



**IMPACTS OF CARPOOL UTILIZATION
ON THE KATY FREEWAY
AUTHORIZED VEHICLE LANE
12-MONTH "AFTER" EVALUATION**

RESEARCH REPORT 484-3

**TEXAS TRANSPORTATION INSTITUTE
THE TEXAS A&M UNIVERSITY SYSTEM
COLLEGE STATION, TEXAS**

**STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION**

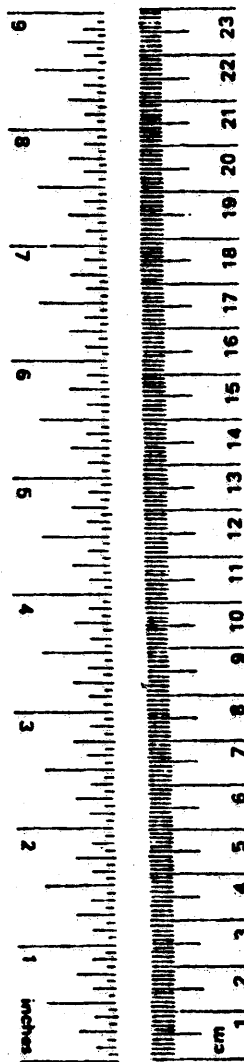
**METROPOLITAN TRANSIT AUTHORITY
OF HARRIS COUNTY**

In cooperation with the
Department of Transportation
Federal Highway Administration

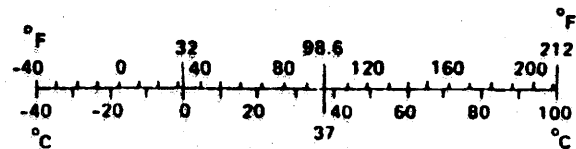
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16. Abstract A major commitment has been made in the Houston area to develop physically separated authorized vehicle lanes in the medians of freeways. The lanes are reserved for specially authorized high-occupancy vehicles. Phase 1 of the first completed authorized vehicle lane (AVL) opened on the Katy Freeway (I-10) in October 1984. Since that is the first of many such lanes, in some respects it is being used as a laboratory to determine desirable approaches for operating the AVL facilities. To increase potential utilization, in addition to buses and vanpools, a decision was made to permit authorized carpools to begin using the AVL 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 April through June 1986, one year after carpool utilization of the AVL was permitted. Comprehensive traffic data, both on the AVL and the freeway, were collected. In addition, surveys of transit users on the AVL, vanpool drivers on the AVL, vanpool passengers on the AVL, carpool drivers on the AVL, carpool passengers on the AVL, and motorists not using the AVL were undertaken. In this report, these data are compared to similar data collected before carpool utilization was permitted to identify the impacts of permitting carpools to use the AVL.					
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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures				Symbol
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



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



* 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
AUTHORIZED VEHICLE LANE
12-MONTH "AFTER" EVALUATION**

by

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

Research Report 484-3

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
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College Station, Texas 77843

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ABSTRACT

A major commitment has been made in the Houston area to develop physically separated authorized vehicle lanes in the medians of freeways. The lanes are reserved for specially authorized high-occupancy vehicles.

Phase 1 of the first completed authorized vehicle lane (AVL) opened on the Katy Freeway (I-10) in October 1984. Since that is the first of many such lanes, in some respects it is being used as a laboratory to determine desirable approaches for operating the AVL facilities.

To increase potential utilization, in addition to buses and vanpools, a decision was made to permit authorized carpools to begin using the AVL 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 April through June 1986, one year after carpool utilization of the AVL was permitted. Comprehensive traffic data, both on the AVL and the freeway, were collected. In addition, surveys of transit users on the AVL, vanpool drivers on the AVL, vanpool passengers on the AVL, carpool drivers on the AVL, carpool passengers on the AVL, and motorists not using the AVL were undertaken. In this report, these data are compared to similar data collected before carpool utilization was permitted to identify the impacts of permitting carpools to use the AVL.

This is the third of a series of reports to be prepared as part of this research effort. Previous reports were:

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

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

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. Authorized 4+ carpools were allowed to use the authorized vehicle lane (AVL) in April 1985. To generate additional carpool utilization, authorized 3+ carpools were permitted to use the AVL in September 1985. This report evaluates the impacts of permitting carpools to use the Katy Transitway.

Trends in Transitway Utilization

In April 1986, just less than 6,200 persons used the transitway on a daily basis. Since opening, person trips on the Katy AVL have increased by 49%; vehicle trips have increased by 112%. Carpools represent approximately 40% of total vehicles using the AVL; the carpools transport 11% to 12% of total persons moved on the priority facility.

Katy AVL Utilization Relative to Other Freeway HOV Projects

A review of carpooling on other freeway HOV lanes leads to the following observations.

1. The Katy AVL, with 50 to 75 carpools per peak hour, is operating at a significantly lower volume than other freeway HOV facilities.
2. A consensus exists among the agencies operating freeway HOV lanes that, to maintain a reliable high-speed lane, per lane capacity is in the range of 1,000 to 1,500 vehicles per hour. Access/egress on the Katy AVL may somewhat limit capacity. However, capacities are considerably greater than existing volumes.

3. On several HOV facilities, carpools and vanpools move 50% or more of total person volume. On the Katy AVL, carpools and vanpools move approximately 30% of total volume.
4. Most freeway HOV lanes have resulted in substantial increases (non-weighted average of 288%) in carpooling. To date, the Katy AVL has generated little or no increase in total carpooling.
5. Relative to other projects, growth in person movement has been slow. The average annual growth rate for the first two years on the Katy AVL has been 22%. For the first two years on other HOV projects, the average was 67% on the Shirley Highway, 68% on the El Monte busway, and 89% on the North Freeway contraflow.

Most of the other HOV facilities referred to above are at least 10 miles in length. While volumes are currently relatively low on the Katy AVL, the above data suggest that there is reason to expect significant increases in utilization once Phase 2 of the AVL opens in early 1987; this is expected to occur since the Phase 2 extension will provide significant additional travel time savings, particularly to users of the Addicks park-and-ride facility located at SH 6 and Katy Freeway.

Criteria for Judging the Success of the Carpool Experiment

Prior to allowing carpools onto the AVL, 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 10 in the main report presents the criteria and the basis for evaluation; each criterion can be rated "highly successful", "successful", "somewhat unsuccessful", and "highly unsuccessful". In the overall evaluation, a numerical rating is assigned; "highly successful" is considered to be a 4, with "highly unsuccessful" considered to be a 1.

Criterion 1. Change in Person Movement on the AVL Directly Attributable to Carpooling

Relative Weighting. 25%

Relevant Findings. April 1986 data suggest that carpools increased person movement in the a.m. peak period by 13% and by 12% in the p.m. peak period. However, 14% of the carpools previously used the AVL in either a bus (7%) or a van (7%). Thus, carpools have effectively increased person movement by approximately 10%.

Conclusion. In regard to this criterion, the experiment is considered a "success".

Criterion 2. Non-User Perception of Katy AVL Utilization

Relative Weighting. 30%

Relevant Findings. While the perception of the users of the AVL is that it is sufficiently utilized, over 90% of the non users feel the AVL is not sufficiently utilized. It is recognized there may be some, and possibly a considerable amount of bias among non users regarding any priority facility not operating at the same speed and volume as the mixed-flow lanes. Due to the heavy weighting given this criterion, this is a concern that will be addressed in the future as part of this research effort.

Conclusion. In regard to this criterion, the experiment is considered "highly unsuccessful".

Criterion 3. Change in Travel Time on the AVL

Relative Weighting. 20%

Relevant Findings. If anything, average speeds on the AVL have increased slightly since carpools began using the facility.

Conclusion. In regard to this criterion, the experiment is considered "highly successful".

Criterion 4. Change in Person Delay to Mixed-Flow Traffic

Relative Weighting. 15%

Relevant Findings. No change in mixed-flow traffic operations are identified that can be attributed to the AVL. Other factors influencing mixed-flow traffic are more significant than the AVL.

Conclusion. In regard to this criterion, the experiment is considered "highly successful".

Criterion 5. Increase in Frequency of Breakdowns on the AVL

Relative Weighting. 5%

Relevant Findings. Total AVL breakdowns have increased by about 14% due to carpools. However, the absolute number of carpool breakdowns has been small, and none of the breakdowns have blocked the AVL.

