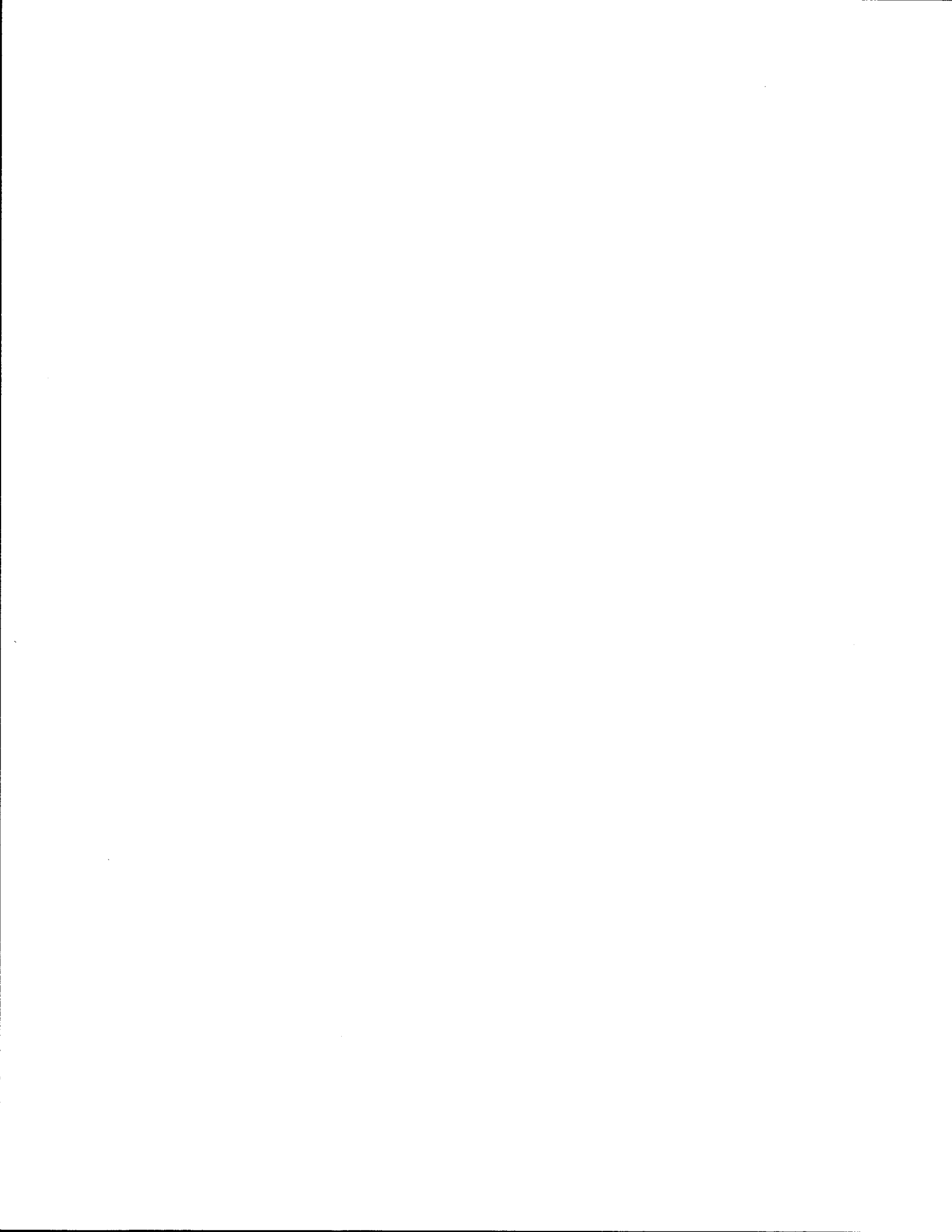


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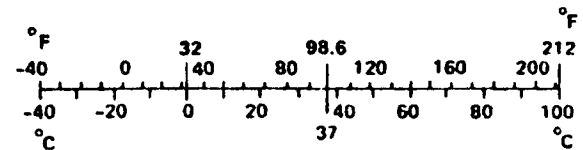
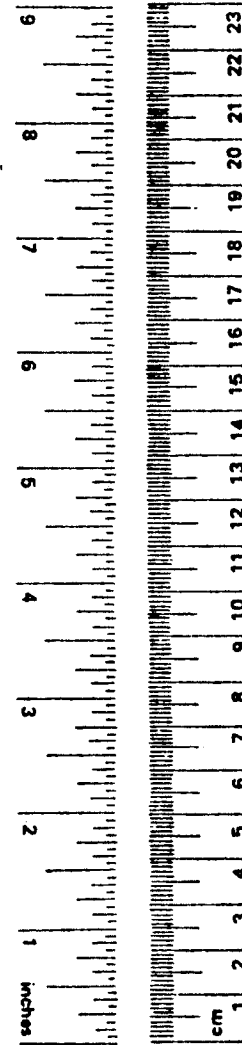
## METRIC CONVERSION FACTORS

### Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
<b>LENGTH</b>				
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
<b>AREA</b>				
in <sup>2</sup>	square inches	6.5	square centimeters	cm <sup>2</sup>
ft <sup>2</sup>	square feet	0.09	square meters	m <sup>2</sup>
yd <sup>2</sup>	square yards	0.8	square meters	m <sup>2</sup>
mi <sup>2</sup>	square miles	2.6	square kilometers	km <sup>2</sup>
	acres	0.4	hectares	ha
<b>MASS (weight)</b>				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
<b>VOLUME</b>				
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 <sup>3</sup>	cubic feet	0.03	cubic meters	m <sup>3</sup>
yd <sup>3</sup>	cubic yards	0.76	cubic meters	m <sup>3</sup>
<b>TEMPERATURE (exact)</b>				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

### Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
<b>LENGTH</b>				
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
<b>AREA</b>				
cm <sup>2</sup>	square centimeters	0.16	square inches	in <sup>2</sup>
m <sup>2</sup>	square meters	1.2	square yards	yd <sup>2</sup>
km <sup>2</sup>	square kilometers	0.4	square miles	mi <sup>2</sup>
ha	hectares (10,000 m <sup>2</sup> )	2.5	acres	
<b>MASS (weight)</b>				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
<b>VOLUME</b>				
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 <sup>3</sup>	cubic meters	35	cubic feet	ft <sup>3</sup>
m <sup>3</sup>	cubic meters	1.3	cubic yards	yd <sup>3</sup>
<b>TEMPERATURE (exact)</b>				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



\* 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.

**THE IMPACTS OF CARPOOL UTILIZATION  
ON THE KATY FREEWAY TRANSITWAY  
30-MONTH "AFTER" EVALUATION**

by  
Dennis L. Christiansen  
Research Engineer  
and  
William R. McCasland  
Research Engineer

Research Report 484-7

An Evaluation of the Impact of Permitting Carpools to Use  
the Katy Transitway  
Research Study Number 2-10-85-484

Sponsored by  
Metropolitan Transit Authority of Harris County  
and  
State Department of Highways and Public Transportation  
in cooperation with the  
U.S. Department of Transportation  
Federal Highway Administration

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

September 1988



## ABSTRACT

A major commitment has been made in the Houston area to develop physically separated transitways in the medians of freeways. The lanes are reserved for high-occupancy vehicles. Phase 1 of the first completed transitway opened on the Katy Freeway (I-10) in October 1984. Phase 2 opened in June 1987. To increase potential utilization of this facility, carpools began using the transitway on a test basis in April 1985. This research study, funded jointly by the Metropolitan Transit Authority of Harris County and the Texas State Department of Highways and Public Transportation, was initiated to undertake a comprehensive analysis of the effects of permitting carpool utilization. This report documents the data collected in October 1987, 2.5 years after carpool utilization of the transitway was permitted. In this report, these data are compared to similar data collected both before carpool utilization was permitted and on several occasions after carpool utilization was permitted.

Key Words: High-Occupancy Vehicle Lanes, Transitways, Busways, Carpools, HOV Facilities, Authorized Vehicle Lanes.



## SUMMARY

The Katy Transitway was opened to authorized buses and vanpools in October 1984. To increase transitway vehicular utilization, authorized 4+ carpools were allowed onto the facility in April 1985; in September 1985, authorized 3+ carpools were allowed to use the transitway. In August 1986, authorization requirements were eliminated, and 2+ vehicles were permitted to use the transitway.

This report evaluates the impacts of allowing carpools to use the transitway. Data in the report cover the period from April 1985 through October 1987.

### Trends in Transitway Utilization

In October 1987, during the a.m. peak period nearly 8,800 persons used the Katy Transitway; 68% of these persons are moved in carpools. Of those carpools, approximately 10% have been attracted from either buses or vans that use the transitway. Carpools comprise approximately 95% of the vehicles using the transitway.

During the peak hour, 1,437 vehicles used the transitway. This value approaches, but does not yet exceed, the capacity of the transitway, which is estimated to be approximately 1,500 vph. Allowing carpools to use the lane has increased the frequency of transitway vehicle breakdowns; over 80% of the disabled vehicles on the transitway are carpools. However, this has not resulted in an unacceptable operational or safety problem.

### Motorist Attitudes Concerning the Transitway

Motorists operating in the freeway mainlanes (not transitway users) during the a.m. peak period have been surveyed on several occasions to identify their attitudes concerning the transitway. As transitway utilization has increased -- largely as the result of allowing carpools onto the priority facility -- acceptance of the transitway by the motorists has



increased noticeably (Table S-1). Over 60% of the motorists state that the transitway is a good transportation improvement.

Table S-1. Perception of the Utilization of the Katy Transitway By  
Motorists in the General Freeway Lanes

Measure of Effectiveness	Survey Date			
	3/85 <sup>1</sup>	4/86 <sup>2</sup>	4/87 <sup>3</sup>	10/87 <sup>3</sup>
Transitway A.M. Peak Period Vehicle Volume	138	256	2410	2922
Is the transitway sufficiently utilized?				
Yes	3%	3%	36%	44%
No	90%	92%	55%	42%
Not Sure	7%	5%	9%	14%
Is the transitway a good transportation improvement?				
Yes	41%	36%	56%	63%
No	35%	43%	29%	20%
Not Sure	24%	21%	15%	17%

<sup>1</sup>Authorized buses and vanpools (before carpools)

<sup>2</sup>Authorized buses, vanpools and 3+ carpools

<sup>3</sup>2+ vehicles, no authorization

### Criteria for Judging the Success of the Carpool Experiment

Prior to allowing carpools onto the transitway, both the State Department of Highways and Public Transportation and the Metropolitan Transit Authority agreed upon a set of criteria to use in evaluating the success of the carpool experiment. Each criterion is addressed in this report. Table 5 in the main report presents the criteria and the basis for their evaluation. Each criterion can be rated as "highly successful", "successful", "unsuccessful", or "highly unsuccessful". In the overall evaluation, the individual criterion are weighted, and a numerical value is assigned; "highly successful" is considered to be a 4, with "highly unsuccessful" considered to be a 1. Thus, a 2.5 would represent a neutral evaluation, midway between "unsuccessful" and "successful".

Data have been collected in April 1986, April 1987, and October 1987 that permit analysis, based on the criteria shown in Table 5, of the success of the carpool experiment. As carpool volumes have increased on the transitway, the success of the experiment has also increased. In April 1986 the experiment was rated a 2.6 (between "successful" and "unsuccessful"); in April 1987 and October 1987, the experiment was ranked at 3.2 and 3.3, respectively (between "successful" and "highly successful"). The data for these three analyses are summarized in Table S-2. More detailed data for the October 1987 analysis are shown in Table S-3.

Since the introduction of 2+ carpools to the transitway, the success of the carpool experiment, based on the predetermined criteria, has increased markedly. The experiment, as of October 1987, can be considered to be a success.

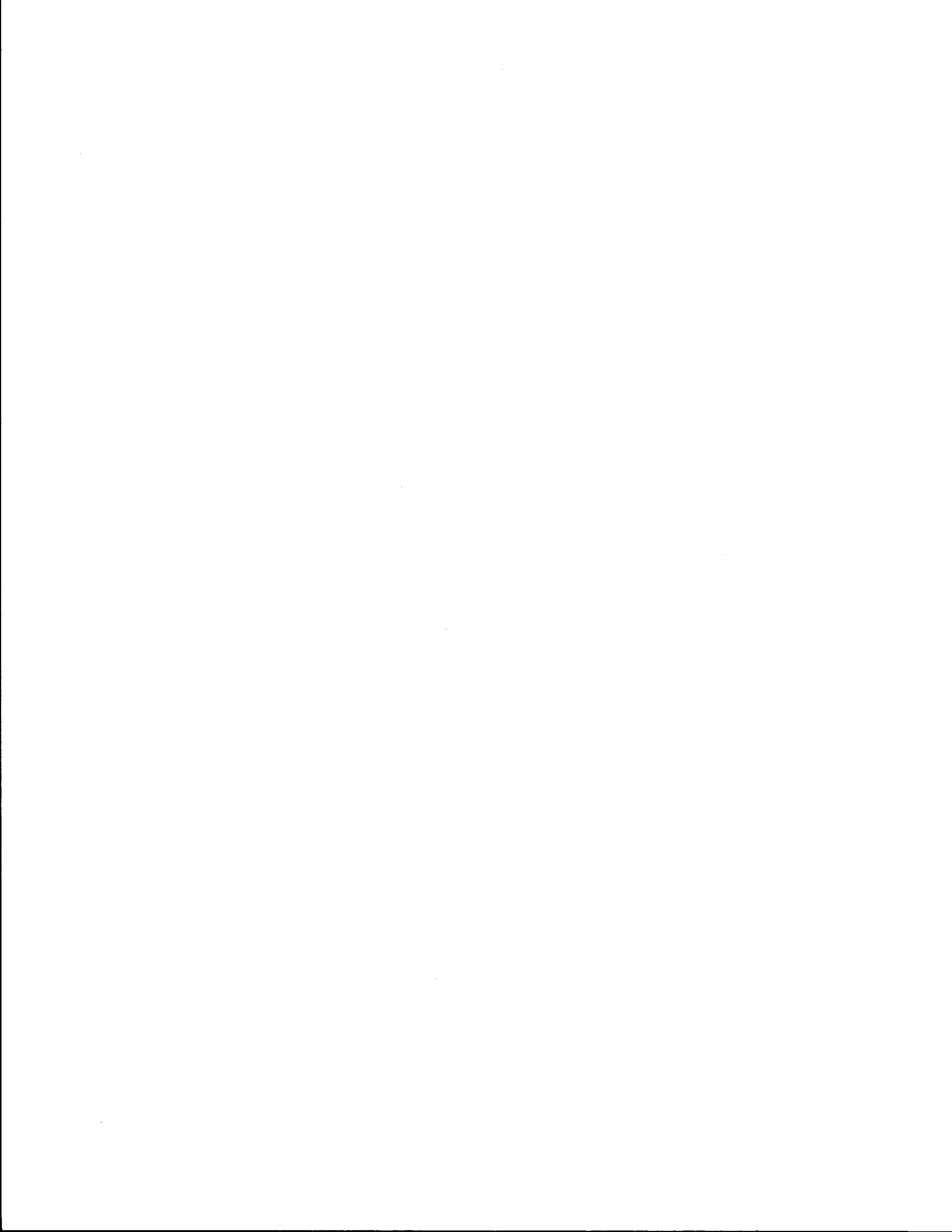
Table S-2. Overall Evaluation of Katy Transitway Carpool Experiment, April 1986, April 1987  
and October 1987

Criterion	Relative Weighting	Conclusion Pertaining to Experiment		
		April 1986	April 1987	October 1987
1. Change in Person Movement on the transitway Directly Attributable to Carpooling	25%	Between "Successful" and "Unsuccessful"	"Highly Successful"	"Highly Successful"
2. Non-User Perception of Katy Transitway Utilization	30%	"Highly Unsuccessful"	"Unsuccessful"	"Successful"
3. Change in Travel Time on the Transitway	20%	"Highly Successful"	"Highly Successful"	"Successful"
4. Change in Delay to Mixed-Flow Traffic	15%	"Highly Successful"	"Highly Successful"	"Highly Successful"
5. Increase in Frequency of Transitway Breakdowns	5%	"Successful"	"Highly Unsuccessful"	"Highly Unsuccessful"
6. Increase in Authorization and Enforcement Costs	5%	"Successful"	"Successful"	"Successful"
Total	100%	2.60 Between "Successful" and "Unsuccessful"	3.20 Between "Successful" and "Highly Successful"	3.30 Between "Successful" and "Highly Successful"

Table S-3. Overall Evaluation of Katy Transitway Carpool Experiment, 30 Months After Carpools Were Allowed Onto the Transitway

Criterion	Relative Weighting	Conclusion Pertaining to Experiment	Relevant Data
1. Change in Person Movement on the transitway Directly Attributable to Carpooling	25%	"Highly Successful"	<ul style="list-style-type: none"> <li>● Carpools move over 60% of total person movement</li> </ul>
2. Non-User Perception of Katy Transitway Utilization	30%	"Successful"	<ul style="list-style-type: none"> <li>● Just over 50% of non-users feel the transitway is sufficiently utilized.</li> </ul>
3. Change in Travel Time on the Transitway	20%	"Highly Successful"	<ul style="list-style-type: none"> <li>● Average speeds have generally remained stable with a slight decrease during peak periods</li> </ul>
4. Change in Delay to Mixed-Flow Traffic	15%	"Highly Successful"	<ul style="list-style-type: none"> <li>● Mixed flow speeds have increased slightly</li> </ul>
5. Increase in Frequency of Transitway Breakdowns	5%	"Highly Unsuccessful"	<ul style="list-style-type: none"> <li>● Over 80% of transitway vehicle breakdowns are carpools. Approximately 5 breakdowns occur per week.</li> </ul>
6. Increase in Authorization and Enforcement Costs	5%	"Successful"	<ul style="list-style-type: none"> <li>● Marginal increase in costs due to carpool has not been substantial.</li> </ul>
Total	100%	Between "Successful" and "Highly Successful"	

XI



## **IMPLEMENTATION STATEMENT**

Since there is relatively little experience with operating exclusive, reversible, high-occupancy vehicle lanes, many of the operating procedures and approaches to be used in Houston will be developed through experience. A key operating issue involves the type of vehicles that will be allowed to utilize the special lanes.

