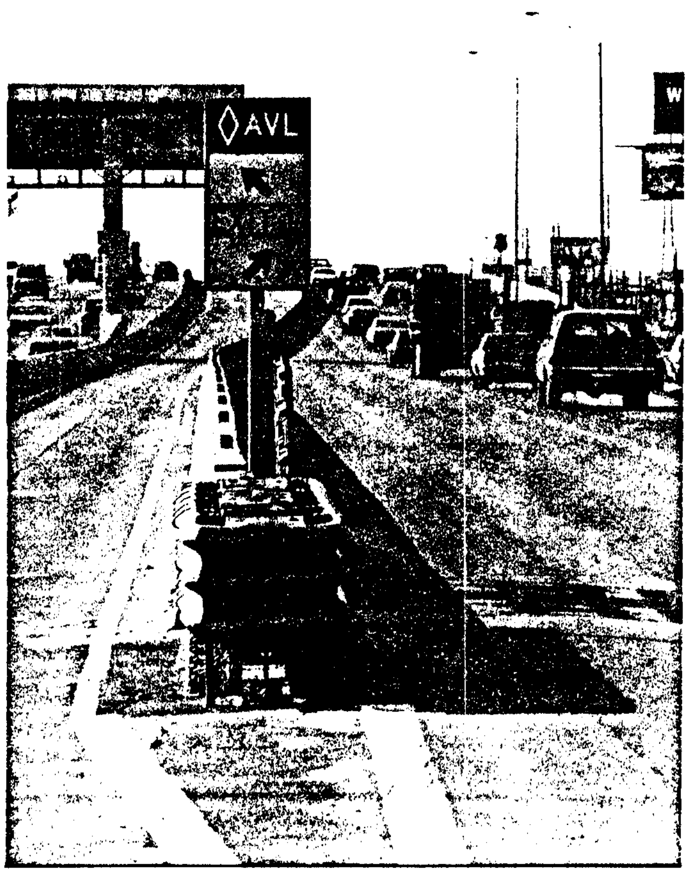


Figure 44. Transitway Signing at Gessner Egress

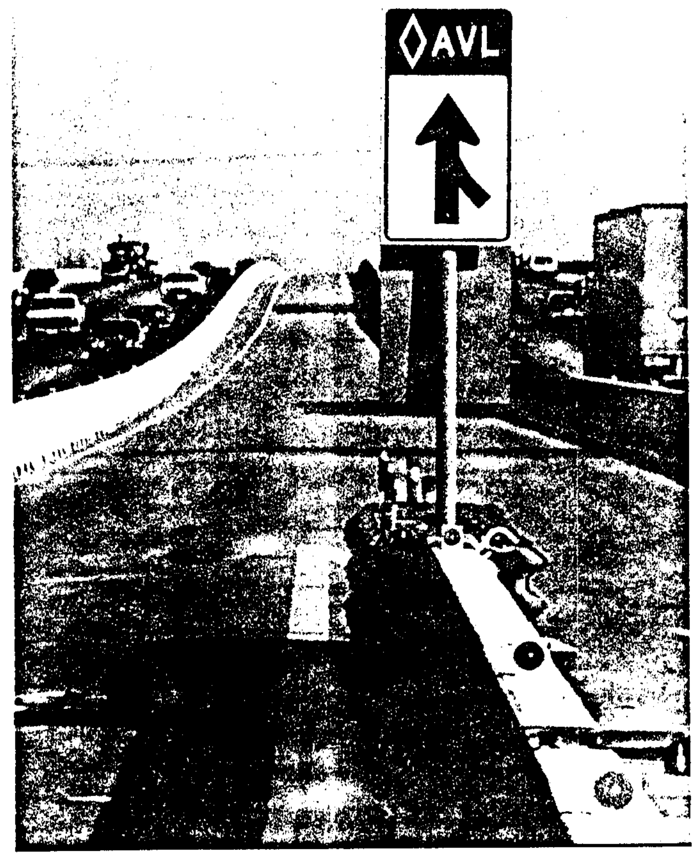


Figure 45. Transitway Signing at Gessner Access

Figure 46. Closure Signing During Non-Operating Hours

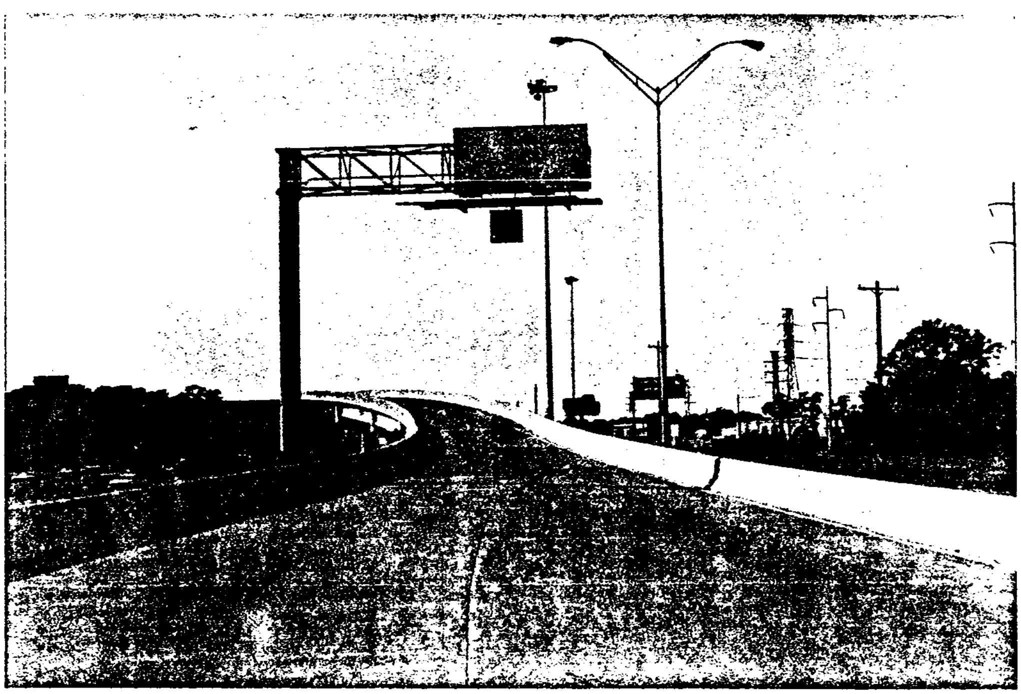


Figure 47. Signing, Eastern Terminus

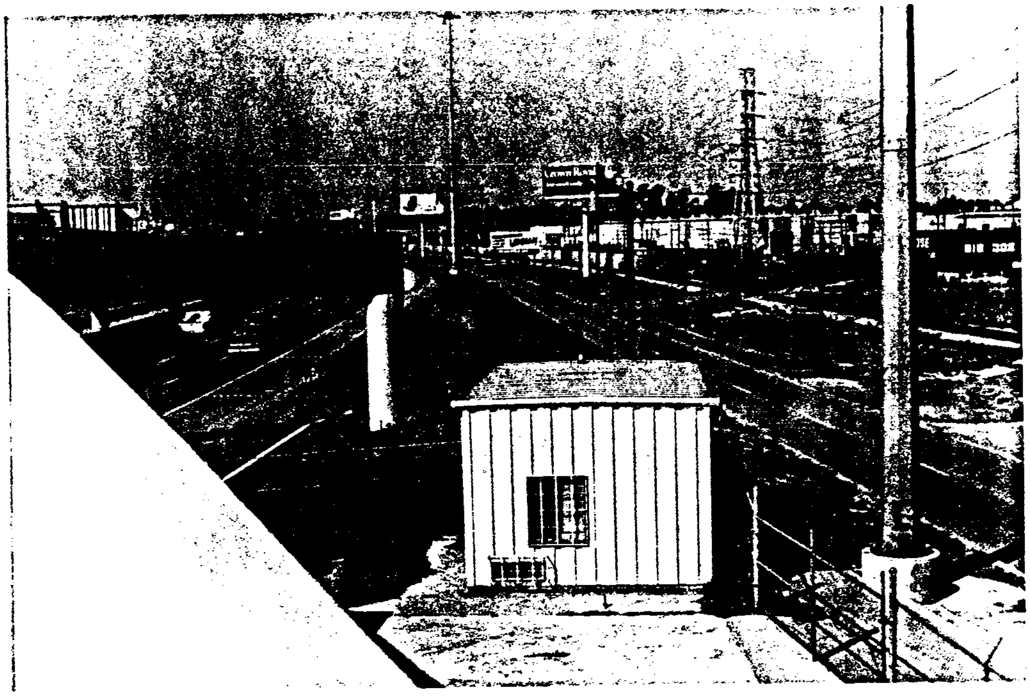


Figure 48. Exterior of Katy Transitway SC&C Satellite Building

Figure 49. Interior of Katy Transitway SC&C Satellite Building

Figure 50. Afternoon Peak Period Congestion

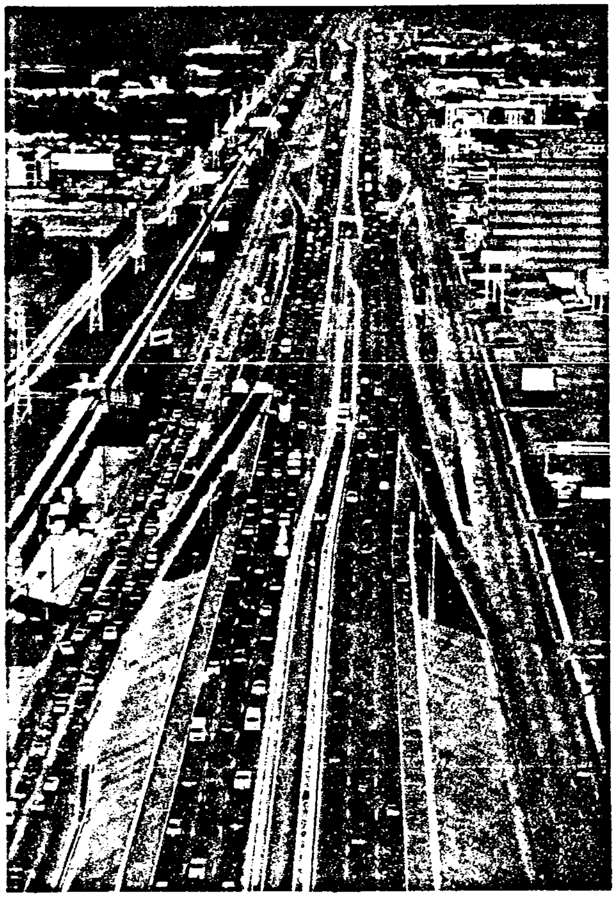


Figure 51. Afternoon Peak Period Operation at Gessner Terminus

The primary function of the automated surveillance, communications, and control (SC&C) system on the Katy Transitway is to enhance operating efficiency and safety within the facility. For example, with the SC&C system, the transitway will be under surveillance and, thus, the time to detect and to respond properly to transitway incidents can be minimized. The complete SC&C system will provide traffic control, user communication, and incident management capabilities for the operation of the Katy Transitway. The system will be comprised of the following elements:

- Overhead lane control signals (LCS),
- Embedded vehicle detection loops,
- Changeable message signs (CMS),
- Closed circuit television (CCTV) surveillance,
- Coaxial cable communications,
- Computer control, and
- Entry authorization gates and metering devices where appropriate.