Conclusion. In regard to this criterion, the experiment is considered "successful".

Criterion 6. Increase in Authorization and Enforcement Costs

Relative Weighting. 5%

Relevant Findings. The marginal increase in costs due to carpooling has been small, and no significant problems have been encountered.

Conclusion. In regard to this criterion, the experiment is considered "successful".

Conclusion

The overall evaluation is summarized in Table S-1. Based on that evaluation, as of April 1986 the carpool experiment is judged to be between "somewhat unsuccessful" and "successful". If numerical values are assigned to the possible outcomes (with "highly successful" = 4; "successful" = 3; "somewhat unsuccessful" = 2; and "highly unsuccessful" = 1), the weighted value for the carpool experiment is 2.62. A value of 2.5 is midway between "successful" and "somewhat unsuccessful".

However, in terms of the most heavily weighted criterion -- non-user perception of Katy AVL utilization -- the carpool experiment is judged to be "highly unsuccessful". If AVL volumes increase sufficiently to alter the non-user perception, it is reasonable to assume that other evaluation criteria will be adversely impacted by that volume increase. Further monitoring of the experiment will identify such impacts. Surveys to be conducted in 1987 will identify, now that the transitway is essentially operating at vehicular capacity, to what extent the non-user perception of transitway utilization can be adjusted upward.

Table S-1. Overall Evaluation of Katy AVL Carpool Experiment 12 Months After Carpools Were Allowed Onto the AVL

Criterion	Relative Weighting	Conclusion Pertaining to Experiment	Relevant Data
1. Change in Person Movement on the AVL Directly Attributable to Carpooling	25%	Between "Successful" and "Somewhat Unsuccessful"	<ul style="list-style-type: none"> ● AVL person movement increased by 10% due to carpooling
2. Non-User Perception of Katy AVL Utilization	30%	"Highly Unsuccessful"	<ul style="list-style-type: none"> ● Over 90% of non-users feel the AVL is not sufficiently utilized.
3. Change in Travel Time on the AVL	20%	"Highly Successful"	<ul style="list-style-type: none"> ● If anything, average speeds on the AVL have increased.
4. Change in Delay to Mixed-Flow Traffic	15%	"Highly Successful"	<ul style="list-style-type: none"> ● No change was detected.
5. Increase in Frequency of AVL Break-downs	5%	"Successful"	<ul style="list-style-type: none"> ● Breakdowns increased by 14% due to carpooling; the number of breakdowns was small and none blocked the AVL
6. Increase in Authorization and Enforcement Costs	5%	"Successful"	<ul style="list-style-type: none"> ● Marginal increase in costs due to carpools has not been substantial.
TOTAL	100%	Between "Somewhat Unsuccessful" and "Successful"	

Note: If numerical ratings are assigned to the possible outcomes ("Highly Successful" = 4; "Successful" = 3; "Somewhat Unsuccessful" = 2; "Highly Unsuccessful" = 1), the experiment has a weighted rating value of 2.62. A rating of 2.5 is midway between "Highly Successful" and "Highly Unsuccessful".

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 State Department of Highways and Public Transportation in the implementation and operation of the authorized vehicle lanes. The study, through analysis and comparison of both "before" and "after" data, assesses the impacts of permitting authorized 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 Texas 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.

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I. INTRODUCTION

In October 1984, Phase 1 of the Katy Freeway authorized vehicle lane (AVL) became operational. Detailed descriptions of that project are included in other reports.¹

At the time the AVL opened, only buses and vanpools authorized by the Metropolitan Transit Authority (Metro) were allowed to utilize the AVL. However, in order to address a perception that the AVL was underutilized, authorized 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 AVL, 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 AVL, thereby adversely impacting the level-of-service that is so important to AVL operation; 3) if carpool volumes were restricted sufficiently to assure a high level-of-service on the AVL, the increase in vehicles using the AVL might not be great enough to change the perception that the AVL is underutilized; 4) the increased carpool volumes might result in increases in vehicle breakdowns on the AVL, thereby reducing the travel time reliability attribute of the transitways; and 5) other safety related concerns might develop.

Since the Katy AVL 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

¹"The Katy Freeway Authorized Vehicle Lane: Evaluation of the First Year of Operation". Texas Transportation Institute Research Report 339-6, February 1986. "The Impact of Carpool Utilization on the Katy Freeway Authorized Vehicle Lane, 'Before' Data." Texas Transportation Institute Research Report 484-1, December 1985.

Public Transportation to assess in detail the impacts of allowing carpools to use the AVL. To undertake this assessment, this report compares data collected in April through July 1986, one year after carpools were allowed onto the AVL, with data collected in March 1985 before carpools were permitted to use the AVL.

Previous Research Reports

This report is the third 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", Texas Transportation Institute Research Report 484-1, December 1985.

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

The first report presents a state-of-the-art overview, identifies criteria for evaluating the "success" of the Katy AVL carpool experiment, and presents traffic data as well as AVL user and non user surveys that identify the operating condition of the freeway and the AVL prior to allowing carpool utilization. The second report documents a survey of AVL carpool users undertaken in October 1985.

No attempt is made in this report to include all the relevant material presented in previous reports. Pertinent data included in Research Reports 484-1 and 484-2 are used in this report to draw conclusions concerning the impacts of allowing carpools onto the AVL.

Organization of the Report

Following this introductory section is a section (Section II) describing trends in utilization on the Katy Authorized Vehicle Lane. Section III restates the criteria to be used in evaluating the success of the AVL 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 484-4). The appendices document data collection procedures as well as details of the data collected. In essence, the appendices provide further documentation and substantiation of the material presented in this report.

II. KATY AVL UTILIZATION

The Katy Freeway authorized vehicle lane 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 AVL and to address the perception that the AVL 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 AVL beginning April 1, 1985.

Background on Katy AVL 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 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%. 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 and were allowed to travel through the Katy Transitway.

This 3+ requirement has remained in effect. However, the carpool requirements will be changed to 2+ without authorization beginning August 11, 1986. This study will monitor the impacts of that 90-day demonstration.

Trends in Katy AVL Utilization

Trends in average peak-period AVL utilization are shown in Figure 1. Since the AVL opened, person trips per peak period have increased by 49%, vehicle trips per peak period have increased by 112%. In April 1986, on a daily basis, buses represented 32% of vehicles using the AVL and moved 70% of the people; vanpools were 28% of vehicles and moved 19% of the people; carpools were 40% of vehicles and moved 11% of the people.

Data pertaining to AVL utilization are summarized in Tables 1, 2, and 3. Since carpools were initially allowed onto the AVL, bus passenger volumes have increased by 21% and vanpool person volumes have decreased by 26%. The vanpool decline appears to be more a function of the downturn in the Houston economy than it is the introduction of carpools.