This study was specifically undertaken to assist the Metropolitan Transit Authority and the State Department of Highways and Public Transportation in the implementation and operation of the transitways. This study, through analyses and comparison of both "before" and "after" data, assesses the impacts of permitting carpools to utilize the special high-occupancy vehicle lanes.

## **DISCLAIMER**

The contents of this report reflect the views of the authors who are responsible for the opinions, findings and conclusions presented herein. The contents do not necessarily reflect the official views or policies of the State Department of Highways and Public Transportation, the Federal Highway Administration, or the Metropolitan Transit Authority of Harris County. This report does not constitute a standard, specification, or regulation.



## TABLE OF CONTENTS

	Page
Abstract .....	iii
Summary .....	v
Trends in Transitway Utilization .....	v
Motorist Attitudes Concerning the Transitway .....	v
Criteria for Judging the Success of the Carpool Experiment ...	vii
Implementation Statement .....	xi
Disclaimer .....	xi
I. Introduction .....	1
Previous Research Reports .....	2
Organization of This Report .....	3
II. Katy Transitway Utilization .....	5
Background on Katy Transitway Carpool Utilization .....	5
Trends in Katy Transitway Utilization .....	6
Carpool Data, Katy Transitway and Selected Other HOV Projects .....	11
Increase in Carpooling Due to Transitway Implementation .	17
III. Criteria For Evaluating the Success of the Transitway Carpool Experiment .....	23
IV. Person Movement Impacts of Carpooling .....	25
Carpool Component .....	25
Conclusion Pertaining to Evaluation Criterion .....	26
V. Perception of Transitway Utilization .....	27
Conclusion Pertaining to Evaluation Criterion .....	28



TABLE OF CONTENTS (Continued)

	Page
VI. Change in Average Travel Time on the Transitway .....	29
Speeds .....	29
Conclusion Pertaining to Evaluation Criterion .....	31
VII. Mixed-Flow Traffic Lanes .....	33
Travel Time .....	33
Freeway Mainlane Volumes .....	37
Travel Time Savings .....	41
Conclusion Pertaining to Evaluation Criterion .....	46
VIII. Transitway Vehicle Breakdown Data .....	47
Conclusion Pertaining to Evaluation Criterion .....	47
IX. Authorization and Enforcement Costs .....	49
Increase in Enforcement Costs .....	49
Conclusion Pertaining to Evaluation Criterion .....	49
X. Conclusions .....	51

## I. INTRODUCTION

In October 1984, the first 5 miles (Phase 1) of the Katy Freeway (I-10) Transitway became operational. In June 1987, the transitway was completed to SH 6, a total distance of 11.5 miles. Detailed descriptions of that project are included in other reports<sup>1</sup>.

At the time the transitway opened, only buses and vanpools authorized by the Metropolitan Transit Authority (Metro) and the State were allowed to utilize the priority facility. However, in order to address a perception that the transitway was underutilized, carpools were allowed to begin using the priority lane in April 1985. While allowing carpools onto the priority lane represented a means to increase the volume of vehicles operating on the transitway, the following concerns were associated with such an action: 1) carpools might simply attract riders away from buses or vans, thereby moving no more people but requiring more vehicles; 2) introduction of carpools might exceed the capacity of the transitway, thereby adversely impacting the level-of-service that is so important to transitway operation; 3) if carpool volumes were restricted sufficiently to assure a high level-of-service on the transitway, the increase in vehicles using the facility might not be great enough to change the perception that the transitway is underutilized; 4) the increased carpool volumes might result in an increase in vehicle breakdowns, thereby reducing the travel time reliability attribute of the transitways; and 5) other safety related concerns might develop.

Since the Katy Freeway Transitway is the first of several such facilities being developed in Houston, this study was sponsored by both the Metropolitan Transit Authority of Harris County and the State Department of Highways and Public Transportation to assess in detail the impacts of allowing carpools to use the transitway. To undertake this assessment, major

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<sup>1</sup>"The Katy Freeway Authorized Vehicle Lane: Evaluation of the First Year of Operation." TTI Research Report 339-6, February 1986.

"The Impact of Carpool Utilization on the Katy Freeway Authorized Vehicle Lane, 'Before' Data". TTI Research Report 484-1, December 1985.

"The Katy Freeway Transitway, Evaluation of the Second Year of Operation". TTI Research Report 339-11, August 1987.

data collection efforts have been conducted on several occasions. Data were collected in March 1985 before carpools used the transitway. Data were collected in April through July 1986, approximately one year after carpools were allowed onto the transitway. A major data collection effort was also undertaken in October 1987, 2.5 years after carpools began using the transitway. In addition, several minor data collection efforts have been performed. In this report, this information is combined and evaluated to assess the impact of carpools on the operation of the transitway and freeway for the 2.5-year period since carpools were first allowed onto the transitway.

### Previous Research Reports

This report is the seventh report prepared as part of this research effort. Previous reports are listed below.

"The Impact of Carpool Utilization on the Katy Freeway Authorized Vehicle Lane, 'Before' Data", Research Report 484-1, December 1985.

"The Impact of Carpool Utilization on the Katy Freeway Authorized Vehicle Lane, Initial Carpool Surveys", Research Report 484-2, December 1985.

"Impacts of Carpool Utilization on the Katy Freeway Authorized Vehicle Lane, 12-Month 'After' Evaluation", Research Report 484-3, August 1986.

"An Analysis of Survey Data From the Katy and North Transitways", Research Report 484-4, March 1987.

"Off-Peak Use of the Houston Transitway System", Research Report 484-5, December 1986.

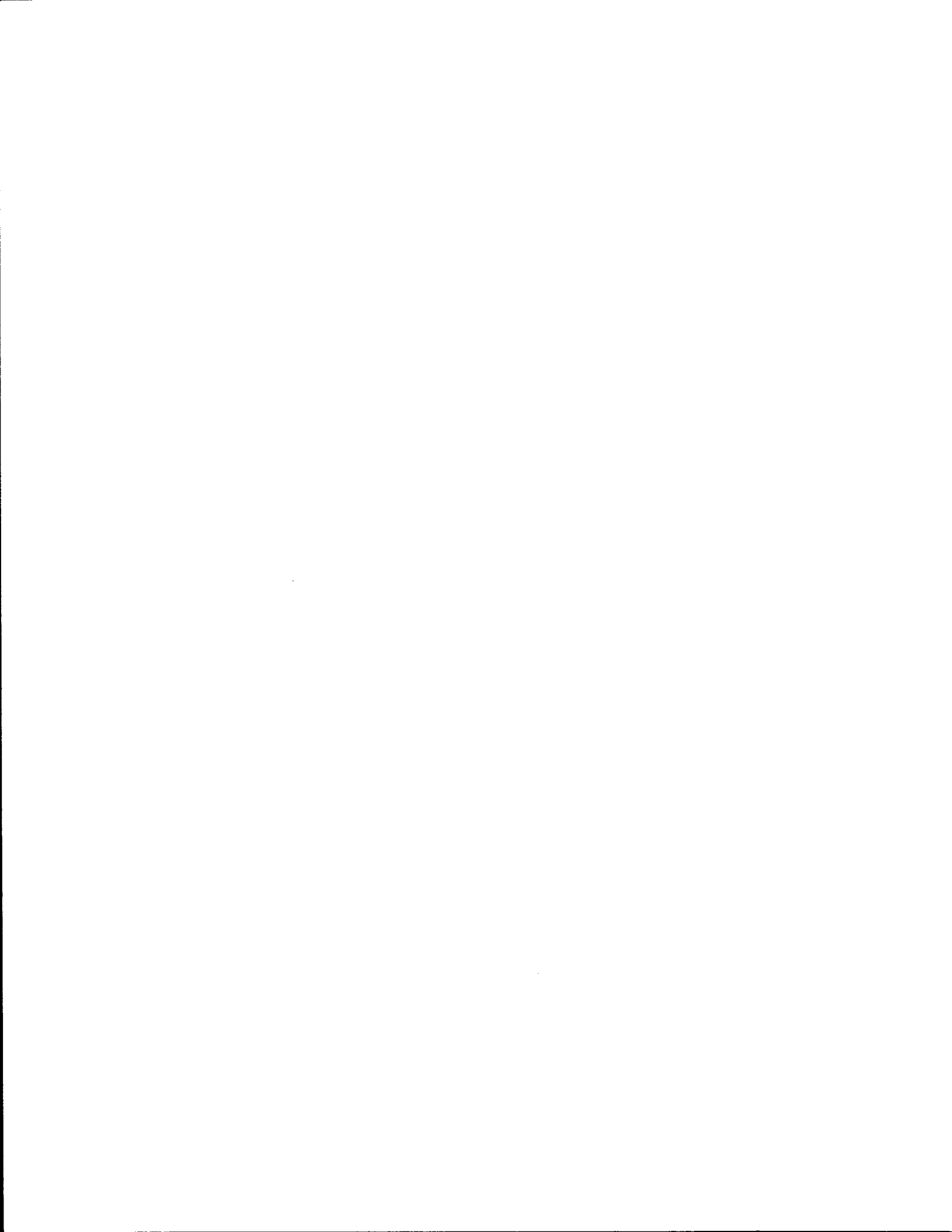
"Options for Managing Speeds and Volumes on the Katy Transitway", Research Report 484-6, September 1987.

The first report presents a state-of-the-art overview, identifies criteria for evaluating the "success" of the Katy Transitway carpool experiment, and presents traffic data as well as transitway user and non user surveys that identify the operating condition of the freeway and the transitway prior to allowing carpool utilization. The second report documents a survey of transitway carpool users undertaken in October 1985. The third report evaluated the success of the carpool experiment 12 months after it was initiated. The fourth report documents survey data collected as part of the project. The fifth report documents a special analysis of alternative off-peak uses for the transitway, and the sixth report analyzes options for managing vehicular demand on the transitway.

No attempt is made in this report to include all the relevant material presented in previous reports. Some pertinent data from previous reports are used in this report to draw conclusions concerning the impacts of allowing carpools onto the transitway.

### Organization of This Report

Following this introductory section is a section (Section II) describing trends in utilization on the Katy Transitway. Section III restates the criteria to be used in evaluating the success of the transitway carpool experiment. Each criterion is addressed individually in Sections IV through IX. Conclusions are presented in Section X. A series of appendices to this report have been prepared as a separate document (Research Report 484-8). The appendices document details of the data collected. In essence, the appendices provide further documentation and substantiation of the material presented in this report.



## II. KATY TRANSITWAY UTILIZATION

The Katy Freeway Transitway opened October 29, 1984. At the time it opened, buses and vanpools were the only authorized users. In order to increase the volume of vehicles using the transitway and to address the perception that it was underutilized, a decision was made by Metro and the State Department of Highways and Public Transportation to begin, on a trial basis, to allow carpools to use the priority facility beginning April 1, 1985.

### Background on Katy Transitway Carpool Utilization

Transitway carpool utilization was initially restricted to authorized automobiles carrying four or more persons. In order to become authorized, carpools had to have: 1) certified drivers; 2) valid Texas vehicle 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) pass a visual inspection of the vehicle by Metro. If an authorized carpool had fewer than four persons on any day due to a carpool member's work schedule, travel, illness, or vacation, it was not permitted onto 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+ carpool designation could possibly generate a sufficient vehicular volume to 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, 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 extremely 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, 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 and were allowed to travel through the Katy Transitway.

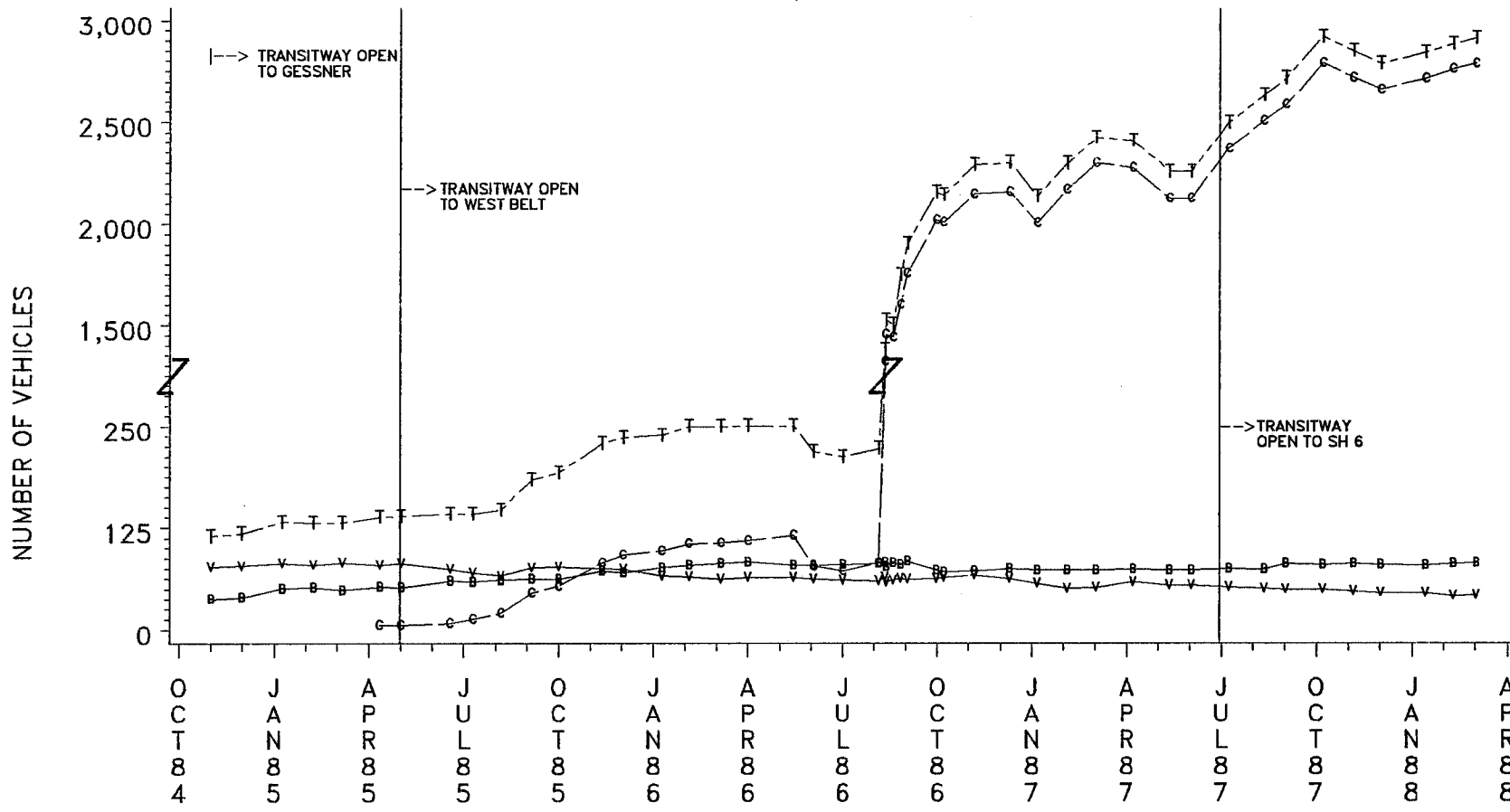
However, even with the 3+ designation, peak-hour carpool volumes remained less than 100 vph. A perception existed that the transitway was underutilized. As a consequence, on August 11, 1986, all authorization procedures were eliminated, and the eligible carpool definition was reduced to 2+. As shown subsequently, this caused a significant increase in transitway carpool volumes; it should also be noted that this increase occurred after the 12-month evaluation (Research Report 484-3) had been conducted.