Once the automated SC&C system is implemented, the overhead lane control signals will indicate the appropriate direction of travel, and the changeable message signs will provide additional user and non-user communications. The detection loops will be able to supply controllers with operating data such as vehicle volumes, types, density and speeds on the transitway. Closed circuit television will be used to visually survey the transitway in operation and to verify incidents identified by the detection loops. Finally, the entire network of lane control signals, changeable message signs, detection loops, and closed circuit television will be interconnected by coaxial cable and integrated through a system computer.

As stated earlier, operational data and CCTV signals will be collected through the coaxial cable trunkline and routed to a system computer. On an interim basis, the system computer for the Katy Transitway will be located in a satellite building at the eastern terminus of the transitway near North Post Oak (Figures 48 and 49). Ultimately, satellite buildings are conceived to be small, self-contained, unmanned buildings located near each individual transitway. The Katy Transitway satellite building will be the only satellite building designed to be manned even temporarily. Generally, these buildings will house the traffic control and communications equipment that receive the data generated by the field equipment (CMS, LCS, CCTV, etc.). From the satellite buildings, the data collected will be transmitted to a central control center through one of the three methods under consideration: microwave, coaxial cable, or fiber optics. Preliminary information indicates that microwave transmission would be the most cost effective method.

Conceptual design is currently underway for the central control center. This control center will house the equipment necessary to operate and monitor all transitways from a single manned center. Equipment will include several CCTV monitors, a mimic board display of the transitway system, control consoles to monitor and operate "in-field" electronic hardware, and a communication link to deployment/enforcement personnel.

The Katy Transitway, Phase I, is the first fully operational transitway with an automated SC&C system in Houston. As such, it is serving as a "test" facility to evaluate transitway SC&C needs and equipment. Once the central control center is completed, this satellite facility should revert to being an unmanned facility. Construction costs for the SC&C for the first phase of the Katy Transitway total approximately $1.3 million. This amount includes the construction of the satellite control center, more than 6 miles of SC&C for the transitway, and any incentive payments earned by the contractors for early completion of the project. The SC&C for Phases 2 and 3 of the Katy Transitway is estimated to cost a total of approximately $1.1 million for an additional 6 miles of coverage. The cost of providing SC&C for Phases 2 and 3 has been projected to be less than that incurred for Phase 1 because Phases 2 and 3 will use the same computer and satellite control center provided in Phase 1. Overall, the entire Katy Transitway SC&C system is projected to cost approximately $2.38 million (6), for a cost per mile of $0.2 million.

Freeway Mainlanes

Due to continued population and economic growth as well as to latent travel demand along the Katy Freeway corridor, freeway congestion has not improved substantially since the implementation of the transitway. Freeway mainlanes adjacent to the Phase I segment of the transitway were operating at depressed levels-of-service during peak periods prior to transitway implementation and continue to be highly congested. Slight differences in the duration and the intensity of traffic congestion have been observed, but these differences have not been exhibited consistently between the morning and the afternoon peak periods.

Figures 52 and 53 illustrate morning peak period mainlane traffic conditions in terms of average vehicle speeds and volumes. As indicated by the higher minimum average travel speed within a typical morning peak period of operation, the intensity of congestion appears to have decreased slightly in the morning since the transitway was implemented (Figure 52). Furthermore, the volume diagram in Figure 53 reinforces the inference that traffic congestion has declined slightly in the morning peak period since the implementation of the transitway. Vehicle volumes per 15-minute time period before and after the transitway begin at approximately the same level; however, as the peak period progresses, the pre-transitway freeway mainlanes experience an earlier breakdown in traffic flow rates than do the post-transitway freeway mainlanes.

A similar examination of afternoon travel speeds and traffic flow rates indicates a different conclusion regarding the relative operating conditions of the freeway mainlanes. Whereas the traffic conditions appear to have improved very slightly in the morning, they have not demonstrated the same improvement in the afternoon. Afternoon travel speeds appear to have declined an average of approximately five miles per hour over the entire peak period, and the duration of congestion appears to have lengthened (Figures 54 and 55). The speed diagram in Figure 54 indicates that the intensity of the congestion has increased, but the volume diagram in Figure 55 does not support this inference.

Although differences in mainlane operating conditions may be inferred from the speed and the volume graphs, these differences are not substantial nor consistent between the morning and the afternoon peak periods. They could easily be traced to the daily variations in traffic conditions that are common to peak period traffic flow. Overall, mainlane traffic conditions do