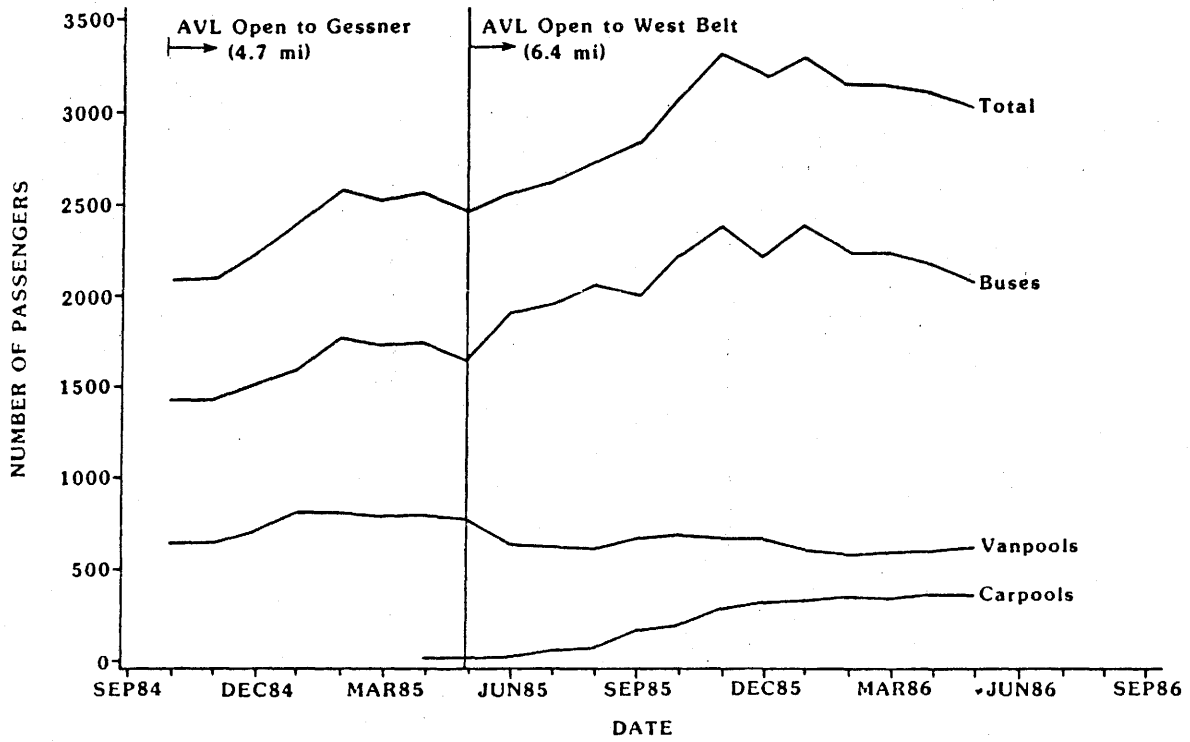
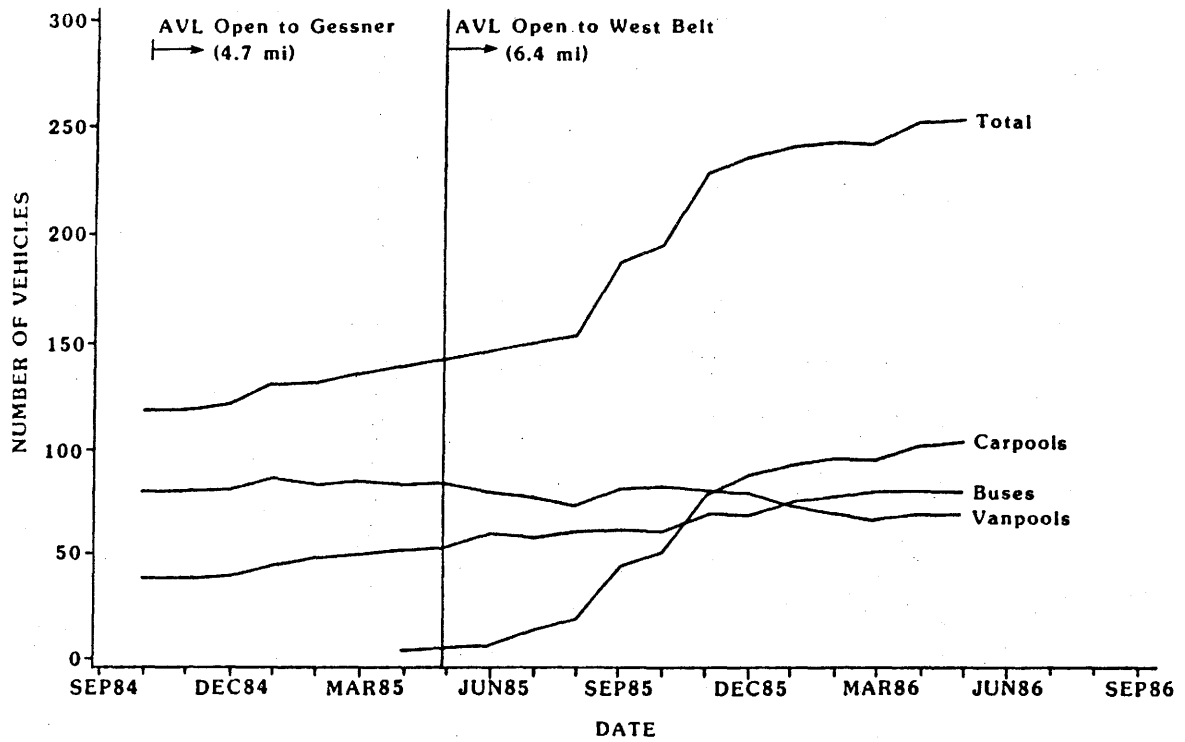


Figure 1. Trends in Average Peak-Period Utilization of the Katy Transitway

Table 1. Trends in Daily Utilization of the Katy AVL

Authorized Vehicle	Volume			Percent Change 3/85 to 4/86
	11/84	3/85	4/86	
Buses				
Vehicles	78	100	160	+60%
Passengers	2860	3450	4302	+21%
Vanpools				
Vehicles	160	170	140	-18%
Passengers	1304	1596	1180	-26%
Carpools				
Vehicles	0	0	204	----
Passengers	0	0	706	----

Source: Texas Transportation Institute Counts.

Carpool Data, Katy AVL and Selected Other HOV Project

Trends in carpool utilization are shown in Figure 2. Carpool demand is somewhat higher in the a.m. This may be due to the fact that many of the carpools using the AVL are transporting children to school; thus, their afternoon travel may not coincide with the peak commuter period. In recent months, carpooling has begun to level off.

During an average peak period, carpools represent over 40% of total vehicles using the AVL (Figure 3). Those vehicles move just over 11% of the total persons moved on the AVL.

Table 2. Trends in Katy AVL Utilization, Vehicles

Month	Buses		Vanpools		Carpools		Total	
	Peak Hr.	Peak Period	Peak Hr	Peak Period	Peak Hr	Peak Period	Peak Hr	Peak Period
11/84 a.m.	19	38	67	77	--	--	86	115
11/84 p.m.	19	40	57	83	--	--	76	123
12/84 a.m.	20	40	67	78	--	--	87	118
12/84 p.m.	19	41	59	84	--	--	78	125
1/85 a.m.	23	51	70	81	--	--	93	132
1/85 p.m.	18	39	63	91	--	--	81	130
2/85 a.m.	19	52	66	79	--	--	85	131
2/85 p.m.	20	45	56	87	--	--	76	132
3/85 a.m.	20	49	66	82	--	--	86	131
3/85 p.m.	23	52	55	88	--	--	78	140
4/85 a.m.	20	53	66	79	3	6	89	138
4/85 p.m.	19	51	51	87	3	4	73	142
5/85 a.m.	24	52	68	81	3	6	95	139
5/85 p.m.	20	54	53	87	1	6	74	147
6/85 a.m.	26	60	61	74	5	8	92	142
6/85 p.m.	28	61	35	84	3	5	66	150
7/85 a.m.	25	59	62	70	8	13	95	142
7/85 p.m.	29	57	52	83	7	15	88	155
8/85 a.m.	26	61	50	66	12	20	88	147
8/85 p.m.	27	61	51	79	8	17	86	157
9/85 a.m.	26	62	62	76	26	46	114	184
9/85 p.m.	25	62	53	85	20	42	98	189
10/85 a.m.	28	62	64	77	27	54	119	193
10/85 p.m.	24	59	50	86	22	48	96	193
11/85 a.m.	30	72	54	75	55	82	139	229
11/85 p.m.	27	68	55	85	30	73	112	226
12/85 a.m.	27	70	59	74	53	92	139	236
12/85 p.m.	30	67	39	83	34	83	103	233
1/86 a.m.	34	76	45	66	71	97	150	239
1/86 p.m.	34	73	35	79	30	88	99	240
2/86 a.m.	28	79	46	65	63	106	137	250
2/86 p.m.	37	78	30	73	35	93	102	244
3/86 a.m.	31	81	39	62	64	107	134	250
3/86 p.m.	34	78	31	72	38	83	103	233
4/86 a.m.	34	83	43	64	76	110	153	257
4/86 p.m.	33	77	45	76	49	94	127	247
5/86 a.m.	35	79	41	64	72	116	148	259
5/86 p.m.	39	79	34	76	41	91	114	246