#### Trends in Katy Transitway Utilization

Trends in average peak-period transitway utilization are shown in Figures 1 through 4. In October 1987, on a daily basis, buses represented 3% of vehicles using the transitway and moved 27% of the people; vanpools were 2% of vehicles and moved 5% of people; carpools were 95% of the vehicles and moved 68% of the people. Carpools have become the dominant mode of transitway person movement since 2+ vehicles were allowed to use the transitway.

Data pertaining to daily transitway utilization are summarized in Table 1. Since carpools were initially allowed onto the transitway, bus passenger volumes have increased by 36%, and vanpool person volumes have decreased by 41%. The vanpool decline appears to be more a function of the downturn in the Houston economy than it is the introduction of carpools; this conclusion is validated subsequently where previous mode is documented for transitway carpoolers.

### KATY FREEWAY (IH 10W) TRANSITWAY A.M. PEAK PERIOD VEHICLE UTILIZATION



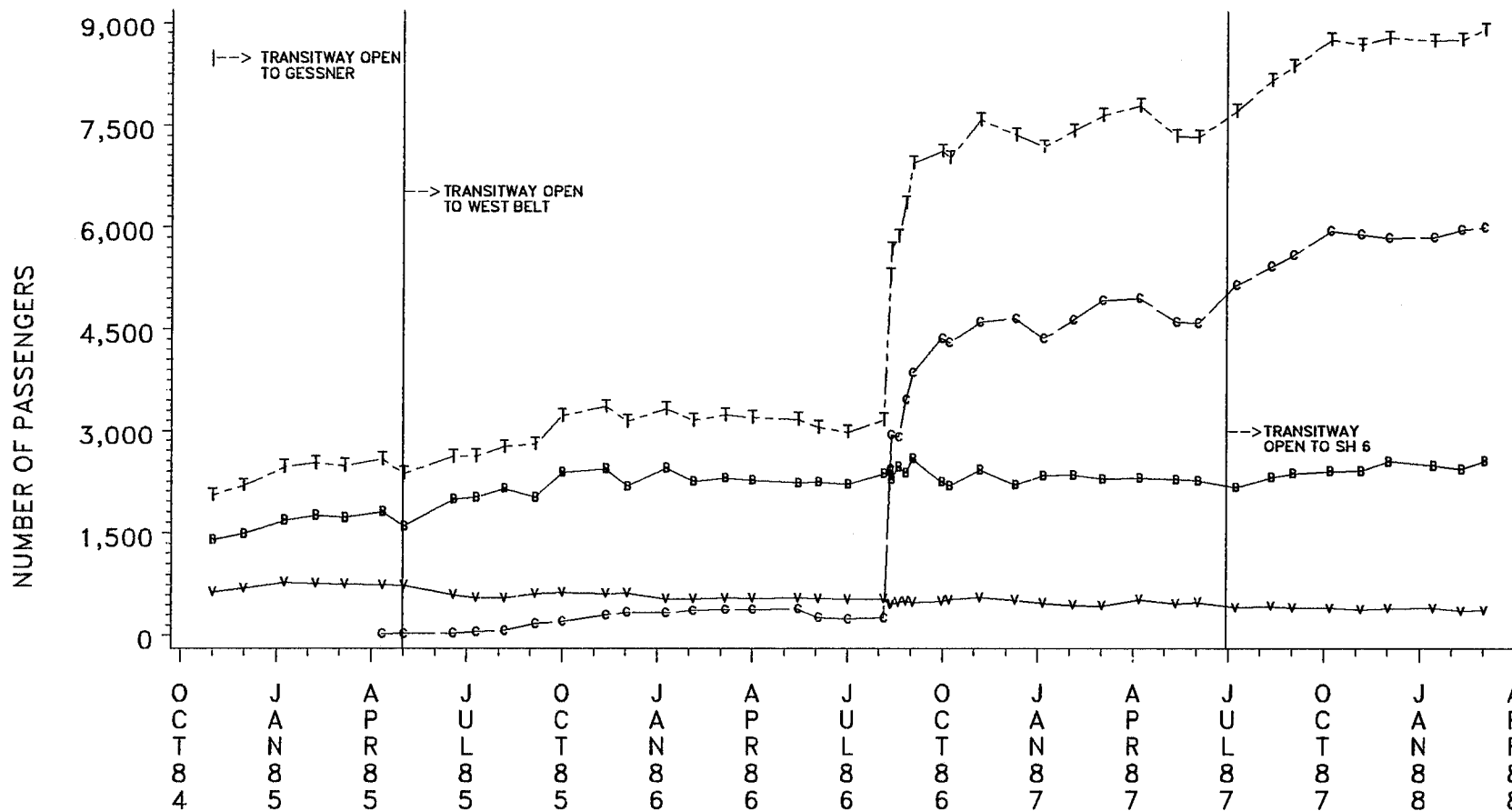
KATY TRANSITWAY PHASE 1, POST OAK TO GESSNER (4.7 MI.), OPENED OCTOBER 29, 1984  
 TRANSITWAY EXTENSION FROM GESSNER TO WEST BELT (1.7 MI.) OPENED MAY 2, 1985  
 OFF-PEAK, UNAUTHORIZED & 2+ CARPOOL OPERATION BEGAN AUGUST 11, 1986  
 TRANSITWAY EXTENSION FROM WEST BELT TO SH 6 (5.0 MI.) OPENED JUNE 29, 1987  
 PEAK PERIOD IS 5:45 - 9:30 AM  
 SOURCE : TEXAS TRANSPORTATION INSTITUTE

LEGEND : T = TOTAL HOV VEHICLES  
 B = TOTAL BUSES  
 V = TOTAL VANPOOLS  
 C = TOTAL CARPOOLS

Figure 1. A.M. Peak-Period Transitway Vehicle Utilization



### KATY FREEWAY (IH 10W) TRANSITWAY A.M. PEAK PERIOD PERSON MOVEMENT



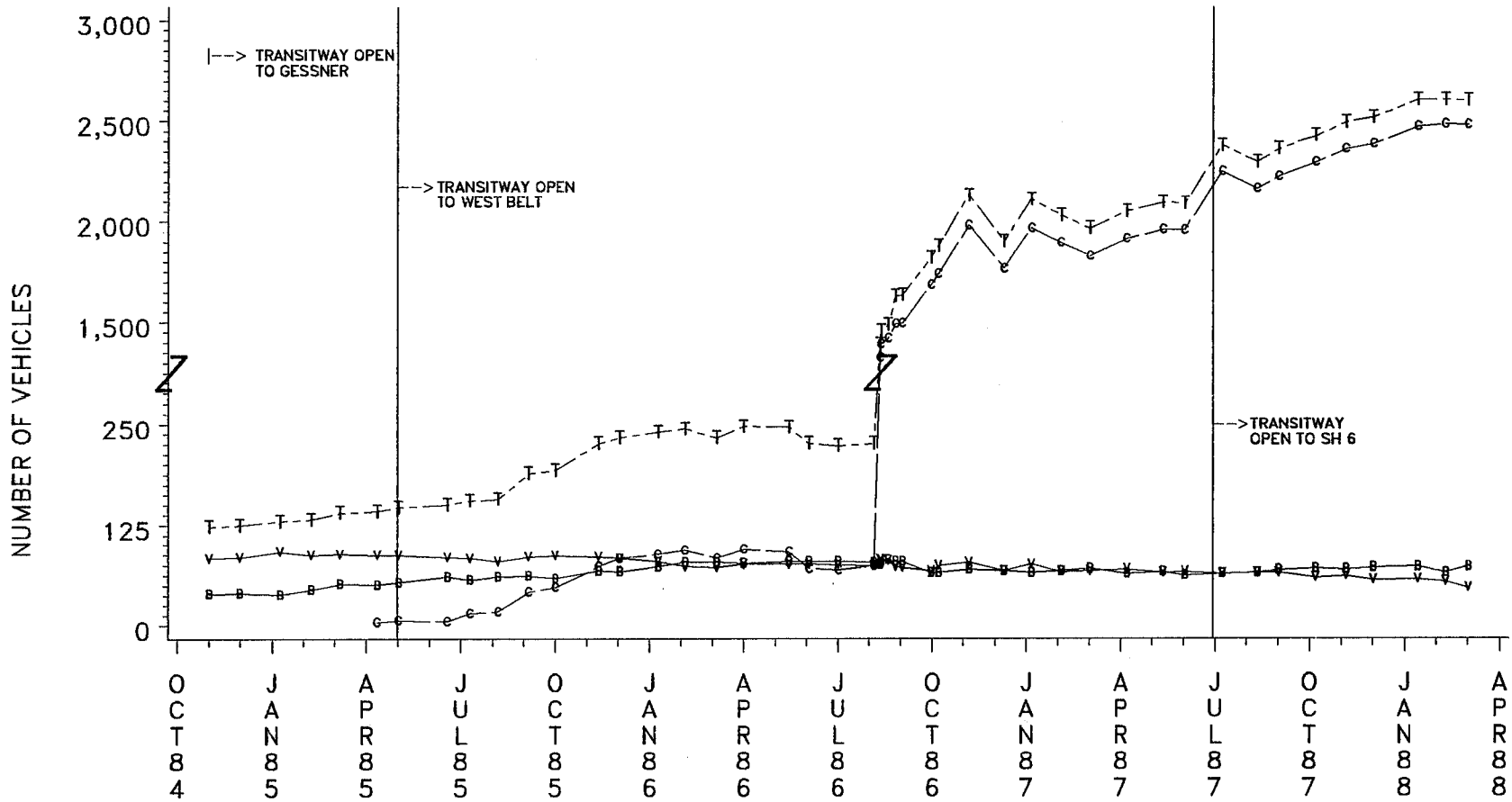
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KATY TRANSITWAY PHASE 1, POST OAK TO GESSNER (4.7 MI.), OPENED OCTOBER 29, 1984  
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 PEAK PERIOD IS 5:45 - 9:30 AM  
 SOURCE : TEXAS TRANSPORTATION INSTITUTE

LEGEND : T = TOTAL HOV PASSENGERS  
 B = TOTAL BUS PASSENGERS  
 V = TOTAL VANPOOLERS  
 C = TOTAL CARPOOLERS

Figure 2. A.M. Peak-Period Transitway Person Movement

### KATY FREEWAY (IH 10W) TRANSITWAY P.M. PEAK PERIOD VEHICLE UTILIZATION



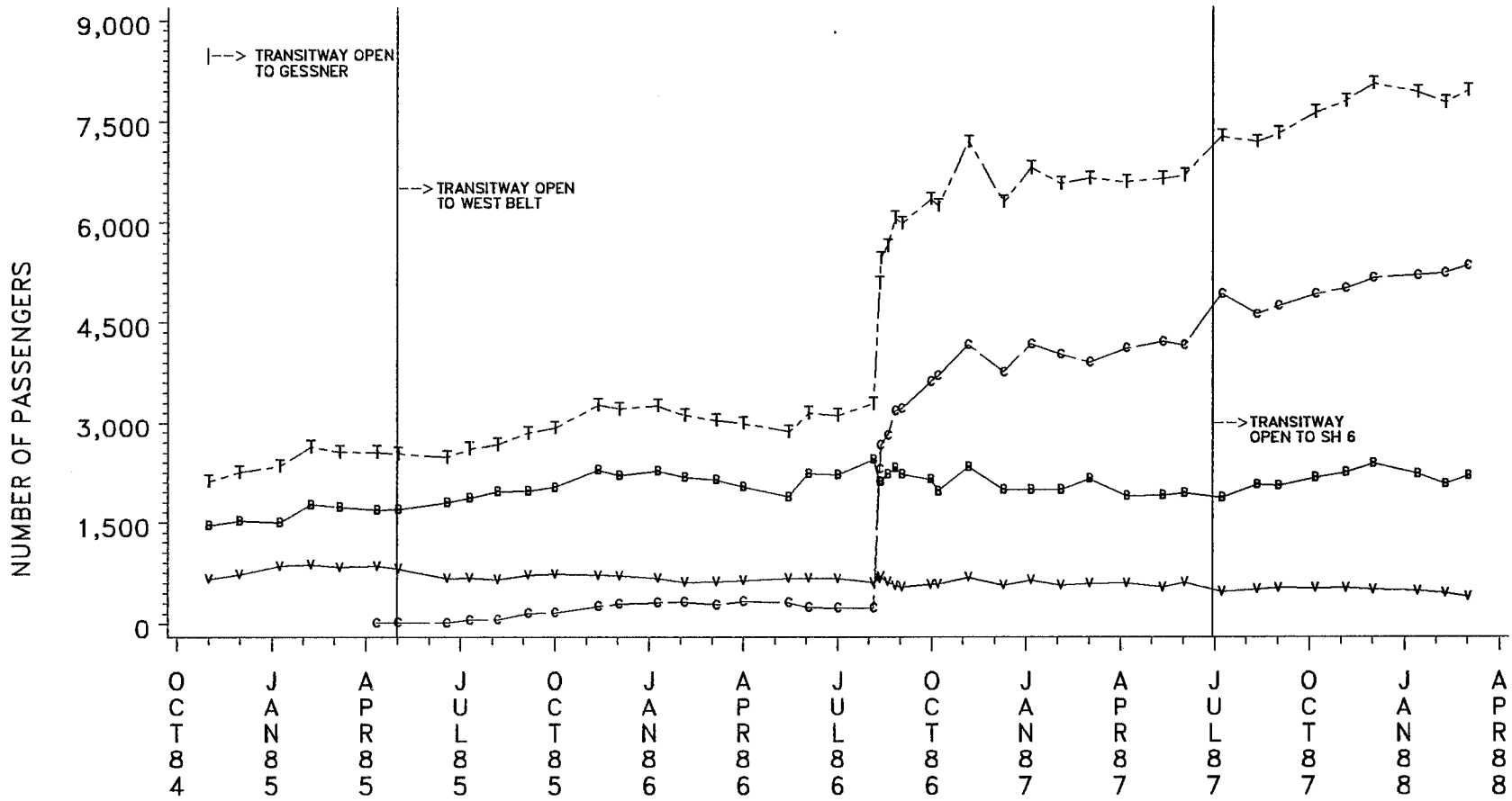
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 B = TOTAL BUSES  
 V = TOTAL VANPOOLS  
 C = TOTAL CARPOOLS

Figure 3. P.M. Peak-Period Transitway Vehicle Utilization

### KATY FREEWAY (IH 10W) TRANSITWAY P.M. PEAK PERIOD PERSON MOVEMENT

10



KATY TRANSITWAY PHASE 1, POST OAK TO GESSNER (4.7 MI.), OPENED OCTOBER 29, 1984  
 TRANSITWAY EXTENSION FROM GESSNER TO WEST BELT (1.7 MI.) OPENED MAY 2, 1985  
 OFF-PEAK, UNAUTHORIZED & 2+ CARPOOL OPERATION BEGAN AUGUST 11, 1986  
 TRANSITWAY EXTENSION FROM WEST BELT TO SH 6 (5.0 MI.) OPENED JUNE 29, 1987  
 PEAK PERIOD IS 5:45 - 9:30 AM  
 SOURCE : TEXAS TRANSPORTATION INSTITUTE

LEGEND : T = TOTAL HOV PASSENGERS  
 B = TOTAL BUS PASSENGERS  
 V = TOTAL VANPOOLERS  
 C = TOTAL CARPOOLERS

Figure 4. P.M. Peak-Period Transitway Person Movement

Table 1. Trends in Daily Utilization of the Katy Transitway

Transitway Vehicle Type	Volume				Percent Change 3/85 to 10/87
	11/84 <sup>1</sup>	3/85 <sup>2</sup>	4/86 <sup>3</sup>	10/87	
Buses					
Vehicles	78	100	160	156	+56%
Passengers	2860	3450	4302	4,685	+36%
Vanpools					
Vehicles	160	170	140	112	-34%
Passengers	1304	1596	1180	942	-41%
Carpools					
Vehicles	0	0	204	5,466	----
Passengers	0	0	706	11,716	----

<sup>1</sup>First full month of transitway operation.

<sup>2</sup>Month before carpools were allowed onto the transitway.

<sup>3</sup>Data from 12-month evaluation report (Research Report 484-3).

Source: Texas Transportation Institute Counts.