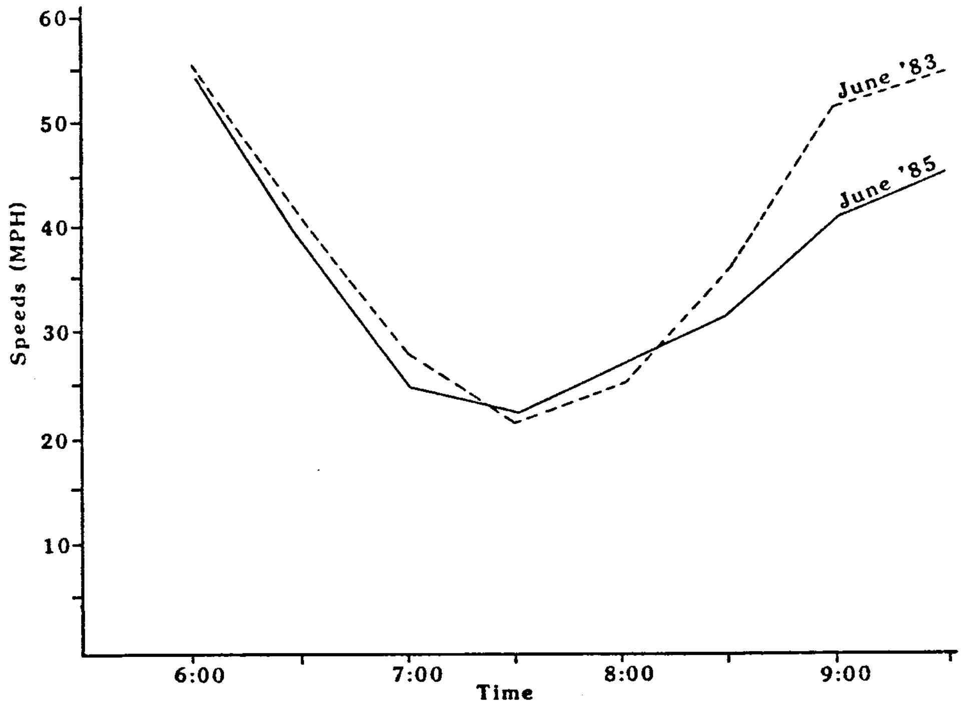


Figure 52. Katy Freeway AM Peak-Period Mainlane Speed Profiles

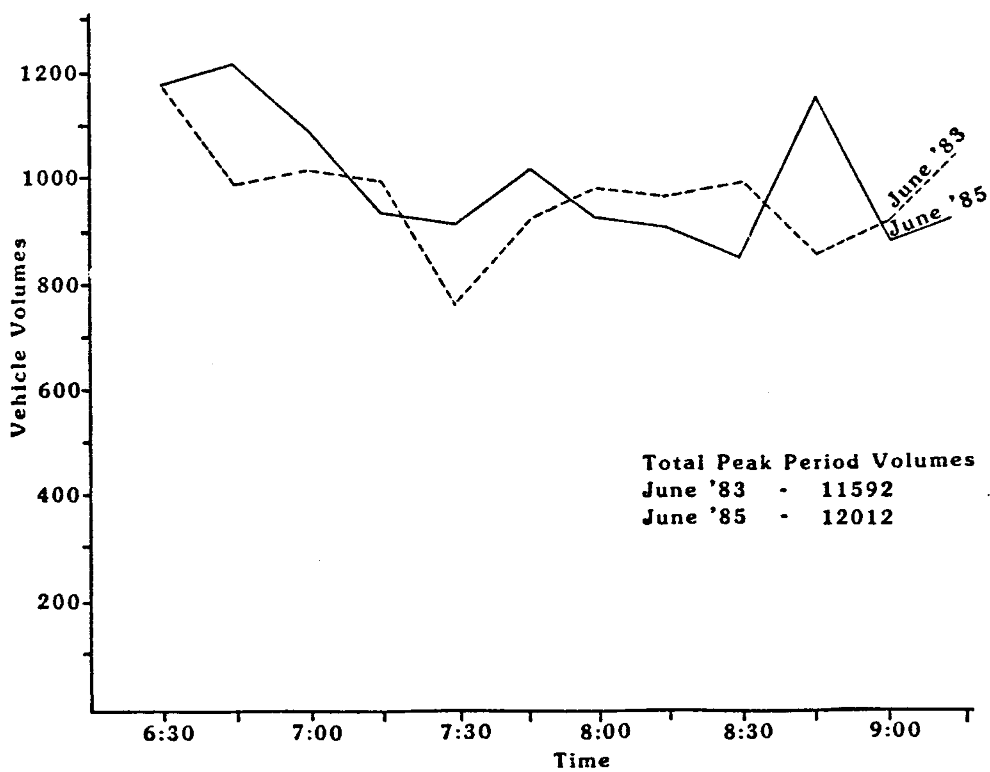


Figure 53. Katy Freeway AM Peak-Period Mainlane 15-Minute Volumes (Bunker Hill, 3 lanes cross-section)