Source: Texas Transportation Institute

Table 3. Trends in Katy AVL Utilization, Persons

Month	Buses		Vanpools		Carpools		Total	
	Peak Hr.	Peak Period	Peak Hr	Peak Period	Peak Hr	Peak Period	Peak Hr	Peak Period
11/84 a.m.	720	1400	567	641	--	--	1287	2041
p.m.	750	1460	484	662	--	--	1234	2122
12/84 a.m.	800	1490	577	698	--	--	1377	2188
p.m.	710	1530	497	728	--	--	1207	2258
1/85 a.m.	790	1680	695	785	--	--	1485	2465
p.m.	700	1500	621	851	--	--	1321	2351
2/85 a.m.	710	1750	673	769	--	--	1383	2519
p.m.	780	1770	571	871	--	--	1351	2641
3/85 a.m.	780	1720	627	763	--	--	1407	2483
p.m.	840	1730	522	833	--	--	1362	2563
4/85 a.m.	760	1800	643	750	12	24	1415	2574
p.m.	680	1690	510	851	12	16	1202	2557
5/85 a.m.	800	1600	638	745	13	26	1451	2371
p.m.	700	1700	526	812	4	24	1230	2536
6/85 a.m.	990	1980	505	603	20	32	1515	2615
p.m.	950	1800	288	668	12	18	1250	2486
7/85 a.m.	970	2010	493	557	33	52	1496	2619
p.m.	1040	1870	425	679	29	59	1494	2608
8/85 a.m.	1020	2140	415	553	44	67	1479	2760
p.m.	950	1960	426	650	30	63	1406	2673
9/85 a.m.	950	2010	499	617	101	171	1550	2798
p.m.	940	1970	455	717	73	156	1468	2843
10/85 a.m.	1220	2385	521	634	96	203	1837	3222
p.m.	930	2025	427	733	77	167	1434	2925
11/85 a.m.	1145	2440	447	617	195	299	1787	3356
p.m.	990	2295	470	716	111	258	1571	3269
12/85 a.m.	960	2180	502	625	198	337	1660	3142
p.m.	1125	2210	339	706	113	295	1577	3211
1/86 a.m.	1235	2450	369	540	248	333	1852	3323
p.m.	1160	2275	295	668	103	313	1558	3256
2/86 a.m.	975	2250	392	541	217	366	1584	3157
p.m.	1185	2185	261	611	120	320	1566	3116
3/86 a.m.	1100	2300	351	553	231	380	1682	3233
p.m.	1130	2140	272	618	129	280	1531	3038
4/86 a.m.	980	2270	377	548	261	378	1618	3196
p.m.	670	2032	366	632	166	328	1202	2992
5/86 a.m.	1085	2230	360	553	243	387	1688	3170
p.m.	1040	1880	305	669	142	311	1487	2860

Source: Texas Transportation Institute

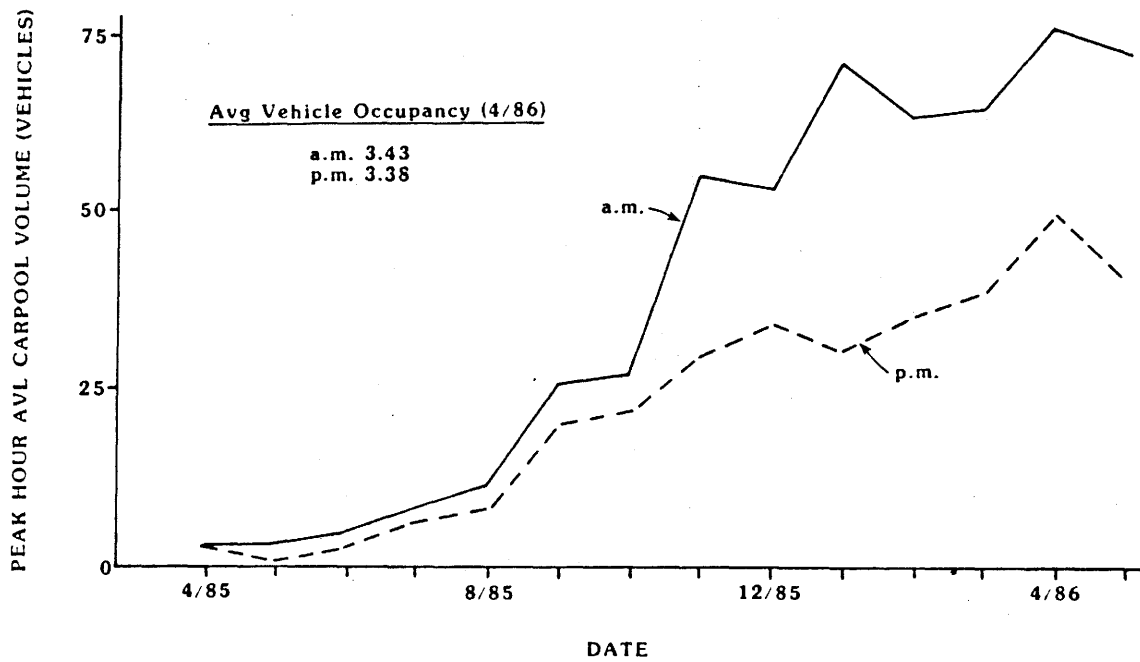
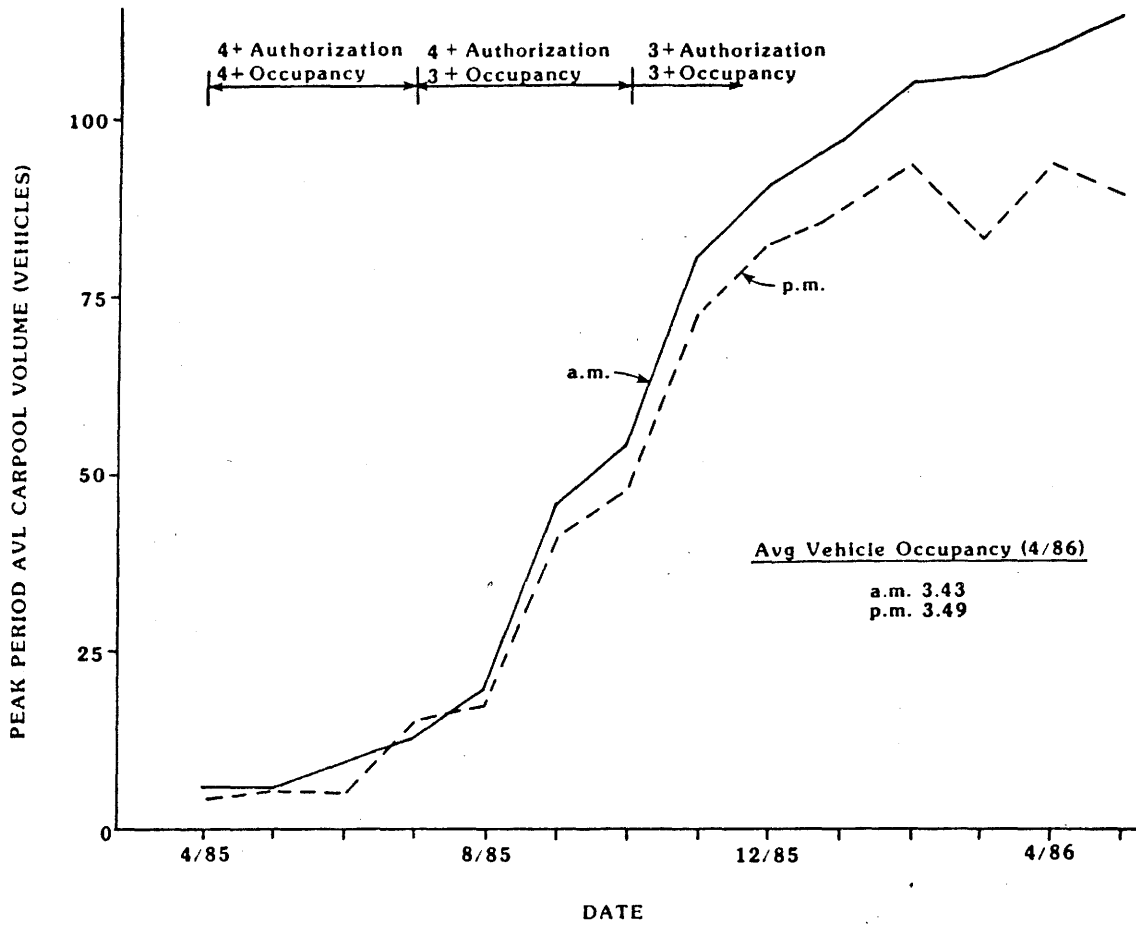


Figure 2. Trends in Peak-Period and Peak-Hour Carpool Utilization of the Katy Transitway