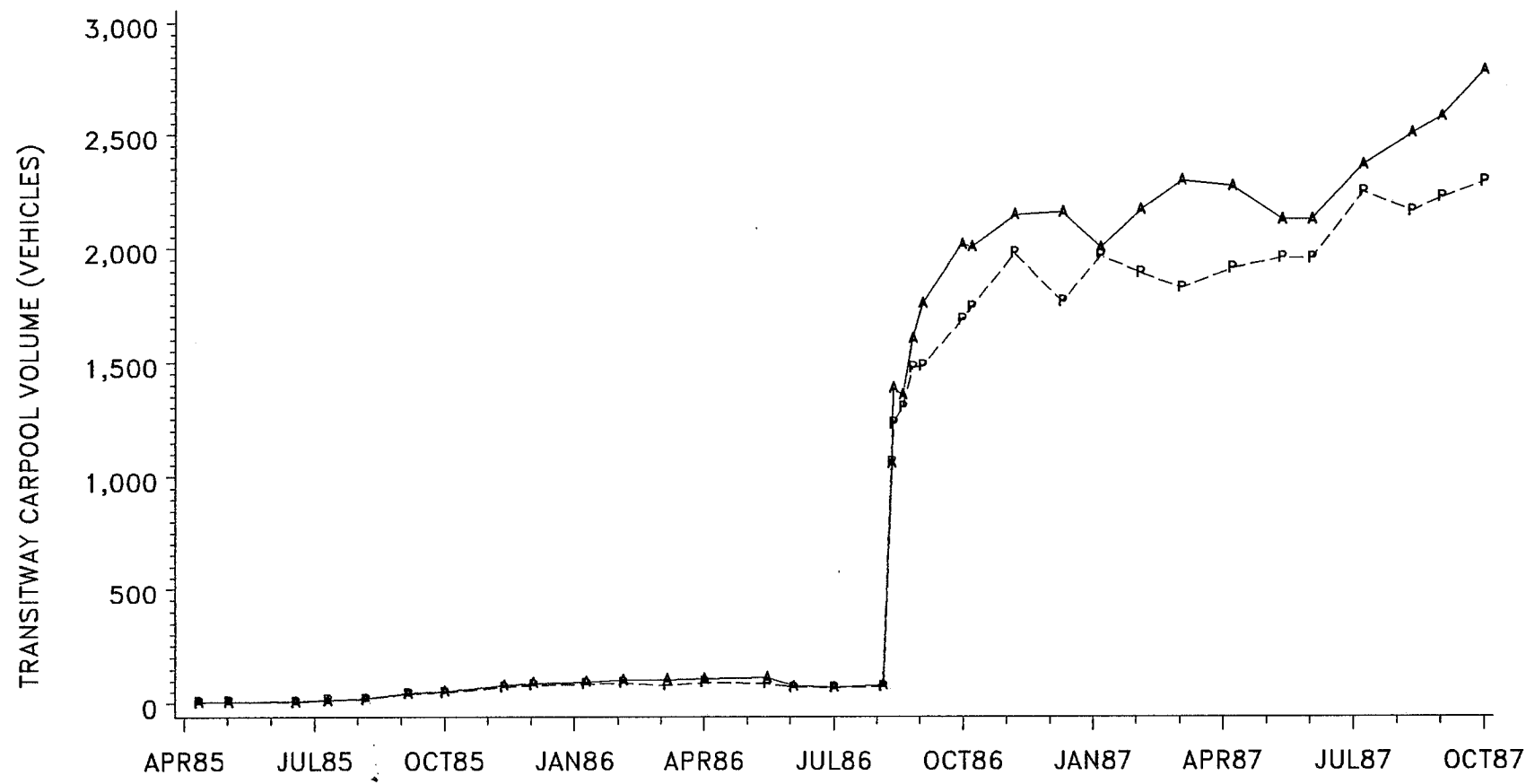
An overall assessment of trend data in the Katy corridor is shown in Table 2. This table compares conditions in the corridor prior to implementation of the transitway with conditions in the corridor as of September 1987. The transitway has been successful in increasing total person throughput and average vehicle occupancy.

#### Carpool Data, Katy Transitway and Selected Other HOV Projects

Trends in carpool utilization are shown in Figures 5 and 6. Carpool demand is somewhat higher in the a.m. This may be due to the fact that many of the carpools using the transitway are transporting children to school; thus, their afternoon travel may not coincide with the peak commuter period.

During an average peak period (average of a.m. and p.m. data) in October 1987, carpools represented over 95% of total vehicles using the transitway (Figure 7). Those vehicles serve just over 64% of the total persons moved on the transitway.

KATY FREEWAY (IH 10W) TRANSITWAY  
 PEAK PERIOD TRANSITWAY CARPOOL UTILIZATION



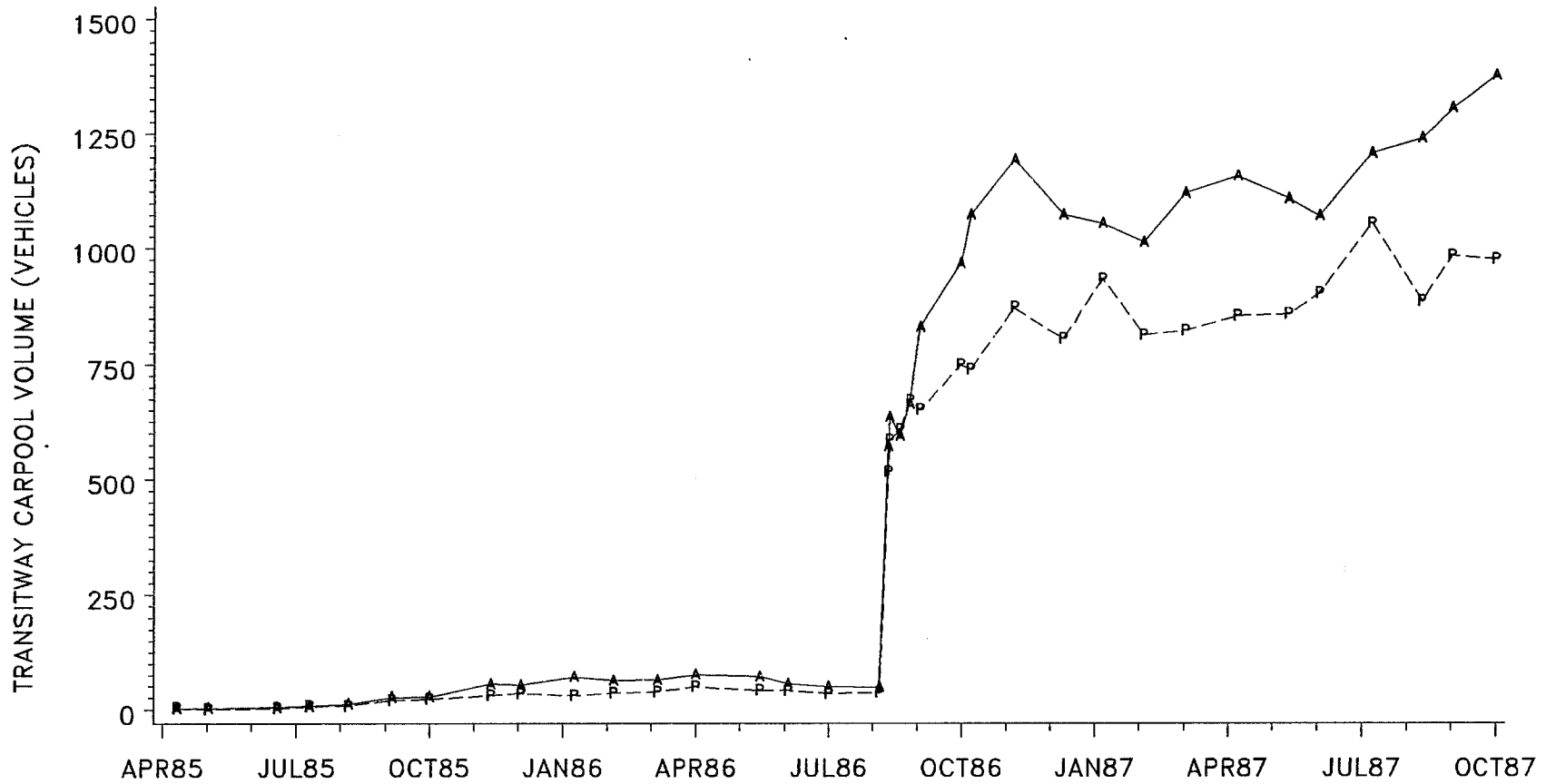
AUTHORIZED 4+ CARPOOLS ALLOWED ON TRANSITWAY, APRIL 1, 1985  
 AUTHORIZED 3+ CARPOOLS ALLOWED ON TRANSITWAY, SEPTEMBER 1985  
 2+ CARPOOLS WITH NO AUTHORIZATION ALLOWED ON TRANSITWAY, AUGUST 1986  
 PEAK PERIOD(S) ARE 5:45-9:30 A.M. & 3:30-7:00 P.M.

LEGEND : A = A.M. PEAK PERIOD  
 P = P.M. PEAK PERIOD

SOURCE : TEXAS TRANSPORTATION INSTITUTE

Figure 5. Peak-Period Transitway Carpool Utilization

KATY FREEWAY (IH 10W) TRANSITWAY  
PEAK HOUR TRANSITWAY CARPOOL UTILIZATION



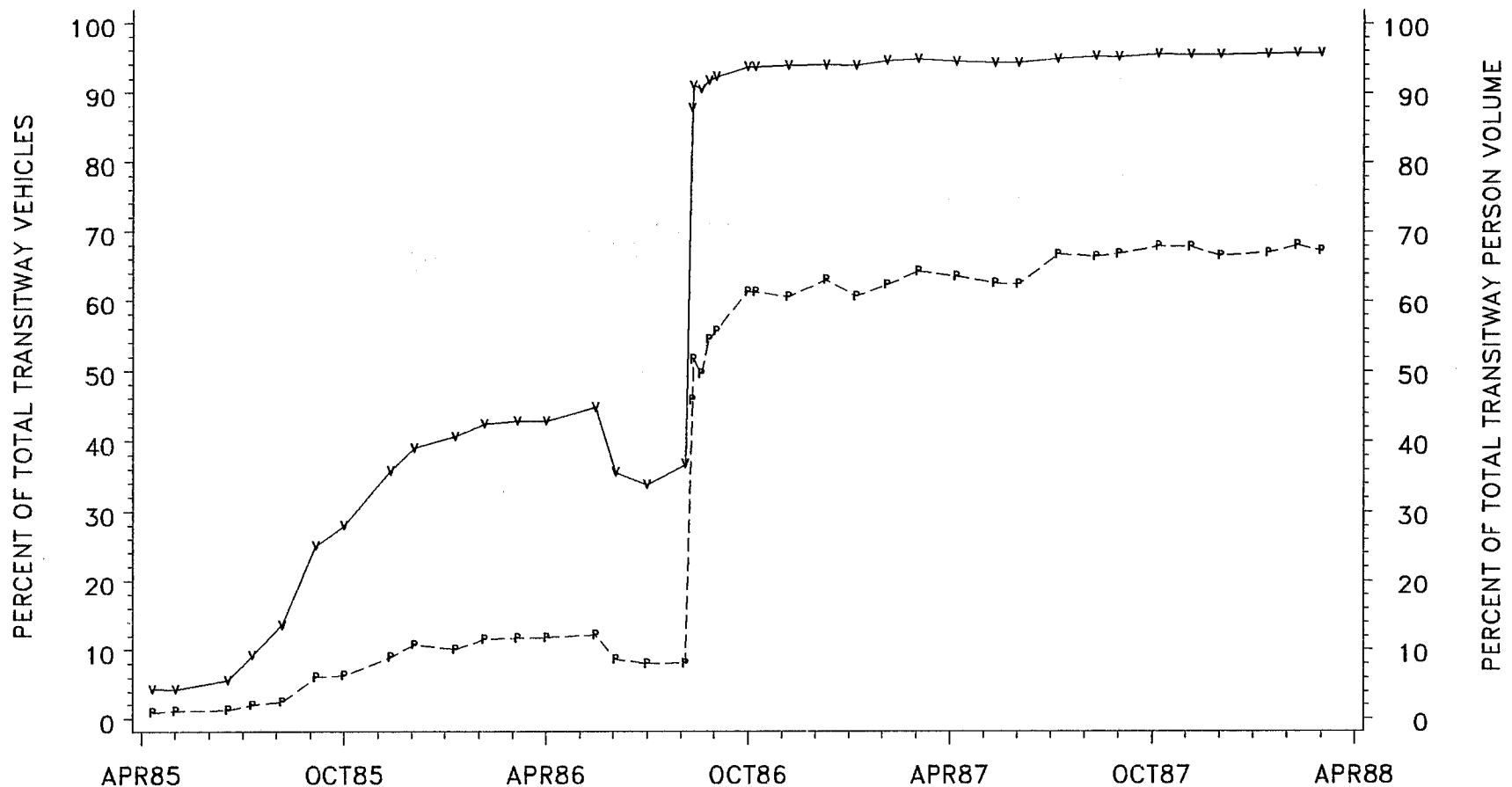
AUTHORIZED 4+ CARPOOLS ALLOWED ON TRANSITWAY, APRIL 1, 1985  
 AUTHORIZED 3+ CARPOOLS ALLOWED ON TRANSITWAY, SEPTEMBER 1985  
 2+ CARPOOLS WITH NO AUTHORIZATION ALLOWED ON TRANSITWAY, AUGUST 1986

LEGEND : A = A.M. PEAK HOUR  
 P = P.M. PEAK HOUR

SOURCE : TEXAS TRANSPORTATION INSTITUTE

Figure 6. Peak-Hour Transitway Carpool Utilization

KATY FREEWAY (IH 10W) TRANSITWAY  
 A.M. PEAK PERIOD CARPOOL VOLUMES AS A PERCENT OF TOTAL KATY TRANSITWAY VOLUMES



KATY TRANSITWAY PHASE 1, POST OAK TO GESSNER (4.7 MI.), OPENED OCTOBER 29, 1984  
 TRANSITWAY EXTENSION FROM GESSNER TO WEST BELT (1.7 MI.) OPENED MAY 2, 1985  
 OFF-PEAK, UNAUTHORIZED & 2+ CARPOOL OPERATION BEGAN AUGUST 11, 1986  
 TRANSITWAY EXTENSION FROM WEST BELT TO SH 6 (5.0 MI.) OPENED JUNE 29, 1987

LEGEND : V = TOTAL VEHICLES  
 P = TOTAL PERSONS

SOURCE : TEXAS TRANSPORTATION INSTITUTE

Figure 7. Transitway Carpools as a Percent of Total Transitway Travel, A.M. Peak Period

Table 2. Comparison of Travel Conditions in the Katy Freeway Corridor Prior to  
Transitway Implementation and in September 1987, A.M. Peak Period,  
Peak Direction

Type of Data	"Representative" Pre-Transitway Value	"Representative" Current Value	% Change
<u>Transitway Data</u>			
Person-Movement			
Peak Hour (7-8 a.m.)	----	4,252	----
Peak Period (6-9:30 a.m.)	----	8,369	----
Total Daily	----	16,737	----
Vehicle Volumes			
Peak Hour	----	1,364	----
Peak Period	----	2,719	----
Accident Rate (Accidents/MVM)	----	0.96	----
Vehicle Breakdowns (VMT/Breakdown)	----	29,000	----
Violation Rate	----	1%	----
<u>Combined Freeway and Transitway Data</u>			
Total Person Movement			
Peak Hour	5,100	9,183	+ 80%
Peak Period	15,655	23,442	+ 50%
Peak-Hour Vehicle Occupancy	1.26	2.55	+ 23.0%
Peak-Period Vehicle Occupancy	1.23	1.38	+ 12.2%
Peak-Period Carpool Volumes	1,570	3,300	+110%
Total Peak-Period Vehicle Volume	12,750	16,941	+ 33%
<u>Freeway Data</u>			
Peak-Period Freeway Vehicle Volume	12,750	14,222	+ 12%
Peak-Period Freeway Person Volume	15,655	15,073	- 3.7%
Peak-Period Freeway Occupancy	1.23	1.06	- 13.8%
Peak-Period Operating Speed in mph (W. Belt to Wirt)	27	27	0
Accident Rate (Accidents/MVM)	1.58	1.34	- 15%
<u>Transit Data</u>			
Vehicles Parked in Park-and-Ride Lots	575	1,250	+117%
Peak-Period Bus Trips	32	90	+181%
Peak-Period Bus Passengers	900	2,400	+167%

Source: Texas Transportation Institute data collection.



## Peak-Hour Carpool Volumes

For selected freeway HOV projects, Table 3 summarizes peak-hour carpool volumes. The Katy Transitway, at approximately 1,000 to 1,400 carpools per peak hour, is presently one of the better used HOV lanes.

Table 3. Carpool Volumes on Freeway High-Occupancy Vehicle Lanes

Facility	Carpool Definition	Peak Hour Carpool Volume <sup>1</sup> (vph)
Katy Transitway, Houston	2+	1379 (a.m.) 979 (p.m.)
I-66, Washington, D.C. (2 lanes)	3+	2980
Shirley (I-395), Washington, D.C. (2 lanes)	4+	2165
Rte. 91, Los Angeles	2+	1370
I-95, Miami	2+	1370
Rte. 55, Orange County	2+	1250
El Monte, Los Angeles	3+	905
I-4, Orlando	2+	900
I-495, Lincoln Tunnel, N.Y.C.	buses only	740 buses
I-5, Seattle	3+	400
US 101, San Francisco	3+	360
SR 520, Seattle	3+	250

<sup>1</sup>Including autos in HOV lane in violation of HOV occupancy requirements.