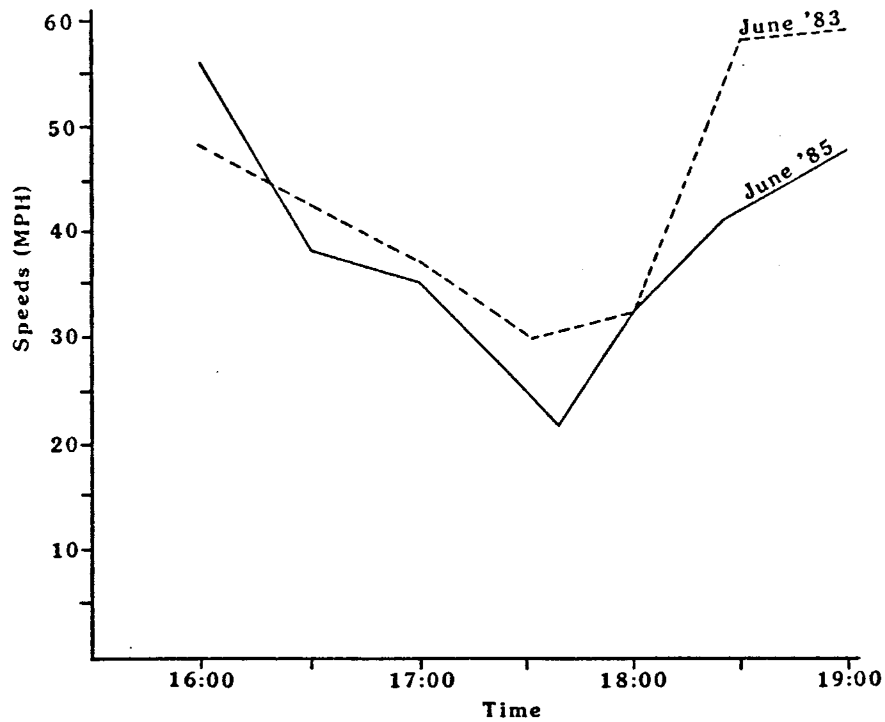


Figure 54. Katy Freeway PM Peak-Period Mainlane Speed Profiles

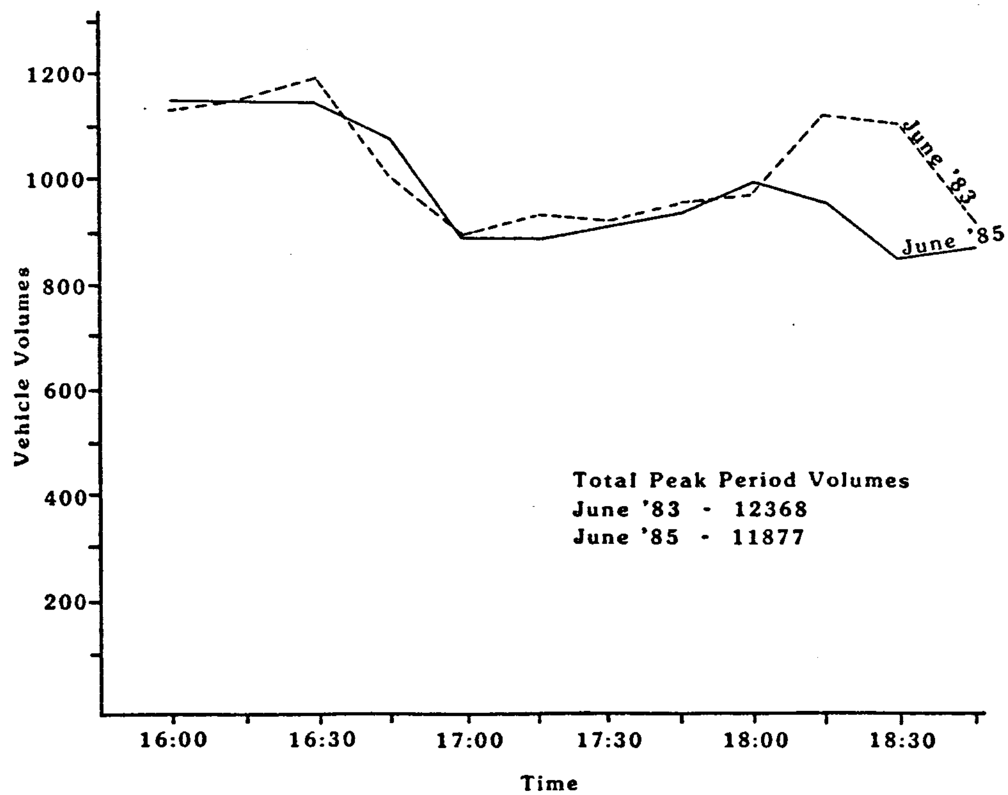


Figure 55. Katy Freeway PM Peak-Period Mainlane 15-Minute Volumes (Bunker Hill, 3 lanes cross-section)

not appear to have changed significantly since the implementation of the Katy Freeway Transitway.

A comparison of accident rates before transitway construction, during construction, and after transitway implementation is summarized in Table 12. As can be seen, overall accident rates increased very slightly during construction but have since dropped to a level lower than the rates experienced prior to the construction. Although no statistical significance tests have been applied to the data, this comparison suggests that the introduction of the transitway into the median does not appear to have resulted in unsafe operating conditions as measured by the frequency of accidents on the freeway mainlanes.

Table 12. Comparison of Accident Rates

(Westview to Washington, 8.7 miles)

Time Period	Total # Accidents	# of Days	Annual ADT	Distance (miles)	Accidents Per Million Vehicle-Miles
6/82-5/83 before	754	365	154,891	8.7	1.53
6/83-10/84 Const.	1182	518	156,471	8.7	1.68
11/84-9/85 After	626	334	158,147	8.7	1.36

Source: (7)

Corridor Totals (Transitway and Freeway Mainlanes)

Table 13 summarizes average 3-hr. peak-period vehicle and passenger movement along the Katy Freeway Corridor between Gessner Drive and I-610. With the transitway, the corridor serves approximately 1,100 more vehicles (+10%) and approximately 2,700 more passengers (+19%). Figure 56 illustrates this graphically. As a result of the transitway volumes, overall corridor occupancy rates have also been increasing (Figure 57). The average peak period occupancy rate in November 1983 was 1.28 passengers per vehicle and in September 1985 the corridor occupancy rate had increased to 1.36 passengers per vehicle with the average on the mainlanes being 1.15 passengers per vehicle and the average on the AVL being 15.12 passengers per vehicle. As