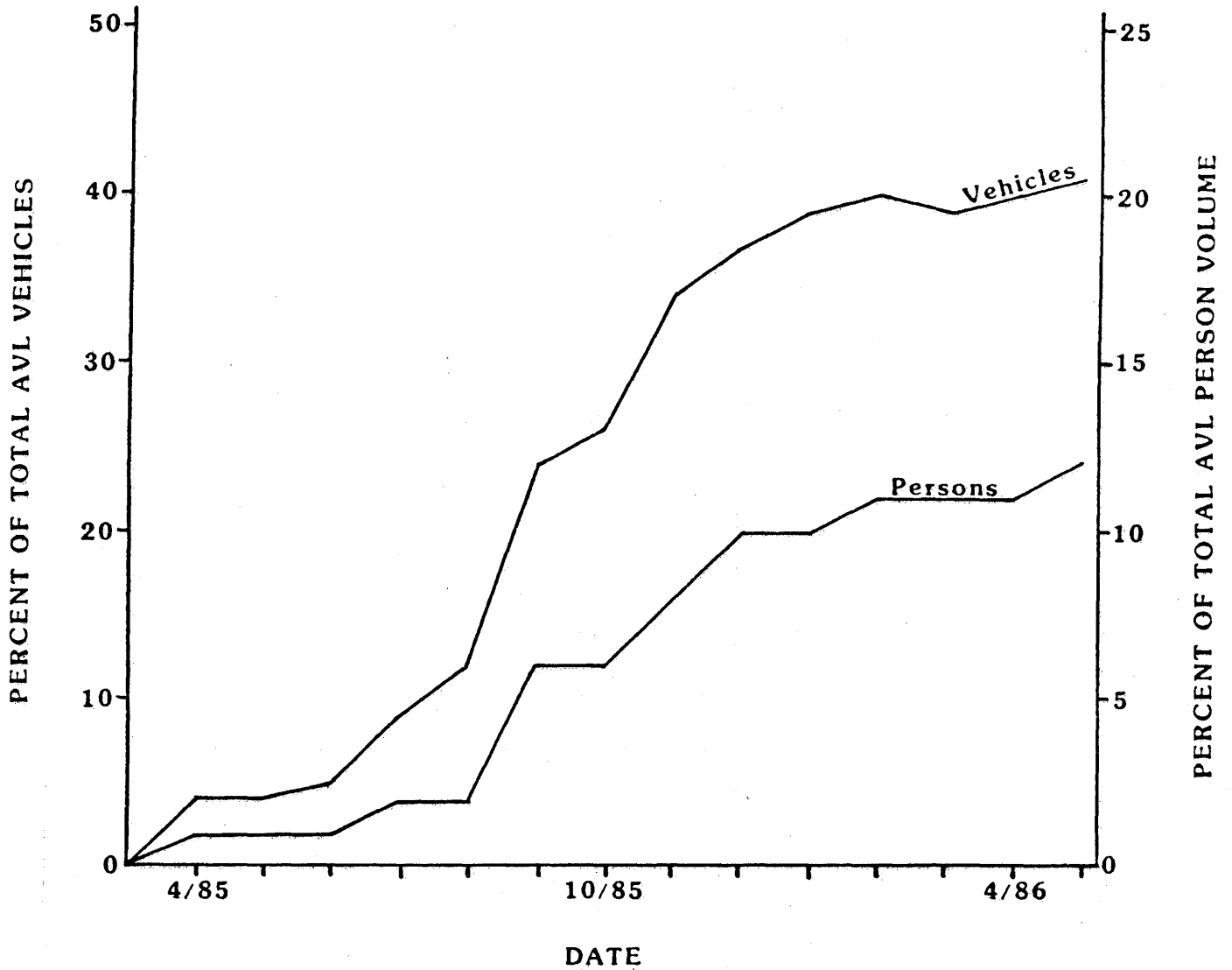


Figure 3. Carpool Volumes as a Percent of Total Katy AVL Volumes

Peak-Hour Carpool Volumes

For selected freeway HOV projects, Table 4 summarizes peak-hour carpool volumes. The Katy AVL, at approximately 50 to 75 carpools per peak hour, is, by far, the lowest carpool volume HOV facility shown in the table.

Table 4. Carpool Volumes on Freeway High-Occupancy Vehicle Lanes

Facility	Carpool Definition	Peak Hour Carpool Volume ¹ (vph)
Katy AVL, Houston	3+	76 (a.m.) 49 (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

¹Including 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 1000 to 1500 vph (Table 5). Given the access/egress characteristics of the Katy AVL, this may be a high estimate for the Katy HOV facility. Nevertheless, the Katy AVL is operating at relatively low vehicular volumes and is also operating below capacity.

Also, in comparison to other projects, relatively few persons are served by carpools and vanpools on the Katy AVL. While this can at least partially be attributed to the high-quality of bus service provided on the AVL, the fact remains that, of the HOV projects summarized in Table 6, the Katy AVL is serving an unusually low volume of total trips in carpools and vanpools.

Table 5. Estimated Maximum Hourly Volume on an HOV Lane, Responses From Agencies
Operating HOV Lanes on Freeways

HOV Facility	Responding Agency	Max. Veh. Per Hr. Per Lane ¹	Current Peak Hour HOV Volume ²	Does Current Vol. Result In		
				Under Utilization	Too Many Veh.	No Problem
El Monte, Los Angeles	Caltrans	1200	1090		X	
Shirley, Wash., D.C.	Va. Dept of Hwy & Trans	1500-1700	2165 (2 lanes)			X
I-66, Washington, D.C.	Va. Dept. of Hwy & Trans	Up to 2000	2980 (2 lanes)		X	
Moanalua, Hawaii	Hawaii DOT	1500+	1750			X
Rte. 91, Los Angeles	Caltrans	1500	1388			X
I-95, Miami	Fl. DOT	1200-1400	1370			X
Rte. 55, Orange Co.	Caltrans	1500	1400			X
I-4, Orlando	Fl. DOT	1200	900			X
US 101, San Francisco	Caltrans	1200-1400	440	X		
I-5, Seattle	Wash. DOT	1300	460			X
SR 520, Seattle	Wash. DOT	500 ³	330			X

¹Estimated upper limit that can effectively be accommodated while maintaining reliable, high-speed operation in the HOV lane.

²All vehicles operating in the HOV lane.

³Special situation due to HOV lane being located on the outside shoulder; HOV traffic merges with normal freeway exit and entrance ramp operations.

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

Increase in Carpooling Due to AVL

Typically, allowing carpools to use an HOV lane increases the total volume of carpools on the freeway. To what extent if any, this has occurred on the Katy Freeway is difficult to establish with a high degree of accuracy.

Extensive "before" data have been collected on the Katy Freeway since 1983. These data are summarized in Figure 4. While the data were collected

Table 6. Estimated Carpool and Vanpool Utilization of HOV Lanes

Facility and Time Period	Bus Passengers		Vanpool and Carpool Passengers		Total Passengers
	No.	%	No.	%	
Katy AVL, Houston (buses, vanpools, carpools) 6-9 a.m.	2,270	71%	926 ¹	29%	3,196
Houston, I-45N (buses, vanpools) 6-8:30 a.m.	5,100	63%	3,000	37%	8,100
Shirley Highway, Washington, D.C. (buses and 4+ carpools) 7-8:00 a.m.	11,800	52%	11,000	48%	22,800
	6-9:30 a.m.	23,700	55%	19,700	45%
El Monte Busway, Los Angeles (buses and 3+ carpools) 6-10:00 a.m.	8,470	54%	7,330	46%	15,800
	peak-hour	3,450	53%	3,040	47%
I-66, Washington, D.C. (buses and 3+ carpools) a.m. peak-hour	2,600	29%	6,500 ²	71%	9,100
I-95 Miami Concurrent Flow a.m. peak-hour	640	23%	2,200 ²	77%	2,840
U.S. 101 Marin County a.m. peak-hour	3,700	79%	980	21%	4,680
Santa Monica, Los Angeles peak period	3,810	20%	15,289	80%	19,099
Banfield, I-80, Portland (buses and 2+ carpools) a.m. peak hour	300	12%	2,100	88%	2,400
Average, non-weighted (not incl. Katy)	-----	44%	-----	56%	-----

¹378 (12%) in carpools, 548 in vanpools.

²Includes illegal vehicles in the priority lane.

Source: Texas Transportation Institute. Year of data not necessarily consistent with data in previous tables.