Sources: TTI Analyses and 1985 ITE Survey of HOV Projects.

In reviewing the volume data, the "capacity" of the HOV lane becomes an issue. A consensus of the agencies involved in operating freeway HOV lanes is that the capacity of these lanes is somewhere in the range of 1,000 to 1,500 vph (Research Report 484-3). As evaluated in Research Report 484-6, it appears that 1,500 vph is representative of the capacity of the Katy Transitway. Thus, with current carpool utilization, capacity in the a.m. peak hour is currently being fully utilized although not exceeded. As demand continues to increase, this will become a concern.

### Increase in Carpooling Due to Transitway Implementation

Typically, allowing carpools to use an HOV lane increases the total volume of carpools on the freeway. With the introduction of 2+ carpools, this has also occurred on the Katy Freeway.

Extensive data have been collected on the Katy Freeway since 1983. These data are summarized in Figures 8 and 9. It is apparent that, particularly since 2+ carpools were allowed onto the transitway, the increase in carpooling has at least been "in line" with that experienced on other projects (Table 4).

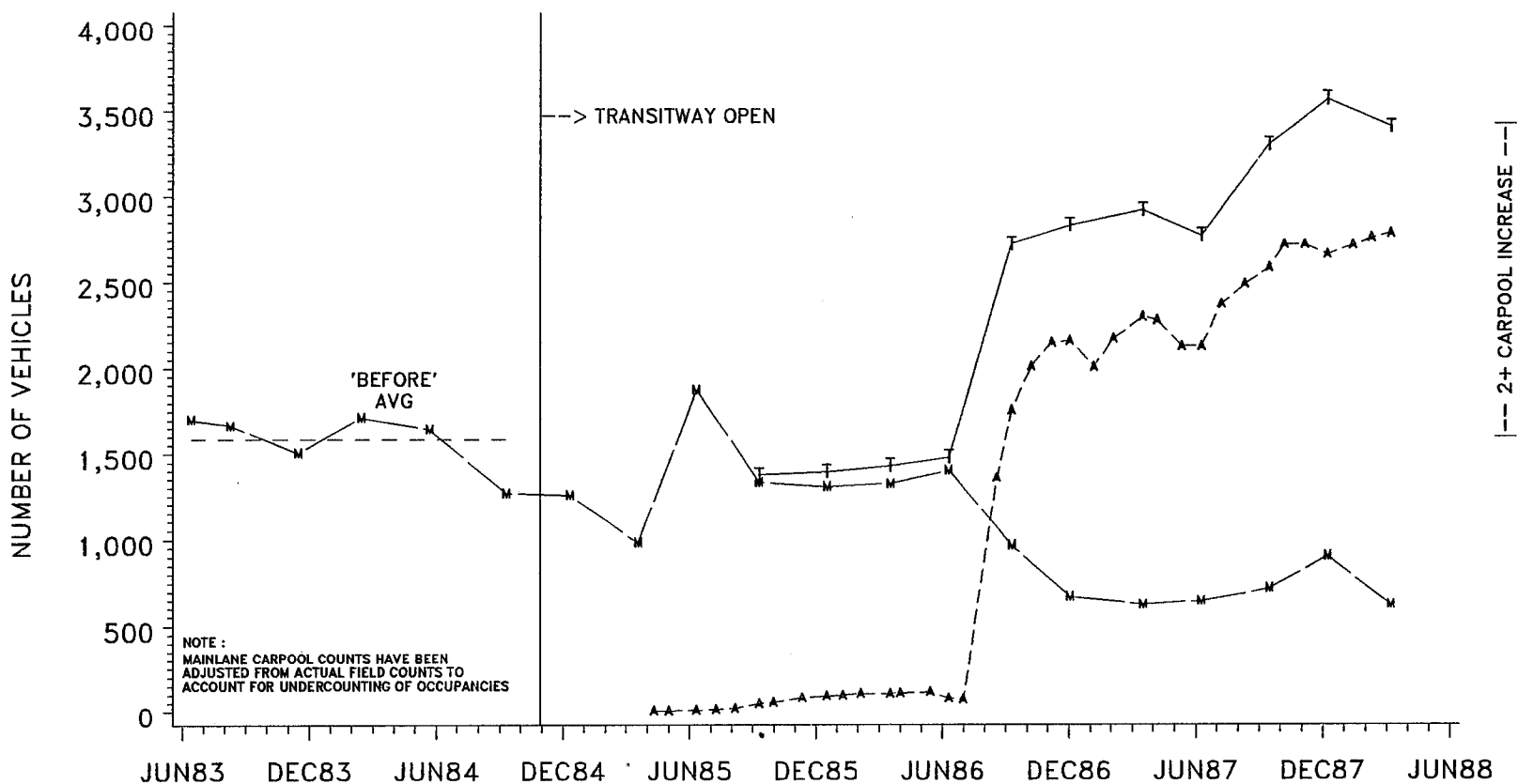
Table 4. Estimated Increases in Carpool Volumes Due to HOV Lane Implementation

Facility	Carpool Volume Before HOV	Carpool Volume After HOV <sup>1</sup>	Percent Change
Katy Transitway, Houston (1983-1987) a.m. peak period (6:00-9:30)	1570	3300	+110%
El Monte, Los Angeles (1976-1985) a.m. peak period	670	2166	+323%
Rte. 91, Los Angeles (4 mo. in 1985) p.m. peak hour	1000	1350	+ 35%
Rte. 55, Orange Co. (1984-6) a.m. peak period	1341	1916	+ 43%
	1925	2473	+ 28%
I-95, Miami (1976-1984) a.m. peak period	2185	2714	+ 24%
Shirley Highway, Washington, D.C. a.m. peak period (1974-1985)	272	3723	+1269%
I-93, Boston (1974-1980) a.m. peak period	315	1224	+ 289%
Banfield Fwy., Portland, Ore. a.m. peak period	106	518	+389%
Moanalua Fwy. (1974-1982) a.m. peak period	600	1750	+192%

<sup>1</sup>Freeway plus HOV lane volume.

Sources: TTI Analyses, ITE 1985 Survey of Operating HOV Projects, and "Study of Current and Planned High-Occupancy Vehicle Lane Use: Performance and Prospects", by Frank Southworth and Fred Westbrook, 1985.

KATY FREEWAY (IH 10W) 2+ CARPOOL UTILIZATION  
A.M. PEAK PERIOD  
DATA COLLECTED AT BUNKER HILL



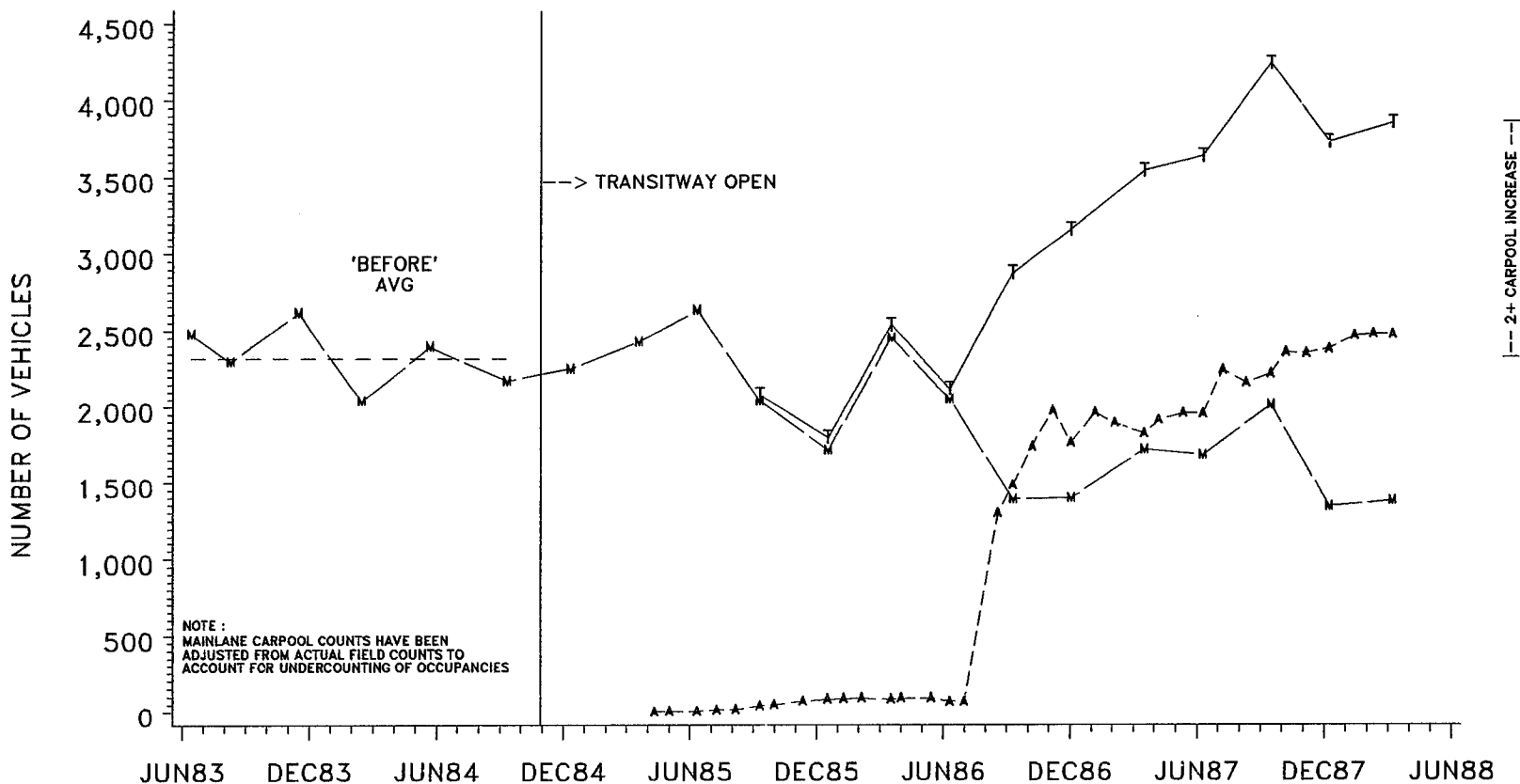
KATY TRANSITWAY PHASE 1, POST OAK TO GESSNER (4.7 MI.), OPENED OCTOBER 29, 1984  
TRANSITWAY EXTENSION FROM GESSNER TO WEST BELT (1.7 MI.) OPENED MAY 2, 1985  
OFF-PEAK, UNAUTHORIZED & 2+ CARPOOL OPERATION BEGAN AUGUST 11, 1986  
TRANSITWAY EXTENSION FROM WEST BELT TO SH 6 (5.0 MI.) OPENED JUNE 29, 1987  
PEAK PERIOD IS 5:45 - 9:30 AM

LEGEND : T = TOTAL 2+ CARPOOLS  
A = TOTAL TRANSITWAY 2+ CARPOOLS  
M = TOTAL MAINLANE 2+ CARPOOLS

SOURCE : TEXAS TRANSPORTATION INSTITUTE

Figure 8. Increases in Carpooling in the A.M. Peak Period

KATY FREEWAY (IH 10W) 2+ CARPOOL UTILIZATION  
P.M. PEAK PERIOD  
DATA COLLECTED AT BUNKER HILL



19

KATY TRANSITWAY PHASE 1, POST OAK TO GESSNER (4.7 MI.), OPENED OCTOBER 29, 1984  
 TRANSITWAY EXTENSION FROM GESSNER TO WEST BELT (1.7 MI.) OPENED MAY 2, 1985  
 OFF-PEAK, UNAUTHORIZED & 2+ CARPOOL OPERATION BEGAN AUGUST 11, 1986  
 TRANSITWAY EXTENSION FROM WEST BELT TO SH 6 (5.0 MI.) OPENED JUNE 29, 1987  
 PEAK PERIOD IS 3:30 - 7:00 PM

LEGEND : T = TOTAL 2+ CARPOOLS  
 A = TOTAL TRANSITWAY 2+ CARPOOLS  
 M = TOTAL MAINLANE 2+ CARPOOLS

SOURCE : TEXAS TRANSPORTATION INSTITUTE

Figure 9. Increases in Carpooling in the P.M. Peak Period

### *Components of the Increase in Carpooling*

The data in Table 4 indicate that carpooling on the Katy Freeway in the a.m. peak period has increased by over 100% since the inception of the transitway. A survey was conducted in March 1987 to determine the origin of those carpools; those data were also collected in October 1987. These analyses are summarized in Figure 10. It is apparent that approximately 55% to 60% of the carpools using the transitway are "new" carpools (sum of previous mode being either "drove alone" or "did not make trip"). It is also evident that the volume of new carpools continued to increase between the March and the October surveys.

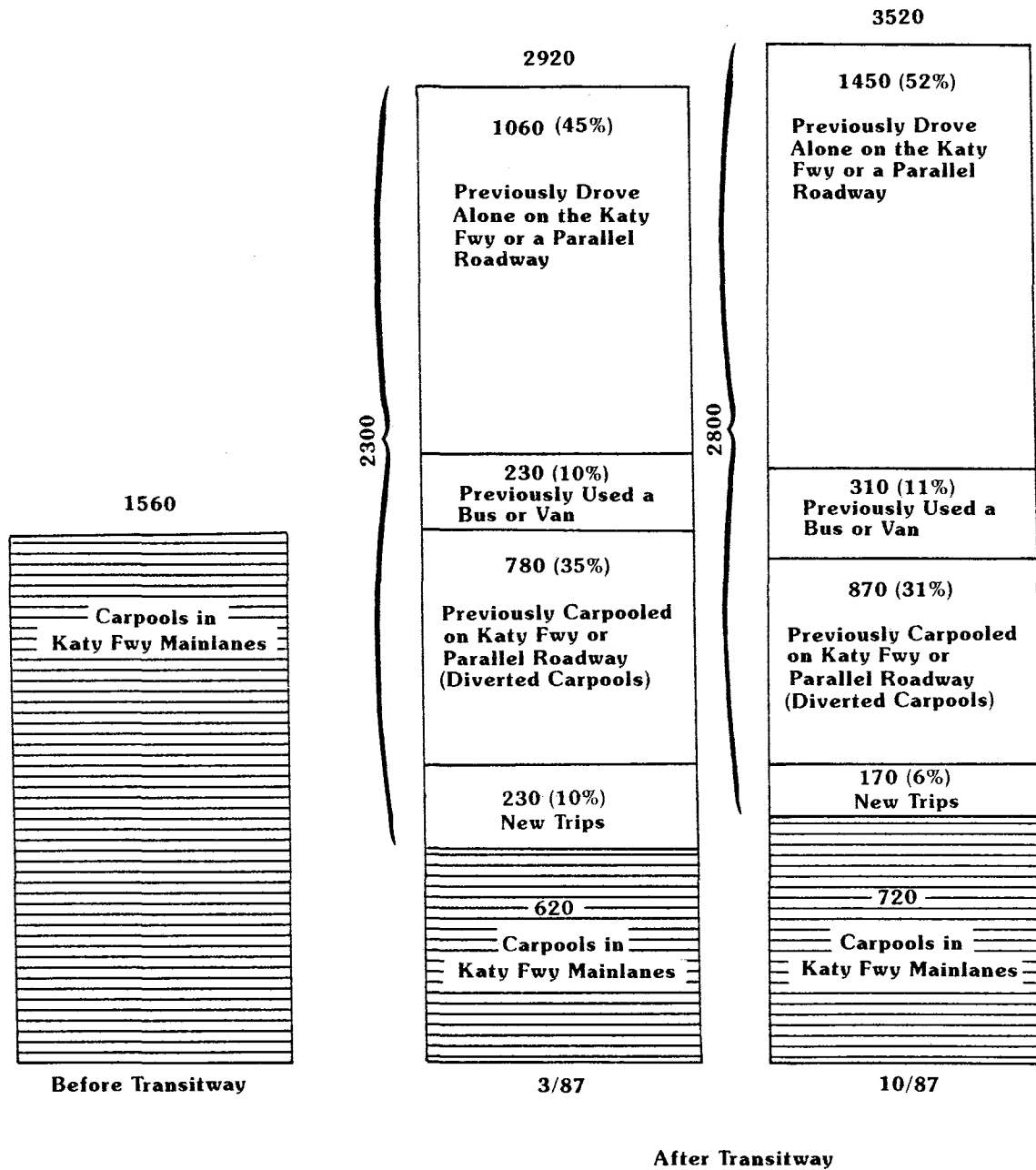


Figure 10. A.M. Peak Period 2+ Carpool Volumes (Freeway + Transitway) "Before" and "After" Transitway



**III. CRITERIA FOR EVALUATING THE SUCCESS OF THE TRANSITWAY**  
**CARPOOL EXPERIMENT**

Carpools were permitted to use the Katy Transitway as an experiment. Prior to allowing carpools on the transitway, Metro and the State identified the general criteria that would be used to evaluate the success of the carpool experiment. Those criteria were presented in Research Report 484-1 and are also shown in Table 5.