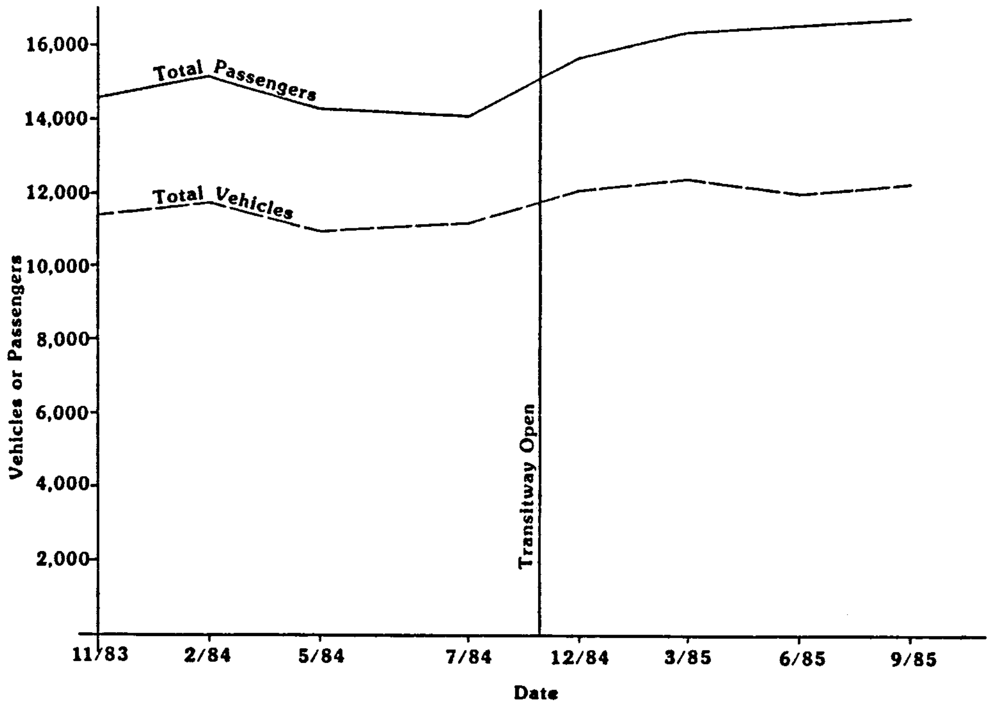


Figure 56. Katy Freeway Corridor Demand (Morning Peak-Period At Bunker Hill)

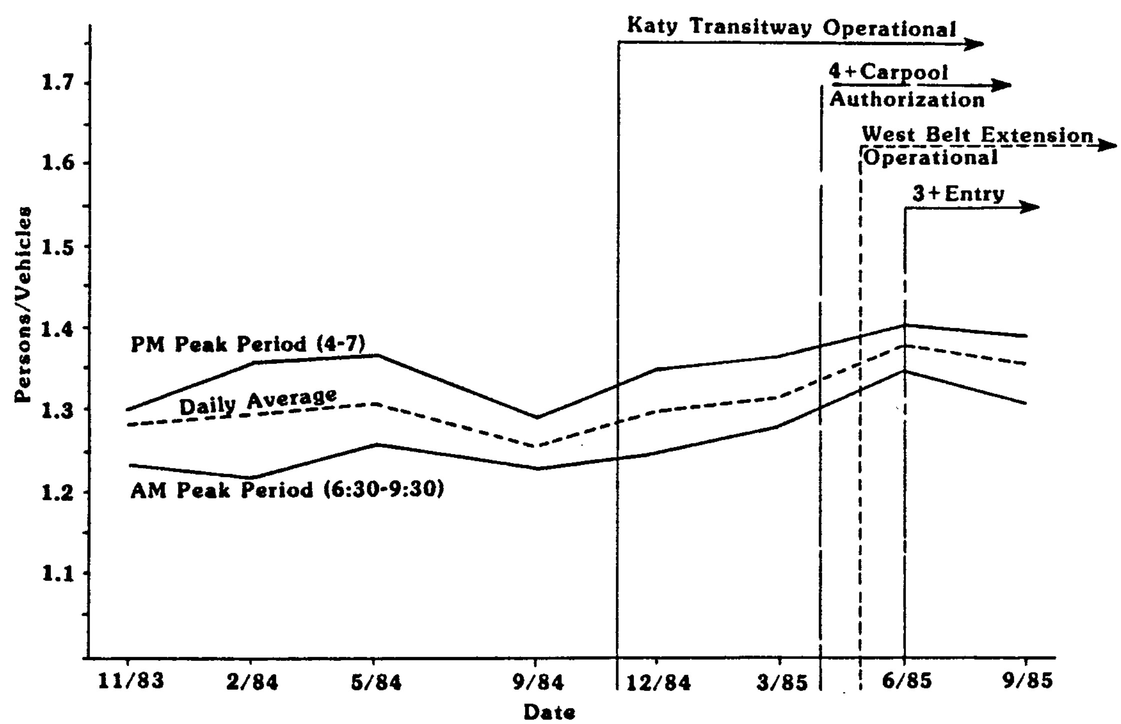


Figure 57. Katy Freeway Corridor Peak-Period Occupancy Rates (Total Freeway Mainlanes and Transitway Volumes)