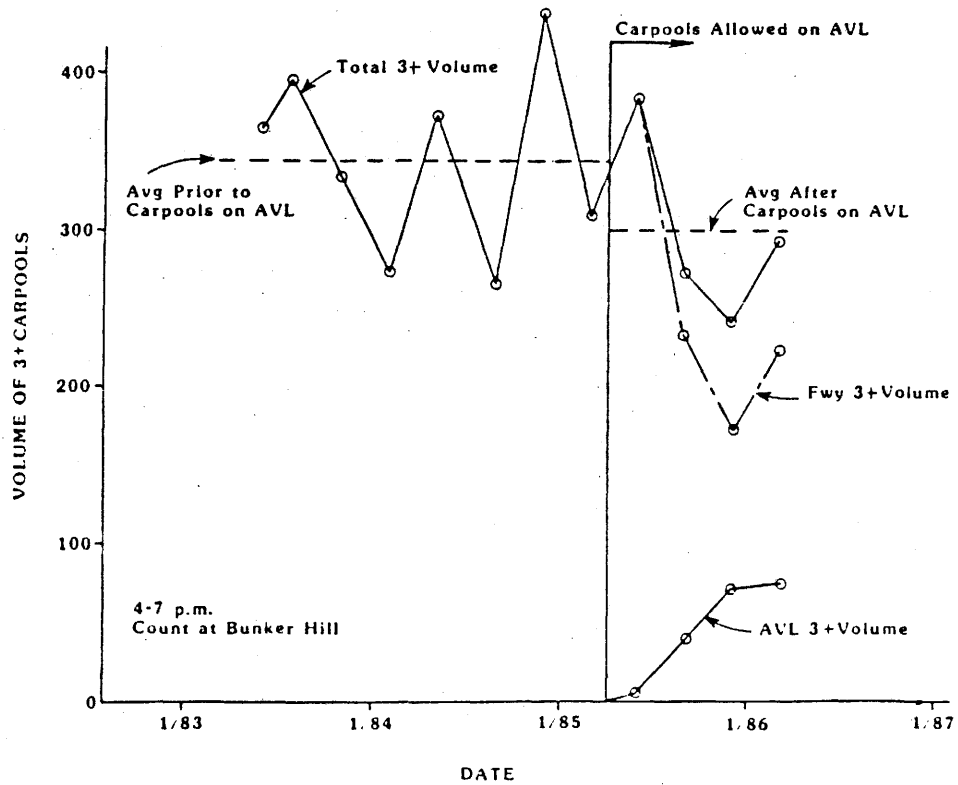
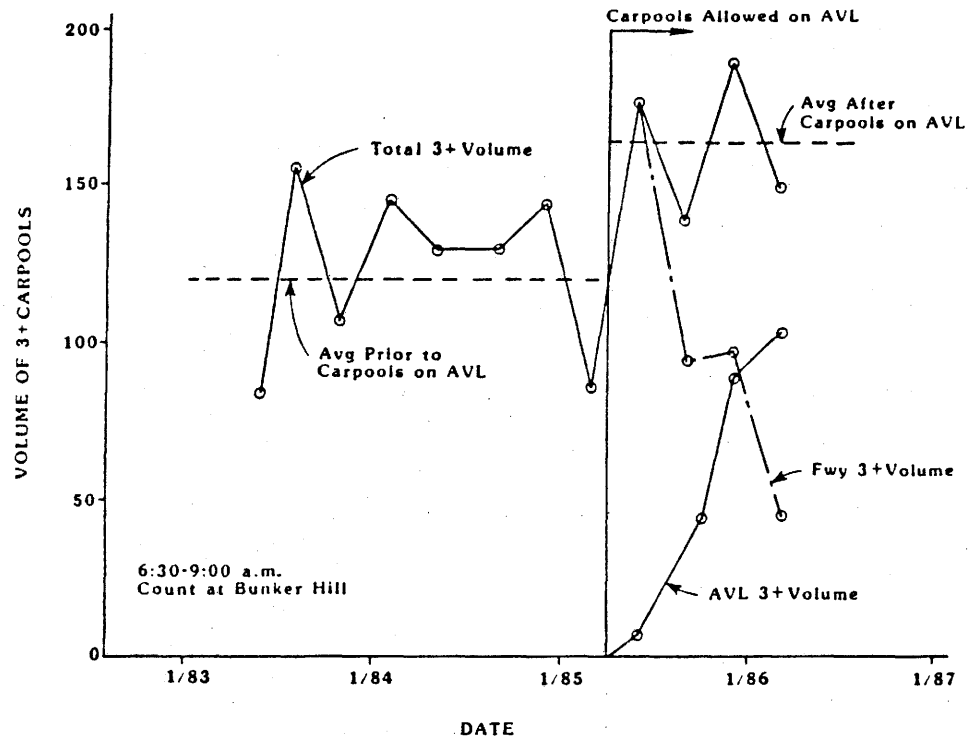


Figure 4. Peak-Period 3+ Carpool Volumes, "Before" and "After" Carpool Utilization of the Katy Freeway and AVL

on the same day of the week, seasonal and other normal traffic variations make it difficult to establish definitive trend lines. The "before" data for the a.m. peak period ranged from a high of 156 3+ carpools to a low of 62 carpools; in the p.m., this volume ranged from a high of 439 carpools to a low of 274 carpools. For purposes of this analysis, the average of the "before" counts is used.

Based on this assumption, in the a.m. peak period, implementation of the AVL increased total 3+ carpools by 37%. However, in the p.m., since carpools were allowed on the AVL, total 3+ carpooling has decreased by 14%. Since the total p.m. carpool volumes (freeway + AVL) are substantially higher than the corresponding a.m. volumes, the average daily increase in 3+ carpools since AVL implementation is effectively zero (Table 7).

The increase in carpools on the Katy, relative to other HOV projects, would be expected to be lower in that: 1) vanpooling has been allowed on the Katy since the AVL opened and the vanpooling mode no doubt serves a portion of potential carpool demand; 2) the Katy AVL is not yet complete, and its 6.4-mile length is less than that for most HOV projects; 3) excellent bus service is offered in the corridor which may also reduce the demand for carpooling; and 4) carpools have only been allowed to use the AVL for a year.

Nonetheless, the Katy AVL has not resulted in the significant carpooling increases experienced on other projects. And, in spite of the lack of consistency in the data base, if carpooling on the Katy had increased by over 100%, such an increase would have been detectable.

AVL Volume Relative to Freeway Volume

In the peak hour of AVL operation, the Katy AVL is typically moving 20% to 25% of total person movement in 2% to 3% of total vehicles (Table 8). The freeway count location may understate freeway volumes; counts of 1600 to 1700 vph per lane have been made at other locations on the Katy Freeway.

Table 7. Estimated Increases in Carpool Volumes Due to HOV Lane Implementation

Facility	Carpool Volume Before HOV	Carpool Volume After HOV ¹	Percent Change
Katy AVL, Houston (1983-1986)			
a.m. peak period (6:30-9:00)	119	163	+ 37%
p.m. peak period (4:00-7:00)	345	297	- 14%
"average" peak period	232	230	0
El Monte, Los Angeles (1976-1985)	670	2166	+323%
a.m. peak period			
Rte 91, Los Angeles (4 mo. in 1985)	1000	1350	+ 35%
p.m. peak hour			
Rte. 55, Orange Co. (1984-6)			
a.m. peak period	1341	1916	+ 43%
p.m. peak period	1925	2473	+ 28%
I-95, Miami (1976-1984)	2185	2714	+ 24%
a.m. peak period			
Shirley Highway, Washington D.C.	272	3723	+1269%
a.m. peak period (1974-1985)			
I-93, Boston (1974-1980)	315	1224	289%
a.m. peak period			
Banfield Fwy., Portland, Ore.	106	518	+389%
a.m. peak period			
Moanalua Fwy. (1974-1982)	600	1750	+192%
a.m. peak period			

¹Freeway 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.