These criteria are addressed individually in subsequent sections of this report. Included in this presentation is relevant data from the 12-month "after" evaluation, the special carpool survey conducted in April 1987, and the 30-month "after" evaluation conducted in October 1987.



Table 5. Criteria for Judging the Success of the Katy Transitway Carpool Experiment

Proposed Evaluation Factor	Relative Weighting	Resulting Impact
1. Change in person movement on the the Katy Transitway directly attributable to carpooling.	25	<p>Highly Successful: Total transitway person movement increases by at least 20% due to carpooling.</p> <p>Successful: Person movement increases by between 5% and 20%.</p> <p>Unsuccessful: Person movement essentially unchanged (0% to 5% increase)</p> <p>Highly Unsuccessful: Person movement decreases.</p>
2. Non-User Perception of Katy Transitway Utilization	30	<p>Highly Successful: At least 70% of non-users respond that transitway is sufficiently utilized.</p> <p>Successful: Between 50% and 70% of non-users respond that transitway is sufficiently utilized.</p> <p>Unsuccessful: Between 50% and 70% of non-users respond that transitway is not sufficiently utilized.</p> <p>Highly Unsuccessful: More than 70% of non-users respond that transitway is not sufficiently utilized.</p>
3. Change in average travel time on the Transitway	20	<p>Highly Successful: No change.</p> <p>Successful: Average travel speed decreases by no more than 3 mph.</p> <p>Unsuccessful: Average travel speed decreases by between 3 mph and 6 mph.</p> <p>Highly Unsuccessful: Average travel speed decreases by more than 6 mph.</p>
4. Change in person delay to mixed-flow traffic	15	<p>Highly Successful: No change or a decrease in total delay.</p> <p>Successful: Delay increases by less than 5%.</p> <p>Unsuccessful: Delay increases by 5% to 10%.</p> <p>Highly Unsuccessful: Delay increases by more than 10%.</p>
5. Increase in frequency of breakdowns on the Transitway	5	<p>Highly Successful: None.</p> <p>Successful: Less than 5%.</p> <p>Unsuccessful: Increase by between 5% and 15%.</p> <p>Highly Unsuccessful: Increases by more than 15%.</p>
6. Increase in authorization and enforcement costs.	5	<p>Values developed by Metro. Authorization has been eliminated.</p>

In this matrix, items #1, 3 and 4 indirectly address change in total corridor delay. In this matrix, item 5 indirectly addresses trip reliability.

#### IV. PERSON MOVEMENT IMPACTS OF CARPOOLING

A desired impact of permitting carpools onto the transitway is to increase the volume of persons moved on the facility. As shown previously (Table 1), carpools are presently moving the majority of persons on the transitway.

#### Carpool Component

The percentage of persons moved by carpool on the transitway is shown in Table 6. As can be seen, the carpool component has increased significantly over time, particularly since 2+ carpools were allowed onto the transitway.

Table 6. Person Movement on the Katy Transitway

Time Period	Bus		Vanpool		Carpool		Total
	Volume	%	Volume	%	Volume	%	
A.M. Eastbound							
Peak Hour							
April 1986	980	61%	377	23%	261	16%	1618
April 1987	1025	27%	256	7%	2531	66%	3812
October 1987	1200	28%	195	4%	2965	68%	4360
Peak Period							
April 1986	2270	71%	548	17%	378	12%	3196
April 1987	2300	30%	534	7%	4960	63%	7794
October 1987	2405	27%	400	5%	5956	68%	8761
P.M. Westbound							
Peak Hour							
April 1986	670	56%	366	30%	166	14%	1202
April 1987	1065	35%	212	7%	1804	58%	3081
October 1987	1175	34%	185	5%	2083	61%	3443
Peak Period							
April 1986	2032	68%	632	21%	328	11%	2992
April 1987	1895	29%	596	9%	4113	62%	6604
October 1987	2175	29%	521	7%	4925	64%	7621

Note: In April 1986, authorized 3+ carpools were allowed to use the transitway. In April 1987 and October 1987, 2+ carpools were allowed onto the facility and authorization requirements had been eliminated.

These data could lead to a determination that, in October 1987, allowing carpools onto the transitway increased person movement by 212% in the a.m. peak period and by 183% in the p.m. peak period. However, such a conclusion

does not consider the fact that some of the carpoolers used other transitway modes prior to carpooling (Table 7).

Table 7. Prior Use of the Transitway By Carpoolers

Did You Use The Transitway Before Carpooling	Carpool Survey Date			
	10/85	4/86	4/87	10/87
Yes, Bus	3%	7.1%	7%	8%
Yes, Van	2%	7.1%	2%	1%
No	95%	85.8%	91%	91%

This suggests that, since 2+ unauthorized carpools were allowed onto the transitway, approximately 9% of carpoolers were drawn from other transitway modes; these trips do not represent an effective increase in transitway person movement due to carpooling. Thus, in effect, carpooling has increased a.m. peak period person movement by about 162%, and it has increased p.m. peak period person movement by about 143%. The average increase is assumed to be approximately 150%.

### Conclusion Pertaining To Evaluation Criterion

The increase in transitway person movement resulting from carpool utilization is a criterion for evaluating the success of the carpool experiment (Table 5). Table 8 summarizes the application of the data to the criterion. As of October 1987, in terms of this criterion, the experiment is judged to be "highly successful".

Table 8. Transitway Person Movement Impacts of Carpooling, Criterion for Assessing the Success of the Katy Transitway Carpool Experiment

Date of Evaluation	A.M. Peak Period Carpool Person Volume	Est. % Increase in Transitway Person Movement	Rating of Criterion (see Table 5)
4/86	378	10%	"Successful"
4/87	4960	135%	"Highly Successful"
10/87	5956	150%	"Highly Successful"

## V. PERCEPTION OF TRANSITWAY UTILIZATION

A major purpose for allowing carpools to use the transitway was to make the facility appear more utilized to the general public. Carpooling has significantly increased the volume of vehicles using the transitway. In March 1985, 138 vehicles used the transitway during a typical peak period; in April 1986, 256 vehicles were using the transitway in the peak period; in April 1987, 2,410 vehicles were on the facility in the peak period, and in October 1987, 2,922 vehicles used the transitway in the peak period.

The effect of this increased volume on the perception of transitway utilization has been noticeable; it is evident that a relationship does exist between vehicular utilization of the transitway and the perception that the transitway is sufficiently utilized.

Table 9. Perception of the Utilization of the Katy Transitway By Users

Measure of Effectiveness	Transitway Users								
	Transit			Vanpool		Carpool			
	3/85	4/86	10/87	3/85	4/86	10/85	4/86	4/87	
Is the Transitway Sufficiently Utilized?									
Yes	49%	66%	77%	30%	41%	34%	45%	82%	
No	33%	14%	7%	51%	34%	43%	32%	9%	
Not Sure	18%	20%	16%	19%	25%	23%	23%	9%	

As would be expected, the persons operating vehicles in the Katy Freeway general purpose lanes -- persons who do not perceive they are directly benefitting from the transitway -- do not believe the facility to be as well utilized as do the users of the transitway. Nevertheless, as transitway volumes have increased, the perception of the freeway motorists regarding the utilization of the transitway has changed perceptibly. The majority of the motorists feel the transitway is a good transportation improvement (Table 10).

Table 10. Perception of the Utilization of the Katy Transitway  
By Motorists in the General Freeway Lanes

Measure of Effectiveness	Non Transitway Users			
	3/85 <sup>1</sup>	4/86 <sup>2</sup>	4/87 <sup>3</sup>	10/87 <sup>3</sup>
Transitway A.M. Peak Period Vehicle Volume	138	256	2410	2922
Is the transitway sufficiently utilized?				
Yes	3%	3%	36%	44%
No	90%	92%	55%	42%
Not Sure	7%	5%	9%	14%
Is the transitway a good transportation improvement?				
Yes	41%	36%	56%	63%
No	35%	43%	29%	20%
Not Sure	24%	21%	15%	17%

<sup>1</sup>Authorized buses and vanpools (before carpools)

<sup>2</sup>Authorized buses, vanpools and 3+ carpools

<sup>3</sup>2+ vehicles, no authorization

### Conclusion Pertaining to Evaluation Criterion

In the criteria for evaluating the success of the carpool experiment, the non-user perception of transitway utilization was the single most important criterion (Table 5). Table 11 summarizes the application of the data to the criterion. As of October 1987, in terms of this criterion, the experiment is judged to be "successful".

Table 11. Perception of Transitway Utilization, Criterion for Assessing the Success of the Katy Transitway Carpool Experiment

Date of Evaluation	A.M. Peak Period Transitway Vehicle Volume	% of Motorists in General Purpose Lanes Who Feel Transitway Is Sufficiently Utilized <sup>1</sup>	Rating of Criterion (See Table 5)
4/86	256	6%	"Highly Unsuccessful"
4/87	2410	40%	"Unsuccessful"
10/87	2922	51%	"Successful"

<sup>1</sup>This represents the sum of those saying the transitway is sufficiently utilized plus one-half of those stating they were "not sure". See Table 10 for data breakdown.

## VI. CHANGE IN AVERAGE TRAVEL TIME ON THE TRANSITWAY

A concern associated with transitway carpool utilization is that the increase in volumes could depress the speeds on the transitway. This, in turn, could reduce the attractiveness of the transitway.

### Speeds

#### Transitway Average Travel Speeds

Time mean speeds were measured for each bus that used the Katy Transitway. The time each bus entered the transitway and the time it exited the transitway were recorded, and average speeds for the length traveled were calculated. Because of the high flow rates during the peak period, the bus speeds were used to estimate the total transitway speeds, since buses ran at average headways of 2 minutes, and the peak hour volumes approached the capacity of the transitway.

The average speed of all buses using the transitway, when there were no carpools and the lane was 6.3 miles in length (May 1985), is compared to the average bus speed for the current conditions with 3,000 carpools and a transitway length of 11 miles (Table 12). There was no change in average speed, but there are slower speeds as a result of the increase in vehicle volume. However, the length of time the low speeds occur, and the length of the transitway that is affected, are small, and the overall average bus speed is not significantly impacted over the operating period. Speed data, collected in July and October 1987, are shown in Figure 11. As shown in the figure, speeds are reduced slightly during a portion of the peak hour.

Table 12. Time Mean Speed for Vehicles on the Katy Transitway, 1985 and 1987

Vehicle Type	Date	
	May 1985	November 1987
Bus	52 mph	52 mph
Van	56 mph	52 mph
Carpool	---	52 mph

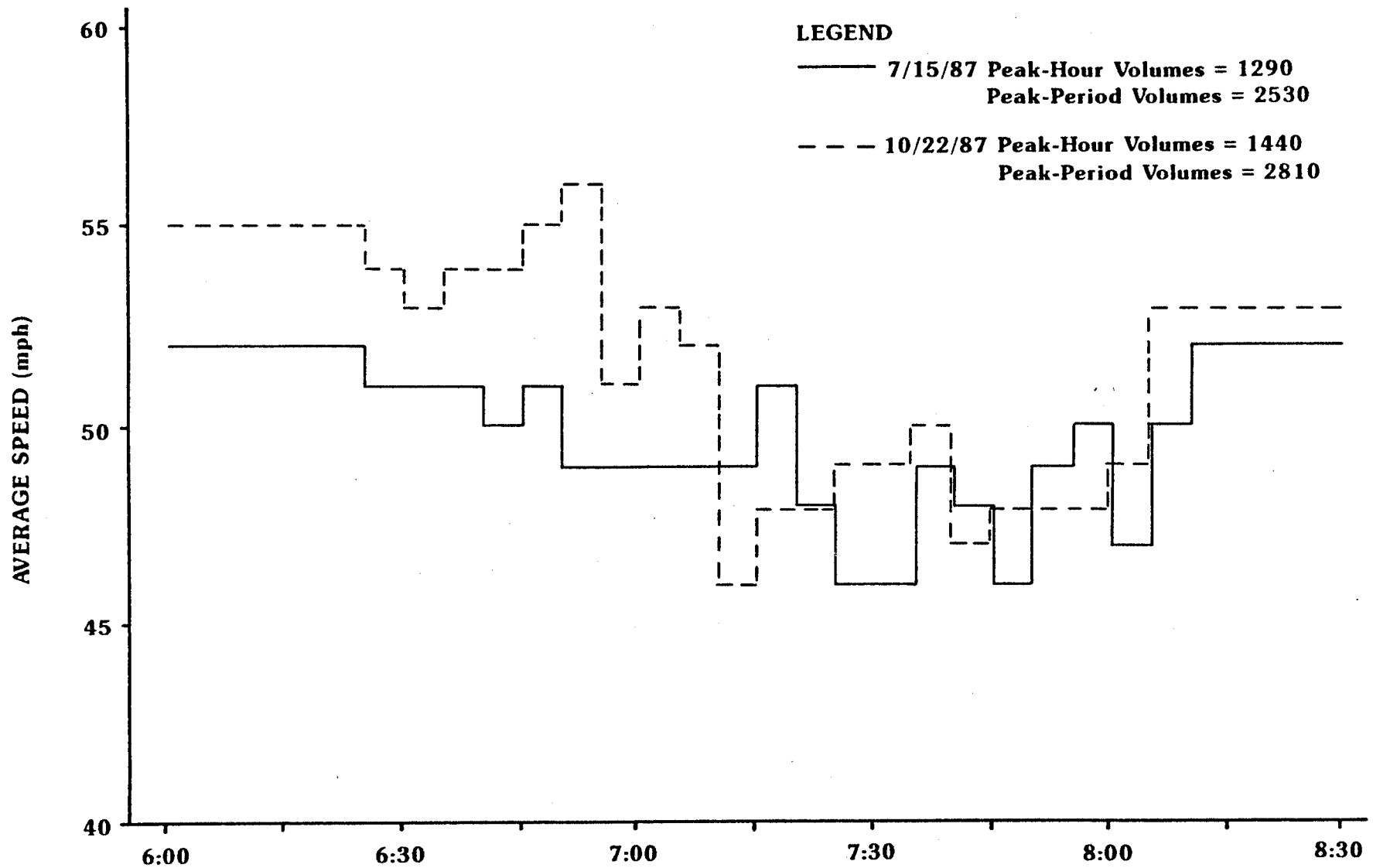


Figure 11. A.M. Average Transitway Running Speeds From Western Terminus to Post Oak Intersection

A profile of transitway travel times in both the a.m. and p.m. peak is shown in the subsequent section of this report as are additional speed data. As would be expected, total travel times for vehicles using the transitway have decreased as a result of the extension of the transitway.

#### Conclusion Pertaining to Evaluation Criterion

Possible changes in transitway operating speed are a criterion for evaluating the success of the carpool experiment (Table 5). The 12-month evaluation (Research Report 484-3) found that, at that time, transitway speeds had actually increased, and this criterion was considered to be "highly successful". As shown in this section, at present, speeds are essentially unchanged or reduced very slightly. Due to the additional delay at the Post Oak intersection, this criterion is considered to be "successful"; that is, average travel speed has decreased by no more than 3 mph.





## VII. MIXED-FLOW TRAFFIC LANES

It is conceivable that allowing carpools onto the transitway could have either a positive or a negative impact on speeds and operation in the mixed-flow lanes. If substantial carpool volumes use the transitway, mainlane volumes could be decreased, which might improve operations. Conversely, the existing access/egress locations to the transitway are not necessarily optimal. Large volumes entering or exiting the transitway (particularly at Gessner) could deteriorate the level-of-service on the mainlanes.

### Travel Time

Travel time studies were conducted on the Katy Freeway between the SH 6 interchange and the S.P.R.R. overpass east of the Washington Avenue interchange at 30-minute intervals. The studies were conducted in October and November 1987. In order to compare the results of the 1987 study with those of the 1985 and 1986 studies presented in Research Report 484-3, the same study length of 13.2 miles was used, but the number of study sections was reduced from 4 to 3, reflecting the closure of the West Belt transitway ramp (Table 13).

Table 13. Section Limits for Travel Time Runs on the Completed Katy Transitway

Section Number		Limits of Section
AM Designation	PM Designation	
1	3	SH 6 to Gessner Access Ramps (6.3 mi.)
2	2	Gessner Access Ramps to east terminus of the AVL at Post Oak (4.7 mi)
3	1	Post Oak to the S.P.R.R. overpass of I-10 (2.2 mi)

### AM Peak Period

Floating car travel times were taken for three days over the 13.2 mile length on the freeway, and the average speeds for the three study sections were calculated (Table 14). The total travel times for the freeway were averaged by time of day at the start of the study. The 1987 data, presented

in Figure 12, can be directly compared to the 1985 data collected when the transitway was completed only to West Belt (6.4 miles).