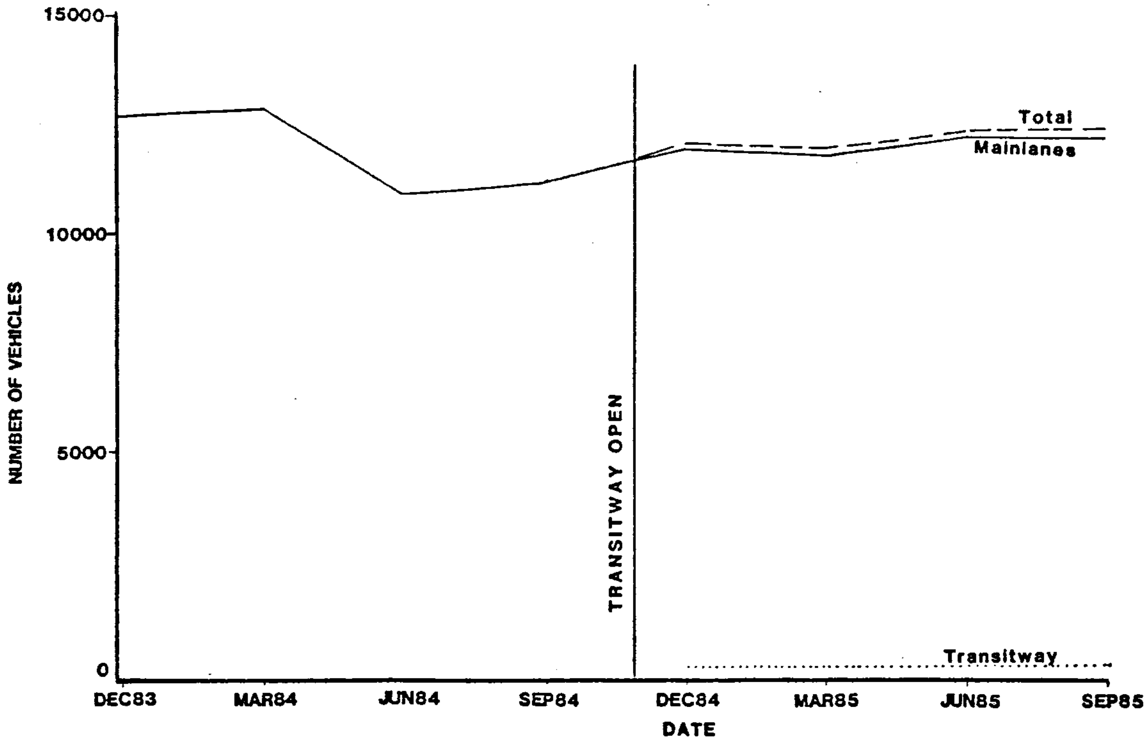


Figure 58. Katy Freeway Corridor Average 3-Hour Peak-Period Vehicle Demand

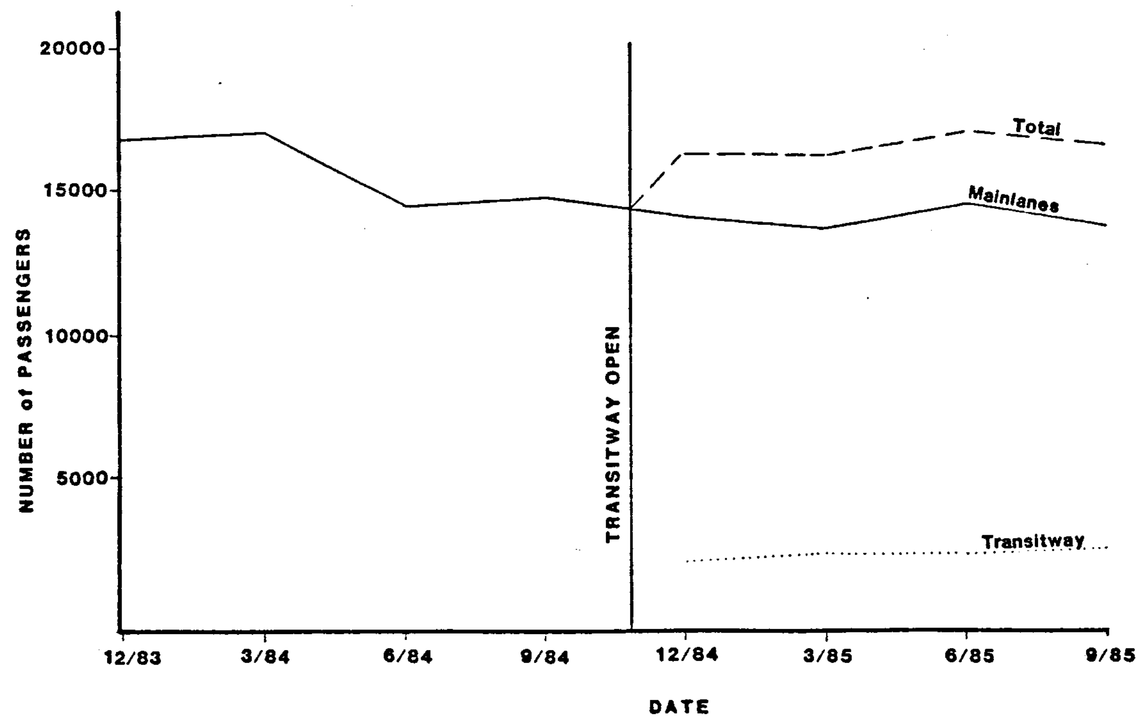


Figure 59. Katy Freeway Corridor Average 3-Hour Peak-Period Person Demand

Table 13. Katy Freeway Corridor Average Peak Period Volumes

	Freeway		Transitway		Total		Cum. % Change	
Month	Vehicles	Passengers	Vehicles	Passengers	Vehicles	Passengers	Vehicles	Passengers
09/84	11,164	14,073	--	--	11,164	14,073	--	--
12/84	11,940	13,492	122	2,223	12,062	15,715	8%	12%
03/85	12,238	13,845	136	8,523	12,374	16,368	11%	16%
06/85	11,894	14,050	146	2,551	12,040	16,601	8%	18%
09/85	12,118	13,935	187	2,821	12,305	16,756	10%	19%

illustrated in Figures 58 and 59, although the Transitway carries only 2% of the corridor's peak period vehicle volume, it serves almost 20% of the total corridor person trips in a peak period. Overall, the volume of high-occupancy vehicles has also been increasing within the Katy Freeway corridor. As shown in Figure 60, overall corridor vanpool volumes have increased from an average of 54 vans per peak period in November 1983 to 82 vans per peak period in September 1985. Bus volumes have increased from 35 to 65 buses per peak period over the same time frame. Finally, while 4+ carpools on the freeway mainlanes have remained steady at about 75 cars per peak period between November 1983 and September 1985, transitway carpools number greater than 50 per peak period from an average corridor-wide total of 120 carpools per peak period in September 1985.