Table 8. Trends In Peak-Hour Freeway and AVL Person Volumes, Katy Freeway

Date Peak Hour	Freeway		AVL		Total	
	Vehicles	Persons	Vehicles	Persons	Vehicles	Persons
12/84 a.m.	3258 (97%)	3628 (72%)	86 (3%)	1377 (28%)	3344	5005
p.m.	4077 (98%)	4702 (80%)	76 (2%)	1207 (20%)	4153	5909
3/85 a.m.	3880 (98%)	4282 (75%)	86 (2%)	1407 (25%)	3966	5689
p.m.	4374 (98%)	5313 (80%)	78 (2%)	1362 (20%)	4452	6675
6/85 a.m.	4410 (98%)	5124 (77%)	92 (2%)	1515 (23%)	4502	6639
p.m.	4025 (98%)	4878 (80%)	66 (2%)	1250 (20%)	4091	6128
9/85 a.m.	4468 (98%)	4914 (76%)	114 (2%)	1550 (24%)	4582	6464
p.m.	4327 (98%)	5140 (78%)	98 (2%)	1468 (22%)	4425	6608
12/85 a.m.	4663 (97%)	4988 (75%)	139 (3%)	1660 (25%)	4802	6648
p.m.	3997 (97%)	4620 (75%)	103 (3%)	1577 (25%)	4100	6197
3/86 a.m.	4319 (97%)	4784 (74%)	134 (3%)	1682 (26%)	4453	6466
p.m.	4136 (98%)	4867 (76%)	103 (2%)	1531 (24%)	4239	6398

Notes: Freeway count location at Bunker Hill (3 lanes), a.m. 6:30-7:30, p.m. 4:30-5:30 based on peak AVL hour which does not necessarily correspond to peak freeway hour.

Source: Texas Transportation Institute counts.

Growth in Total AVL Volume

Relative to other selected major HOV projects, the increase in total AVL person movement since AVL inception has been relatively low on the Katy AVL (Table 9). This would appear to be due, at least in part, to the length of the AVL and the fact that the Houston economy has been depressed during the initial years of AVL operation. Research has demonstrated that the length of HOV lane (which can be a proxy variable for travel time savings) affects HOV ridership. The Katy AVL is less than two-thirds the length of the other projects shown in Table 9.

Table 9. Estimated Annual Growth Rates in Person Volumes on Selected Transitway Projects

Year	Shirley Highway (11 mi.) Washington, D.C. 6-9:30 a.m.		El Monte Busway (11 mi.) Los Angeles 6-10 a.m.		I-45 N Contraflow/AVL (9.6 mi.) Houston both 2.5-hr. peak periods		Katy AVL (6.4 mi.) Houston both 3 hr. peak periods	
	Volume	% Increase (decrease)	Volume	% Increase (decrease)	Volume	% Increase (decrease)	Volume	% Increase
1970	4,500	----						
1971	9,000	+100%						
1972	12,000	+ 3%						
1973	13,500	+ 12%	1,700	----				
1974	20,000 ¹	+ 48%	3,500	+105%				
1975	24,000	+ 20%	4,600	+ 31%				
1976	29,000	+ 21%	8,000 ¹	+ 74%				
1977	34,000	+ 17%	9,200	+ 15%				
1978	37,000	+ 9%	10,000	+ 9%				
1979	43,000	+ 16%	13,000	+ 30%	4,324	----		
1980	43,500	+ 1%	13,700	+ 5%	9,746	+125%		
1981	43,500	0%	14,700	+ 7%	14,808	+ 52%		
1982	41,900(est)	(4%)	13,100	(11%)	14,870	+ 1%		
1983	40,300	(4%)	14,500	+ 11%	15,890	+ 7%		
1984	34,300 ²	(15%)	15,900	+ 10%	16,640	+ 5%	4163	----
1985	28,400 ²	(17%)	15,800	(1%)	15,260	(8%)	5131 ¹	23%
1986	----	-----	----	---	13,791	(10%)	6188	21%
Average, non-weighted		16%			25%		22%	
Average, 1st 2 years		67%			89%		22%	
Average, 1st 5 years		43%			38%		----	

¹Carpools introduced onto project.

²Decrease partially the result of opening I-66. Operating hours also reduced to 6-9 a.m.

The average of the annual growth rates for the first two years of HOV operation was 67% on the Shirley, 68% on the El Monte, 89% on the North, and only 22% on the Katy.

Another point should be noted from Table 9. In the year carpools were allowed to use the Shirley (1974), total HOV utilization increased 48%. In the year carpools were allowed to use the El Monte (1976), total HOV utilization increased 74%. In the year carpools were allowed to use the Katy (1985), total HOV utilization only increased by 23%.

All these data suggest that, once Phase 2 of the Katy opens, an increase in AVL utilization can be expected to occur. This is anticipated to occur since the Phase 2 improvement will generate additional time savings, particularly for users of the Addicks park-and-ride facility located in the vicinity of SH 6. A direct, grade-separated connection is being provided from that park-and-ride lot to the transitway.

III. CRITERIA FOR EVALUATING THE SUCCESS OF THE AVL CARPOOL EXPERIMENT

Carpools were permitted to use the Katy AVL as an experiment. Prior to allowing carpools on the AVL, 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 10. These criteria are addressed individually in subsequent sections of this report.

Table 10. Criteria for Judging the Success of the Katy AVL Carpool Experiment

Proposed Evaluation Factor	Proposed Relative Weighing	Resulting Impact
1. Change in person movement on the the Katy AVL directly attributable to carpooling.	25	<p>Highway Successful: Total AVL person movement increases by at least 20% due to carpooling.</p> <p>Successful: Person movement increases by between 5% and 20%.</p> <p>Somewhat Unsuccessful: Person movement essentially unchanged (0% to 5% increase)</p> <p>Highly Unsuccessful: Person movement decreases.</p>
2. Non-User Perception of Katy AVL Utilization	30	<p>Highly Successful: At least 70% of non-users respond that AVL is sufficiently utilized.</p> <p>Successful: Between 50% and 70% of non-users respond that AVL is sufficiently utilized.</p> <p>Somewhat Unsuccessful: Between 50% and 70% of non-users respond that AVL is not sufficiently utilized.</p> <p>Highly Unsuccessful: More than 70% of non-users respond that AVL is not sufficiently utilized.</p>
3. Change in average travel time on the AVL.	20	<p>Highly Successful: No change.</p> <p>Successful: Average travel speed decreases by no more than 3 mph.</p> <p>Somewhat 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>Somewhat Unsuccessful: Delay increases by 5% to 10%.</p> <p>Highly Unsuccessful: Delay increases by more than 10%.</p>
5. Increase in frequency of break-downs on the AVL	5	<p>Highly Successful: None.</p> <p>Successful: Less than 5%.</p> <p>Somewhat 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	Values developed by Metro.

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 AVL is to increase the volume of persons moved on the facility. As shown previously (Table 6), the percent of total person movement in vanpools and carpools on the Katy AVL is low relative to many other freeway HOV projects.

Carpool Component

Of total peak-period persons moved on the AVL in April 1986, approximately 12% were in carpools (Table 11).

Table 11. Person Movement on the Katy AVL, April 1986

Time Period	Bus		Vanpool		Carpool		Total
	Volume	%	Volume	%	Volume	%	
A.M. EB							
Peak Hour	980	61%	377	23%	261	16%	1618
Peak Period	2270	71%	548	17%	378	12%	3196
P.M. WB							
Peak Hour	670	56%	366	30%	166	14%	1202
Peak Period	2032	68%	632	21%	328	11%	2992

Source: TTI counts, Table 3.

These data could lead to the conclusion that allowing carpools on the AVL has increased person movement in the a.m. peak period by 13% (378/(3196-378)) and by 12% (328/(2992-328)) in the p.m. peak period. However, such a conclusion ignores the fact that some of these carpoolers used other AVL modes prior to carpooling (Table 12).

Table 12. Prior Use of AVL By Carpoolers

Did You Use AVL Before Carpooling	Carpool Survey Date	
	10/85 (n=90)	4/86 (n=197)
Yes, Bus	3%	7.1%
Yes, Van	2%	7.1%
No	95%	85.8%

This suggests that slightly over 14% of those carpooling were drawn from other vehicles using the AVL and, thus, does not represent an effective increase in AVL ridership due to carpooling. This indicates that carpooling has effectively increased AVL utilization by 10% to 11%. Since it is possible that, if carpoolers were not allowed on the AVL, some of the carpoolers would choose to ride a bus or vanpool, this should represent a high estimate of the effective increase in AVL utilization due to carpooling. It should also be noted that the percent of carpoolers who previously used other modes on the AVL increased from 5% in October 1985 to 14% in April 1986.

Other issues should be emphasized. First, allowing carpools to use the Katy AVL did not result in the substantial increases in total AVL utilization that were realized when carpools were allowed onto the Shirley and El Monte HOV facilities. Allowing carpools onto those projects increased total HOV utilization by 48% and 74%, respectively (Table 9). Second, the Katy AVL has not generated the significant increase in carpools typically associated with HOV projects (Table 7). And, since the total utilization of the Katy AVL is less than what might be expected (Table 9), the carpool component is being compared to a relatively low base; this could overemphasize the impact of carpools on effective AVL utilization.