Table 14. Eastbound AM Speeds in the Katy Freeway Mainlanes, October-November 1987

Date of Study	Begin Time (AM)	Average Speeds in MPH			
		Sec 1 (6.3 miles)	Sec 2 (4.7 miles)	Sec 3 (2.2 miles)	Total Length (13.2 miles)
October 20, 1987	6:00	55	56	56	56
	6:30	32	30	53	34
	7:00	22	27	55	27
	7:30	23	24	54	25
	8:00	39	28	53	36
	8:30	45	22	58	34
	9:00	38	47	55	43
October 29, 1987	6:00	56	57	54	56
	6:30	25	29	56	29
	7:00	21	23	55	24
	7:30	18	19	55	20
	8:00	23	28	55	27
	8:30	41	31	56	38
	9:00	58	47	56	53
November 4, 1987	6:00	56	56	56	56
	6:30	41	44	55	44
	7:00	30	29	56	32
	7:30	24	23	56	26
	8:00	48	28	57	39
	8:30	57	40	56	49
	9:00	54	55	55	54

The travel time profiles indicate an improvement in non-transitway travel time, caused by the shift of large volumes of travel in the 2+ carpools to the transitway. The improvements to the travel times in the main lanes of the freeway are presented as average speeds by sections in Table 15. The improvements are in sections 1 and 2, late in the peak period, which indicates that the length of congestion has been significantly reduced. The average speeds measured in 1986 are very high because of the reduced demands on the freeway during the summer months.

For the total length of the study area (13.2 miles), the two- and three-hour averages for the 1987 travel time surveys are shown in Table 16, and the comparable results for the three-year period for the freeway main lanes are in Table 17. The impact of the 2+ carpools in the completed transitway is to

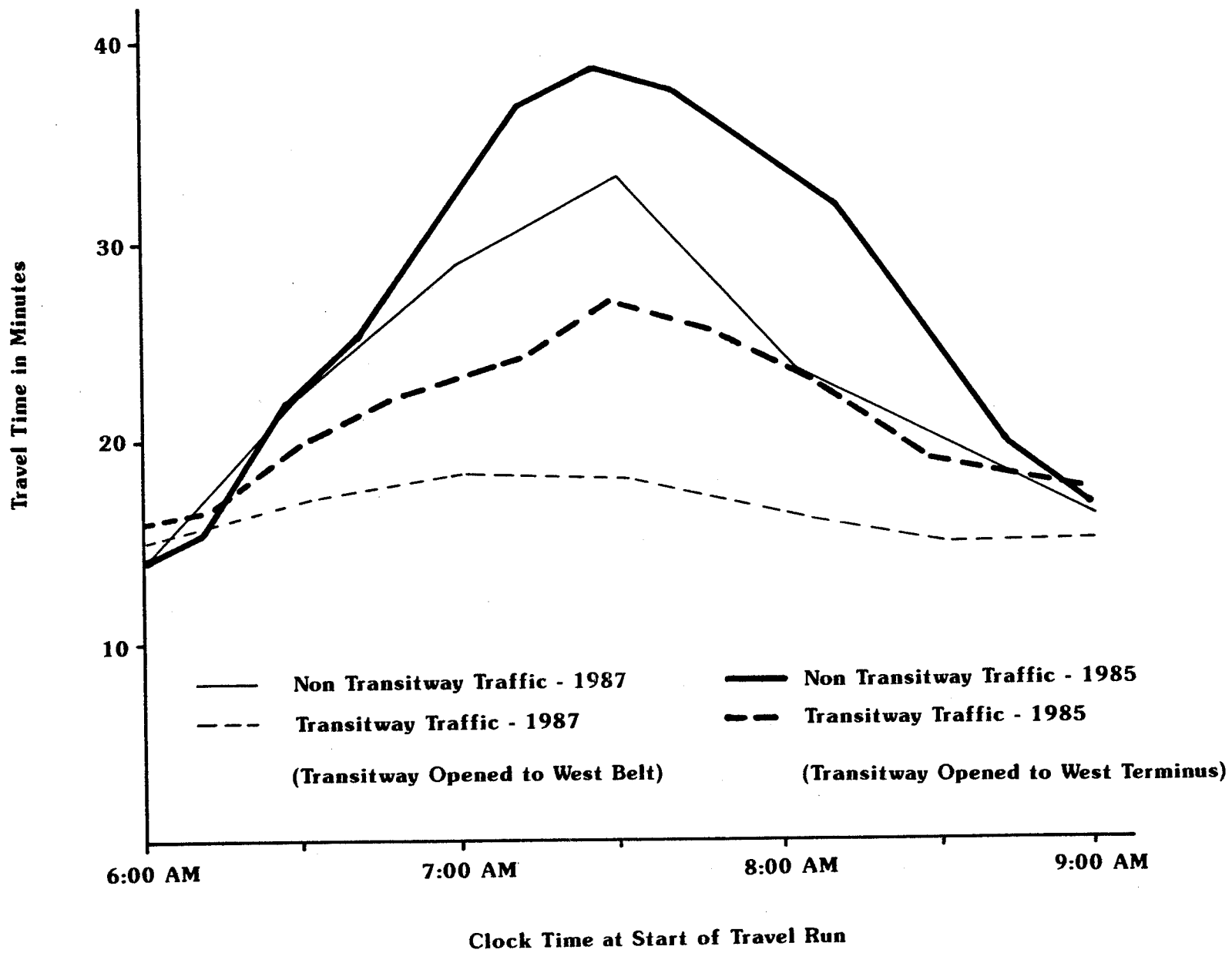


Figure 12. Katy Freeway Mainlane and Transitway Travel Times, AM Eastbound, S.P.R.R. to SH6 (13.2 Miles) 1985 and 1987

Table 15. AM Average Speeds on the Eastbound Katy Freeway Mainlanes  
for 1985, 1986, 1987

Date	Section 1 - AM			Section 2 - AM			Section 3 - AM		
	3/85	7/86	11/87	3/85	7/86	11/87	3/85	7/86	11/87
Time									
6:00	54	53	56	55	59	56	55	55	55
6:30	32	49	33	39	51	34	49	55	55
7:00	22	39	24	28	55	26	54	--	55
7:30	18	28	22	21	25	22	52	55	55
8:00	32	41	37	26	30	28	54	55	55
8:30	37	54	48	28	34	31	55	57	57
9:00	--	--	50	--	--	50	--	--	55

Table 16. Eastbound AM Travel Times and Average Speeds, Freeway  
Mainlanes and Katy Transitway, Katy Freeway, SH 6 to  
S.P.R.R. (13.2 miles), October-November 1987

Traffic and Time Period	Average Travel Time (minutes)	Average Speed (MPH)
3-Hour Period, 6:00-9:00 a.m.		
Non Transitway Traffic	22.0	36
Transitway Traffic	16.6	48
2-Hour Period, 6:30-8:30 a.m.		
Non Transitway Traffic	26.4	30
Transitway Traffic	17.4	46

Table 17. Eastbound AM Travel Times and Average Speeds, Freeway  
Mainlanes, SH 6 to S.P.R.R. (13.2 miles), 1985, 1986,  
1987

Time Period	Average Travel Time (minutes)			Average Speed (MPH)		
	3/85	7/86	11/87	3/85	7/86	11/87
3-Hour Period, 6:00-9:00 a.m.	26.5	19.1	22.0	30	42	36
2-Hour Period, 6:30-8:30 a.m.	30.6	20.9	26.4	26	38	30

reduce the average travel time for non-transitway traffic by 4.5 minutes and increase the average speed by 6 mph.

### PM Peak Period

The westbound freeway speeds, by section, are presented in Tables 18 and 19 for the three days in 1987, and compared to the 1985 and 1986 studies in Tables 20 and 21. The importance of these data is the high speeds that are obtained in Sections 2 and 3. This is due to three factors: 1) the diversion of the high volumes of 2+ carpools to the transitway; 2) the improvements in design to the transitway and freeway mainlanes from West Belt to SH 6; and 3) the closure of two critical entrance ramps at Gessner and West Belt during the construction of the West Belt Toll Road. The total travel time surveys compared to 1985 conditions reflect this improvement (Figure 13).

### Freeway Mainlane Volumes

Volume counts were taken from the loop detectors installed in the mainlanes of I-10 at the Silber overpass and the Gessner overpass in October of 1987. These counts show a decline in the ADT since 1985; the peak period has not significantly changed at Silber. Some substantial changes are evident at Gessner (Table 22). The Silber count should reflect the overall change in travel demands in the area, while the Gessner counts are more directly impacted by the operations at the Gessner access ramp to the transitway and the construction on the main lanes of the freeway. The increase in transitway volume decreases the main lane volume during the peak period at Gessner. The westbound peak hour and peak period volumes are greatly increased by the closure of the Gessner and West Belt entrance ramps.

Peak-period volume data collected at a bottleneck location (Bunker Hill) indicate volumes have increased slightly at that location. However, flow rates at this location are unusually low as it is a bottleneck.

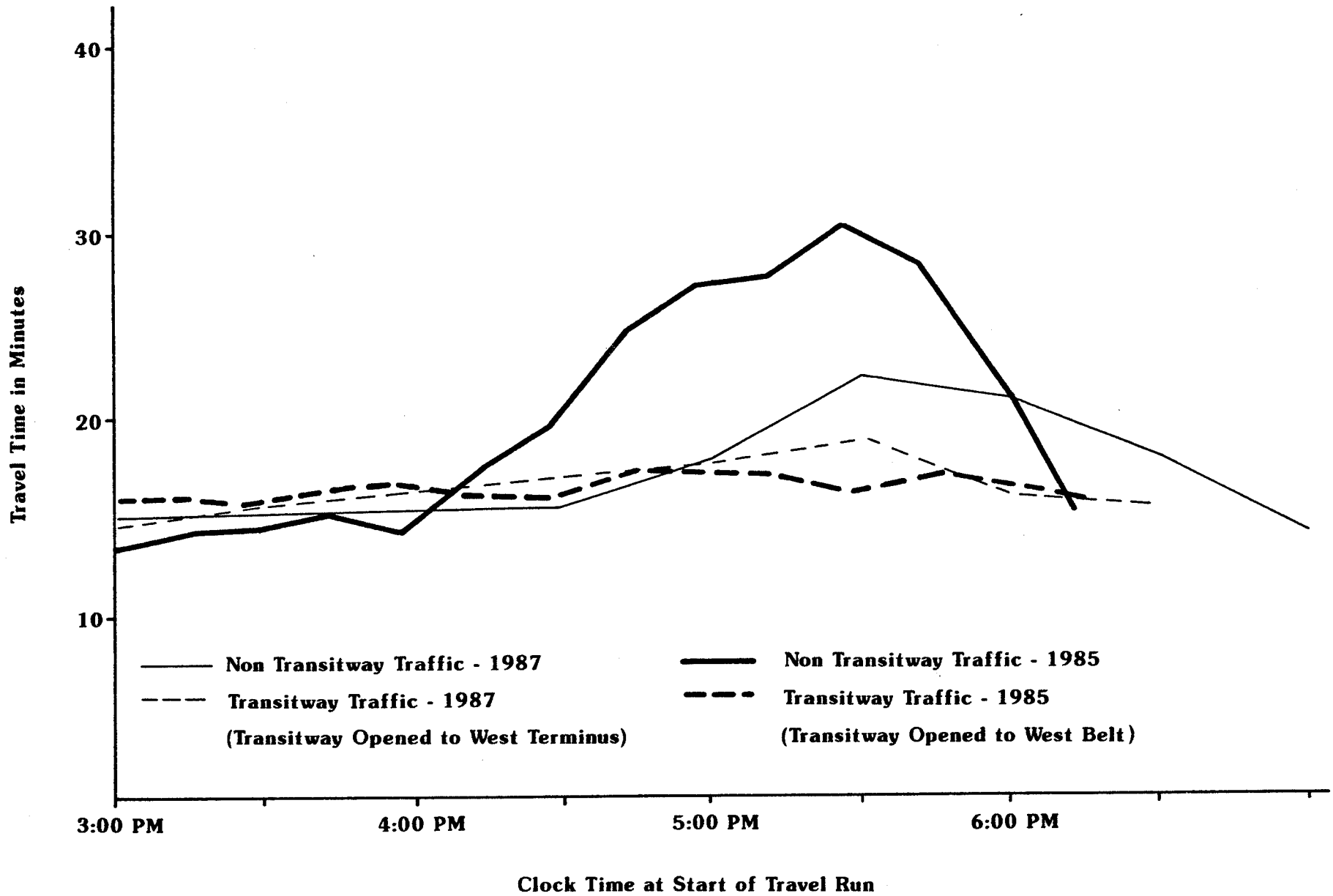


Figure 13. Katy Freeway Mainlane and Transitway Travel Times, PM Westbound, S.P.R.R. to SH6 (13.2 Miles) 1985 and 1987

Table 18. Westbound PM Speeds in the Katy Freeway Mainlanes, October-November 1987

Date of Study	Begin Time (pm)	Average Speeds in MPH			
		Sec 1 (2.2 miles)	Sec 2 (4.7 miles)	Sec 3 (6.3 miles)	Total Length (13.2 miles)
October 20, 1987	4:00	54	48	61	54
	4:30	57	52	58	55
	5:00	55	37	56	47
	5:30	52	27	50	39
	6:00	56	37	55	47
	6:30	56	46	59	53
	7:00	58	53	60	57
October 21, 1987	4:00	44	42	58	49
	4:30	55	41	52	48
	5:00	54	35	53	45
	5:30	32	25	52	35
	6:00	21	30	56	35
	6:30	23	34	58	39
	7:00	53	48	57	53
November 5, 1987	4:00	59	43	60	52
	4:30	53	44	59	52
	5:00	53	30	53	42
	5:30	27	22	51	32
	6:00	19	27	54	33
	6:30	31	35	54	41
	7:00	57	45	61	54



Table 19. Westbound PM Travel Times and Average Speeds, Freeway Mainlanes and Katy Transitway, Katy Freeway, S.P.R.R. Overpass to SH 6 (13.2 miles),  
October-November 1987

Traffic and Time Period	Average Travel Time (minutes)	Average Speed (MPH)
3-Hour Period, 4:00-7:00 a.m.		
Non Transitway Traffic	18.0	44
Transitway Traffic	17.3	46
2-Hour Period, 5:00-7:00 a.m.		
Non Transitway Traffic	19.3	41
Transitway Traffic	17.5	45

Table 20. PM Average Speeds on the Westbound Katy Freeway Mainlanes for 1985, 1986, 1987

Date	Average Speed in MPH								
	Section 1 - PM			Section 2 - PM			Section 3 - PM		
	3/85	7/86	11/87	3/85	7/86	11/87	3/85	7/86	11/87
Time									
3:00	55	59	--	66	44	--	59	52	--
3:30	57	51	--	54	51	--	49	53	--
4:00	55	58	60	60	36	44	54	53	52
4:30	54	51	56	34	29	46	45	53	55
5:00	46	44	54	24	22	34	37	35	54
5:30	49	45	51	19	20	25	31	45	37
6:00	50	52	55	32	25	31	50	44	32
6:30	--	--	57	--	--	38	--	--	37
7:00	--	--	59	--	--	49	--	--	56

Table 21. Westbound PM Travel Times and Average Speeds, Freeway Mainlanes, S.P.R.R. to SH 6 (13.2 miles), 1985, 1986, 1987

Time Period	Average Travel Time (minutes)			Average Speed (MPH)		
	3/85	7/86	11/87	3/85	7/86	11/87
	3-Hour Period, 4:00-7:00 pm	21.3	19.1	18.0	37	41
2-Hour Period, 5:00-7:00 pm	24.7	21.1	19.3	32	38	41

Table 22. Traffic Volumes, Katy Freeway Mainlanes, 1985, 1986, 1987

Location, ADT and Time	Direction and Date					
	Eastbound			Westbound		
	3/85	8/86	10/87	3/85	8/86	10/87
Silber Overpass - 4 Lanes						
ADT	90,325	89,507	87,730	86,978	87,622	85,690
6:30-9:30 pm	20,589	19,445	20,783	14,395	13,864	13,973
3:30-6:30 pm	16,406	16,296	16,662	17,539	17,692	18,535
Peak Hour	7,295	7,113	7,200	6,368	6,278	6,426
Gessner Overpass - 3 Lanes						
ADT	70,069	69,250	64,064	70,919	69,965	69,147
6:30-9:30 am	15,263	15,528	13,448	12,130	11,432	11,375
3:30-6:30 pm	13,547	12,717	12,972	14,270	12,835	16,911
Peak Hour	5,526	5,523	5,127	4,985	4,933	5,886

### Travel Time Savings

Travel time saved by the transitway traffic is calculated by comparing the freeway mainlane to the transitway at the same time period, and determining the number of vehicles and persons using the transitway at the same time period. In Table 23, the eastbound direction from SH 6 to the Gessner access ramp is analyzed. In all time periods, the travel time for the transitway traffic is less than the freeway travel time, and the results are positive savings. In Table 24, for the section from Gessner to the S.P.R.R., the early morning data indicate that the users of the transitway lose time, because of lower speeds and delays at the Post Oak Terminus and the route followed to re enter the I-10 mainlanes. Thus, the travel time savings are negative.