Benefit-Cost Analysis

Based upon October 1985 transitway volumes, persons traveling by authorized bus, vanpool, or carpool on the transitway are realizing a time savings over parallel freeway mainlane travelers of approximately 627 person-hours per day. This estimate assumes conservative travel time savings of 5 minutes for each of the 2,702 people using the transitway as far as Gessner Drive (56% of bus volumes, 14% of vanpool and 11% of carpool volumes) and of 7 minutes for each of the 3,445 people using the transitway all the way to West Belt (Table 5). Placing a value of $7.50 for each person-hour of delay

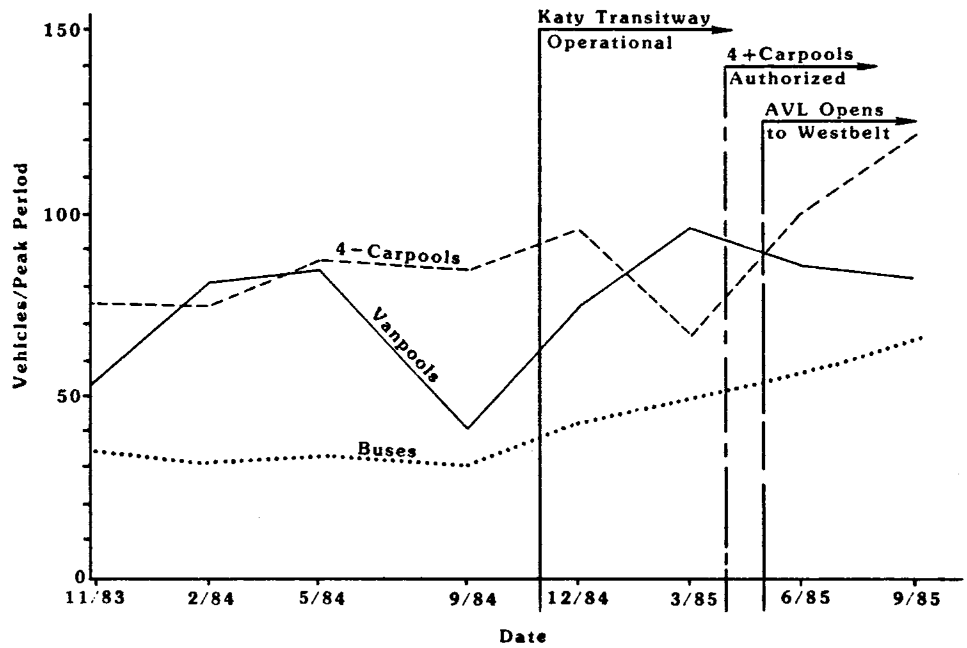


Figure 60. Katy Freeway Corridor Peak-Period HOV Volumes (Total Mainlanes and Transitway)

saved, the travel time savings obtained in November 1985 translates into an annual benefit of $1,226,000/year (8).

A post-implementation assessment of benefits and costs of the Katy Transitway, Phase I, affirms the transitway's long-term cost-effectiveness. The travel time savings are based upon April 1985 (the midpoint of the first year of operation) AVL passenger volumes. These base volumes are assumed to grow at an annual rate of 48% per year for the first four years and held constant for the next sixteen years of the analysis period. The four year high growth allowance is based upon the growth trends experienced on other HOV projects nationwide such as the Shirley Highway in Washington D.C. the El Monte Busway in California, and the I-45N contraflow project in Houston (3, 4). After the fourth year, HOV volumes in the facilities mentioned above continued to grow but at a less rapid rate. For the purposes of this analysis, the Katy AVL volumes have been held constant after the fourth year of operation. This will result in a conservative estimate. Likewise, in the estimation of projected bus operating cost savings, the daily bus vehicle volumes observed in April 1985 were grown at an annual rate of 66%/year through the fourth year and held constant through the end of the analysis period. All construction costs are stated at their nominal value (i.e., are assumed to have been expensed at the time the Katy AVL became operational). Finally, AVL operating costs are based upon the expenses incurred by METRO's transitway program in the first six months after the opening of the Katy AVL. These expenses average approximately $43.3 thousand per month. Since METRO's transitway program is responsible for both the North AVL and the Katy AVL, only one-half of these estimated expenses have been charged to the operation of the Katy AVL. Using a 20 year analysis period and a 10% discount rate, a benefit cost ratio of 2.03 is obtained. Table 14 summarizes the major costs and benefits that are included in this analysis.

Table 14. Estimated Katy Transitway, Phase I, Benefits and Costs

Benefit or Cost Component	Present Value in Dollars (millions of 1985 dollars)	
Benefits		
Travel Time Savings	$24.0	
Reduced Bus Operating Costs (at $60/bus-hour)	5.1	
TOTAL		$29.1
Costs*		
Transitway Construction and Associated Arterial Street Improvement	10.7	
Transitway Operation	2.2	
TOTAL		12.9
Benefit/Cost Ratio		2.3

*Source (6)

CONCLUSIONS

The Katy Freeway Transitway was completed four months ahead of schedule with minimal operational and safety impacts to mainlane traffic during construction of the facility. After one year of operation, the Katy Transitway is carrying more than 6,100 persons per day. A 98% increase in park-and-ride demand has accompanied this rise in transitway utilization. The corridor as a whole (mainlanes + AVL) is carrying almost 30% more people in the peak direction during a three hour peak period than it did before the introduction of the transitway.

In the first year of operation, the Katy Freeway Transitway has accommodated demand by high occupancy vehicles for an increase of approximately 62% per year for vehicles and 48% per year for passengers. Currently, the transitway serves an average of approximately 3,100 peak period passenger trips, more than 20% of the daily directional peak period freeway mainlane person movements. It also provides average 2-hour peak-period travel time savings of 4 to 7 minutes in the morning and 6 to 8 minutes in the afternoon (depending upon the length of the transitway traveled i.e., to Gessner or to West Belt, respectively). Time savings in the heart of the peak hour are as great as 12 minutes per AVL vehicle.

This overall HOV growth trend is below that experienced on similar facilities nationally (9) or on the North Freeway (I-45) contraflow lane in Houston (10). The location and short length of the transitway associated with Phase I implementation could be responsible for this limited growth in HOV volumes. The congestion and depressed level of service on the freeway extends far beyond the transitway terminus of Phase I. As the Katy Freeway Transitway is extended further west, the reduction in travel time will become more substantial and should offer more of an incentive for modal shifts to occur. It is anticipated the growth rate of transitway utilization will be greater as succeeding phases of this project become operational.

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