The number of vehicles, by type and occupancy rate, were determined from independent surveys taken during the same month. Because of the loss of time in the first hour of operation, the two-hour total travel time saved is greater than the three-hour total.

Table 23. Eastbound AM Travel Time Savings for Katy Transitway Traffic,  
November 1987, SH 6 to Gessner (6.3 miles)

Time of Day	Average Travel Time		Time Saved by Transitway (minutes)	Transitway Volumes				Travel Time Saved (Person Minutes)
	Non-Transitway (minutes)	Transitway (minutes)		Vans	Buses	Carpools	Persons	
6:00 am	6.8	6.0	0.8	2	5	70	275	220
6:30	11.6	6.4	5.2	12	10	262	990	5,148
7:00	15.5	7.3	8.2	10	10	413	1,305	10,701
7:30	17.4	6.8	10.6	4	7	373	1,035	10,971
8:00	10.3	6.8	3.5	2	6	192	575	2,013
8:30	7.9	6.0	1.9	1	2	77	200	380
3 Hour Total			6.7	31	40	1,387	4,380	29,433
2 Hour Total			7.4	28	33	1,240	3,905	28,833

Table 24. Eastbound AM Travel Time Savings for Katy Transitway Traffic, November 1987,  
Gessner to S.P.R.R. (6.9 miles)

Time of Day	Average Travel Time		Time Saved by Transitway (minutes)	Transitway Volumes				Travel Time Saved (Person Minutes)
	Non-Transitway (minutes)	Transitway (minutes)		Vans	Buses	Carpools	Persons	
6:00 am	7.4	8.9	-1.5	3	7	91	387	-581
6:30	10.1	10.3	-0.2	18	15	417	1,540	-308
7:00	11.6	11.1	0.5	15	18	706	2,346	1,173
7:30	12.7	11.4	1.3	6	19	747	2,320	3,016
8:00	11.3	9.4	1.9	4	11	430	1,198	2,276
8:30	10.6	8.9	1.7	1	9	219	600	1,020
3 Hour Total			0.8	47	79	2,610	8,391	6,596
2 Hour Total			1.2	26	57	1,102	6,464	7,485

Total Time Saved = 29,433 + 6,596 = 36,029 Person Minutes (6:00-9:00 am)

Total Time Saved = 28,833 + 7,485 = 36,318 Person Minutes (6:30-8:30 am)

The total time saved is approximately 600 person hours per morning peak period for the transitway users. Comparisons with the 1985 and 1986 results are made in Table 25 and reflect the major changes in persons carried and length of the transitway that contributes to travel time savings.

Table 25. Total Travel Time Savings for Eastbound Katy Transitway Traffic, 1985, 1986, 1987

Time of Day	Time Saved by Transitway (minutes)*			Transitway Person Volume			Travel Time Saved (person-minutes)		
	5/85	9/86	11/87	5/85	9/86	11/87	5/85	9/86	11/87
6:00 a.m.	-1.2	-3.1	-0.9	242	361	387	-299	-1,134	-361
6:30	4.0	-0.8	3.1	532	1,185	1,540	2,123	-999	4,840
7:00	9.4	4.5	4.8	646	1,741	2,346	6,061	7,903	11,157
7:30	11.4	5.4	6.1	384	1,640	2,320	4,372	8,882	14,057
8:00	7.8	4.2	4.8	426	1,028	1,198	3,329	4,350	5,735
8:30	3.7	0.8	2.3	150	604	600	558	483	1,400
3 Hour Total	6.8	3.0	4.4	2,380	6,559	8,391	16,144	19,485	36,828
2 Hour Total	8.0	4.3	4.8	1,988	5,013	7,404	15,885	21,618	35,789

\*Time saved by Transitway (minutes) was calculated, and rounded to tenths, by dividing "person-minutes" by person volume.

Similar calculations for the afternoon period are shown in Tables 26, 27 and 28. These data are less impressive because of the improvements to the mainlane speeds.

To more accurately measure the impact of the transitway on travel times, the comparison of the mainlane speeds in 1985 with the mainlane speeds in 1987 can be used. Tables 29 and 30 look at these travel times for the mainline of the freeway and, using the 1987 volume count at Gessner as an average flow rate for the 13.2 miles, calculate the vehicle minutes of travel time saved. Assuming that all carpools on the Katy Freeway use the transitway, the person minutes saved in the freeway mainlanes would equal the vehicle minutes, since the vehicle occupancy rate would be one.

Table 26. Westbound PM Travel Time Savings for Katy Transitway Traffic, November 1987,

S.P.R.R. to Gessner (6.9 miles)

Time of Day	Average Travel Time		Time Saved by Transitway (minutes)	Transitway Volumes				Travel Time Saved (Person Minutes)
	Non-Transitway (minutes)	Transitway (minutes)		Vans	Buses	Carpools	Persons	
3:30 pm	8.2	9.1	-0.9	7	3	135	407	-366
4:00	8.9	9.6	-0.7	17	9	299	1,024	-717
4:30	8.8	10.4	-1.6	19	14	365	1,435	-2,296
5:00	10.8	11.4	-0.6	7	12	534	1,632	-979
5:30	15.5	12.6	2.9	10	19	550	1,909	5,536
6:00	14.3	9.4	4.9	0	8	314	898	4,400
6:30	11.6	9.0	2.6	2	5	164	482	1,253
3 Hour Total			1.0	55	67	2,226	7,380	7,197
2 Hour Total			2.1	19	44	1,562	4,921	10,210

Table 27. Westbound PM Travel Time Savings for Katy Transitway Traffic, November 1987,

Gessner to S.P.R.R. (6.3 miles)

Time of Day	Average Travel Time		Time Saved by Transitway (minutes)	Transitway Volumes				Travel Time Saved (Person Minutes)
	Non-Transitway (minutes)	Transitway (minutes)		Vans	Buses	Carpools	Persons	
3:30 pm	6.4	6.4	0	2	1	55	150	0
4:00	6.4	6.9	-0.5	8	5	117	440	-220
4:30	6.5	7.0	-0.5	8	7	158	700	-350
5:00	7.0	6.8	0.2	2	6	213	740	148
5:30	7.2	6.8	0.4	4	10	215	860	344
6:00	6.9	7.0	-0.1	0	4	128	370	- 37
6:30	6.8	7.0	-0.2	1	2	65	190	- 38
3 Hour Total			---	23	34	896	3,300	-153
2 Hour Total			-0.2	7	22	621	2,160	417

Table 28. Total Travel Time Savings for Westbound Katy Transitway Traffic, 1985  
1986, 1987

Time of Day	Time Saved by Transitway (minutes)*			Transitway Person Volume			Travel Time Saved (person-minutes)		
	5/85	9/86	11/87	5/85	9/86	11/87	5/85	9/86	11/87
3:30 pm	-0.9	-0.2	-0.9	278	341	407	-246	+ 69	-366
4:00	-0.1	-0.4	-0.9	412	895	1,024	- 30	- 21	-937
4:30	5.5	2.6	-1.8	654	1,208	1,435	3,576	3,191	-2,646
5:00	10.3	6.1	-0.5	496	1,402	1,632	5,110	8,527	-831
5:30	12.2	7.7	3.1	364	1,209	1,909	4,436	9,364	5,880
6:00	2.0	3.3	4.5	180	681	898	366	2,272	4,363
6:30						482			1,215
3 Hour Total	5.5	4.0	1.0	2,384	5,736	7,380	13,212	23,102	7,044
2 Hour Total	7.0	4.9	2.2	1,926	4,714	4,921	13,488	23,354	10,627

\*Time saved by Transitway (minutes) was calculated, and rounded to tenths, by dividing "person-minutes" by person volume.

Table 29. Eastbound AM Travel Time Savings for Katy Non Transitway Traffic, November  
1987, S.P.R.R. to SH 6 (13.2 miles)

Time of Day	Non Transitway 1985 (minutes)	Non Transitway 1987 (minutes)	Time Saved 1985-1987 (minutes)	Vehicle Volume at Gessner (vehicles)	Total Time Saved (vehicle minutes)
6:00 am	13.8	14.2	-0.4	2,395	-958
6:30	21.5	21.7	-0.2	2,732	-546
7:00	30.2	21.1	3.1	2,257	6,997
7:30	38.2	30.1	8.1	1,768	14,321
8:00	32.7	21.6	11.1	2,055	22,811
8:30	24.4	18.5	5.9	2,203	12,998
3 Hour Total			4.1	13,410	55,623
2 Hour Total			6.9	8,283	57,127

All of the savings cannot be directly attributed to the transitway and the 2+ carpool authorization, since other factors have improved the traffic operations on the Katy Freeway.

Table 30. Westbound PM Travel Time Savings for Katy Non Transitway Traffic, November 1987, S.P.R.R. to SH 6 (13.2 miles)

Time of Day	Non Transitway 1985 (minutes)	Non Transitway 1987 (minutes)	Time Saved 1985-1987 (minutes)	Vehicle Volume At Gessner (vehicles)	Total Time Saved (Vehicle Minutes)
3:30 p.m.	14.5	14.6	0.1	2,547	255
4:00	14.5	15.3	-0.8	2,742	-2,194
4:30	19.6	15.3	4.3	2,933	12,612
5:00	27.2	17.8	9.4	3,028	28,463
5:30	30.3	22.7	7.6	2,858	21,721
6:00	23.2	21.2	2.0	2,694	5,388
3 Hour Total			3.9	16,802	66,245
2 Hour Total			5.9	11,513	68,184

### Conclusion Pertaining to Evaluation Criterion

Changes in freeway speeds and travel times are a criterion for evaluating the success of the carpool experiment (Table 5). In terms of this evaluation factor or measure of effectiveness, the carpool experiment is considered "highly successful" in that freeway speeds have actually improved. It is recognized that factors other than the transitway have had a major impact on the fact that freeway speeds have improved.

### VIII. TRANSITWAY VEHICLE BREAKDOWN DATA

A concern associated with allowing carpools onto the transitway has been that such an action would increase the frequency of vehicle breakdowns; if those breakdowns blocked the lane, the reliability of service on the transitway would be adversely impacted.

Metro operating data have been analyzed for the period from October 29, 1984 through November 4, 1987. These data are summarized in Table 31.

Since carpools represent 95% of the vehicles on the transitway, allowing carpools to use the transitway has greatly increased the number of vehicle breakdowns that occur. Carpools represent 81% of all disabled vehicles on the transitway since the time carpools began using the facility. The carpool breakdown rate (approximately 1 per 30,000 VMT) is actually less than that which would exist if only buses and vans used the facility (a combined breakdown rate of 1 per 19,000 VMT).

#### Conclusion Pertaining to Evaluation Criterion

Increase in the frequency of breakdowns on the transitway was an evaluation criterion. The criterion was evaluated as follows: "Highly Successful", no increase; "Successful", less than a 5% increase; "Unsuccessful", increase by 5% to 15%; "Highly Unsuccessful", increase by over 15%.

The data suggest that total breakdowns have increased substantially due to carpool utilization of the transitway; this equates to "highly unsuccessful". Even though carpool breakdowns have not physically blocked the lane, their frequency (roughly one per day) does create reliability concerns and requires frequent use of the Metro emergency crews. As a result, the findings for this criterion appear warranted.



Table 31. Vehicle Breakdown Rates, Katy Transitway

Vehicle Group	10/29/84-11/04/87*	Katy Transitway 4/1/85-11/04/87**	8/11/86-11/04/87***
No. of Disabled Vehicles, Total	326	322	270
Buses	53	49	14
Vans	11	11	4
Carpools	262	262	252
No. of Towed Vehicles, Total	193	193	178
Buses	14	14	6
Vans	5	5	4
Carpools	174	174	168
Vehicle Miles of Travel (VMT)			
Total	9,304,030	9,169,880	8,313,240
Buses	608,430	561,580	272,460
Vans	622,430	535,130	218,640
Carpools	8,073,170	8,073,170	7,822,140
VMT Per Disabled Vehicle, Total	28,540	28,478	30,790
VMT Per Disabled Bus	11,480	11,461	19,461
VMT Per Disabled Van	56,585	48,648	54,660
VMT Per Disabled Carpool	30,814	30,814	31,040
VMT Per Towed Vehicle, Total	48,207	47,512	46,704
VMT Per Towed Bus	43,459	40,113	45,410
VMT Per Towed Van	124,486	107,026	54,660
VMT Per Towed Carpool	46,398	46,398	46,560

Note: Towed Vehicles are a subset of disabled vehicles

\* Operating period from inception of the transitway

\*\* Operating period from when carpools allowed onto the transitway

\*\*\* Operating period since unauthorized 2+ carpools allowed onto transitway

## IX. AUTHORIZATION AND ENFORCEMENT COSTS

Allowing carpools onto the transitway could have increased costs for both enforcement and vehicle authorization. However, in August 1986 authorization was at least temporarily eliminated on the Katy Transitway; as a result, authorization costs also were eliminated and, at this time, are not an issue. However, peak-hour authorization is being considered as a means of managing volumes on the transitway in the future. If that alternative is pursued, authorization costs will again become a concern.

### Increase In Enforcement Costs

The Director of Transportation Programs for Metro was requested to address this issue. Her response is summarized below.

Currently, Metro does not have permanent enforcement stations on the Katy or North transitway. The officers assigned to the lanes use a roving patrol or stationary enforcement mode as the situation dictates. Currently, there is a minimum of one officer assigned to each lane which does not represent an increase or decrease in enforcement costs.

The introduction of carpools on the Katy Transitway has resulted in an increase in traffic violations and vehicle breakdowns, however, costs have not been affected at the present time.

### Conclusion Pertaining to Evaluation Criterion

Experience has shown that, at least to date, the transitway can be operated without authorization; thus, authorization costs have been eliminated.

It appears that the marginal impact on enforcement due to transitway carpool utilization has been minimal. In regard to this criterion, the carpool experiment is judged to be "successful". This is the same conclusion found in the 12-month evaluation report (Research Report 484-3).



## X. CONCLUSIONS

A summary of the evaluation of the individual criterion for the 30-month evaluation is shown in Table 32. Based on that evaluation, as of October 1987, the Katy carpool experiment is judged to be between "successful" and "highly successful". If numerical values are assigned to the possible outcomes (with "highly successful" = 4; "successful" = 3; "unsuccessful" = 2; and "highly unsuccessful" = 1), the weighted value for the carpool experiment is 3.30. A value of 2.5 is midway between "successful" and "unsuccessful". All of the individual criterion, with the exception of the "increase in frequency of transitway breakdowns", were rated as at least "successful".

Over time, particularly with the introduction of 2+ carpools, the experiment has become more successful. These trends are shown in Table 33.

This project is scheduled to continue through August 31, 1989. A final "after" evaluation will be undertaken during FY 88-89.

Table 32. Overall Evaluation of Katy Transitway Carpool Experiment, 30 Months  
After Carpools Were Allowed Onto the Transitway

Criterion	Relative Weighting	Conclusion Pertaining to Experiment	Relevant Data
1. Change in Person Movement on the transitway Directly Attributable to Carpooling	25%	"Highly Successful"	<ul style="list-style-type: none"> <li>● Carpools move over 60% of total person movement</li> </ul>
2. Non-User Perception of Katy Transitway Utilization	30%	"Successful"	<ul style="list-style-type: none"> <li>● Just over 50% of non-users feel the transitway is sufficiently utilized.</li> </ul>
3. Change in Travel Time on the Transitway	20%	"Successful"	<ul style="list-style-type: none"> <li>● Average speeds have remained generally stable with a slight decrease during peak periods.</li> </ul>
4. Change in Delay to Mixed-Flow Traffic	15%	"Highly Successful"	<ul style="list-style-type: none"> <li>● Mixed flow speeds have increased slightly.</li> </ul>
5. Increase in Frequency of Transitway Breakdowns	5%	"Highly Unsuccessful"	<ul style="list-style-type: none"> <li>● Over 80% of transitway vehicle breakdowns are carpools. Approximately 5 breakdowns occur per week</li> </ul>
6. Increase in Authorization and Enforcement Costs	5%	"Successful"	<ul style="list-style-type: none"> <li>● Marginal increase in costs due to carpools has not been substantial.</li> </ul>
Total	100%	Between "Successful" and "Highly Successful"	