For purposes of this analysis, it is assumed that allowing carpools onto the AVL has increased effective peak-period AVL person movement by approximately 10%.

Conclusion Pertaining to Evaluation Criterion

The increase in AVL person movement resulting from carpool utilization is a criterion for evaluating the success of the carpool experiment. Table 13 summarizes this criterion.

Table 13. Person Movement Impacts of Carpooling, Criterion for Assessing the Success of the Katy AVL Carpool Experiment

Rating ¹	Associated Impact
4. Highly Successful	Total AVL person movement increases by at least 20% due to carpooling
3. Successful ²	Person movement increases by between 5% and 20%
2. Somewhat Unsuccessful	Person movement increases by between 0% and 5%
1. Highly Unsuccessful	Person movement decreases

¹Of the 6 criteria used to rate the success of the carpool experiment, this criterion is given the second heaviest total rating (25% of total).

²The April 1986 data fall into this category.

Based on the data presented, it could be concluded that, in regard to this criterion, the experiment has been a success. However, due to the number of qualifying factors referred to previously, it is assumed for this analysis that, in terms of the person movement impact, the carpool experiment is midway between "successful" and "somewhat unsuccessful."

V. PERCEPTION OF AVL UTILIZATION

A major purpose for allowing carpools to use the AVL was to make the AVL appear more utilized to the general public. The carpooling has increased the volume of vehicles using the AVL. In March 1985, 135 vehicles used the AVL during a typical peak period; in April 1986, 252 vehicles were using the AVL in the peak period, an 87% increase over the March 1985 volumes.

The effect of this increased volume on the perception of AVL utilization is considerably different between the users and the non users of the AVL. For all AVL user groups, a higher percentage of users feel the AVL is sufficiently utilized in comparison to responses to previous surveys. Given that transit represents approximately 70% of AVL users, a majority of the AVL users believe the AVL is sufficiently utilized. It should be realized that, due to the sharp peaking characteristics typical of the AVL, most of the AVL users see the AVL only during the time period in which it is most intensively utilized.

While the increased volume of AVL traffic has had a positive impact on the perception of utilization by the users of the AVL, the same is not true of the non users of the AVL. This group, in spite of an 87% increase in AVL vehicle utilization, perceives the AVL to still be significantly underutilized. While the negative expression in the April 1986 surveys may be somewhat overstated in that the non AVL users are also being inconvenienced by the Phase 2 AVL construction, the conclusion has to be that allowing carpools to utilize the AVL has not altered the opinion on the part of non AVL users that the priority lane is badly underutilized. The percentage of non users feeling the AVL is a good improvement has also declined over the last year.

These data are summarized in Table 14.

At this time, the non user perception of the AVL is difficult to evaluate. It may be that, unless the AVL operates at speeds and volumes comparable to the mainlanes, a certain portion (and possibly a large portion)

of the non users may feel the AVL is underutilized. Similar surveys have been performed on the North Transitway where peak-hour transitway volumes are between 200 vph and 300 vph; in those surveys, approximately 75% of the non users felt the AVL was underutilized. Since, with 2+ unauthorized carpools allowed onto the Katy Transitway in August 1986, transitway volumes are now over 2000 vehicles per peak period. Surveys presently scheduled for Spring 1987 should give a better indication of how the non user perception of utilization is changed by significant increases in transitway demand. Due to the high weighting given to this evaluation criteria, this issue is a concern that should be resolved as part of the scheduled on-going research effort.

Table 14. Perception of the Utilization of the Katy AVL

Measure of Effectiveness	AVL Users								Non AVL Users	
	Transit		Vanpool		Carpool		Total ¹		Motorists	
	3/85	4/86	3/85	4/86	10/85	4/86	3/85	4/86	3/85	4/86
Is the AVL Sufficiently Utilized										
Yes	49%	66%	30%	41%	34%	45%	43%	59%	3%	3%
No	33%	14%	51%	34%	43%	32%	39%	20%	90%	92%
Not Sure	18%	20%	19%	25%	23%	23%	18%	21%	7%	5%
Is the AVL a Good Improvement										
Yes	---	---	---	---	---	---	---	---	41%	37%
No	---	---	---	---	---	---	---	---	35%	43%
Not Sure	---	---	---	---	---	---	---	---	24%	20%

¹Weighted average for all AVL users (bus and vanpool in 3/85; bus, vanpool and carpool in 4/86).

Source: Texas Transportation Institute Surveys.

Conclusion Pertaining to Evaluation Criterion

In the criteria for evaluating the success of the carpool experiment, the non user perception of the AVL utilization was the single most important

criterion. Table 15 summarizes this criteria. In terms of this evaluation factor or measure of effectiveness, the carpool experiment is considered "highly unsuccessful."

Table 15. Non User Perception of Katy AVL Utilization, Criterion for Assessing the Success of the Katy AVL Carpool Experiment

Rating ¹	Associated Impact
4. Highly Successful	At least 70% of non-users respond that AVL is sufficiently utilized.
3. Successful	Between 50% and 70% of non-users respond that AVL is sufficiently utilized.
2. Somewhat Unsuccessful	Between 50% and 70% of non users respond that AVL is not sufficiently utilized.
1. Highly Unsuccessful ²	More than 70% of non users respond that AVL is not sufficiently utilized.

¹Of the 6 criteria used to rate the success of the carpool experiment, this criterion is given the heaviest relative weighting (30% of the total).

²The April 1986 data fall into this category.

VI. CHANGE IN AVERAGE TRAVEL TIME ON THE AVL

A concern associated with AVL carpool utilization was that the increase in AVL volumes would depress the speeds on the AVL. This, in turn, could reduce the attractiveness of the AVL. To investigate this concern, data have been collected relating to time mean speed, spot speeds, and vehicle headways on the AVL.

AVL Travel Time, Average Speeds, and Headways

Average Travel Speeds

Time mean speeds were measured for each vehicle on the Katy AVL. The times the vehicle entered and exited the AVL were recorded to the nearest second, and the travel time was divided into the length of the priority lane to calculate average travel speeds. Since the vehicles have to reduce speeds to enter and exit the AVL, the time mean speeds are less than the maximum operating speeds attained within the AVL.

Average speeds are shown in Table 16. No significant change has occurred in this average speed, even though total vehicular volume on the AVL increased by 87% between March 1985 and April 1986. The data also indicate a small range of speeds for all types of vehicles operating on the AVL.

Table 16. Time Mean Speeds on the Katy AVL

Average Speed (mph)	Bus		Vanpool		Carpool		Total	
	3/85	5/86	3/85	5/86	3/85	5/86	3/85	5/86
Average Travel Speed (mph)	52	56	56	57	---	56	55	56
Standard Deviation	8.7	3.3	3.3	3.2	---	3.6	3.5	3.4
Coefficient of Variation	0.17	0.06	0.06	0.06	---	0.06	0.06	0.06

Travel time data collected for specific sections of the AVL also confirm that average speed has not been adversely impacted (Table 17).

Table 17. Travel Times and Average Speeds, Katy AVL

AVL Section	Time Period	Avg. Travel Time (min)		Avg. Speed (mph)	
		3/85	4/86	3/85	4/86
West Belt to Gessner 1.7 miles	6-9 a.m.	1.9	1.9	55	55
	6:30-8:30 a.m.	1.9	1.9	55	55
	3:15-6:15 p.m.	1.9	1.8	55	57
	4:15-6:15 p.m.	1.9	1.8	55	57
Gessner to Post Oak 4.7 miles	6-9 a.m.	5.1	5.0	55	56
	6:30-8:30 a.m.	5.1	5.0	55	56
	3:15-6:15 p.m.	5.1	5.2	55	54
	4:15-6:15 p.m.	5.1	5.2	55	54

Spot Speed Studies

A set of vehicle detectors were used to collect spot speeds. This data collection technique is not as reliable as the time mean speed data. The value of this data is to confirm that speeds for the most part are not hindered by other vehicles and are in a narrow range around 55 mph. These data are summarized in Table 18.

Table 18. Spot Speed Surveys, Katy AVL

Date and Direction	Number of Vehicles			Speeds Missed	Less Than 45	Number of Vehicles With Speeds						Over 66	Average Speed (mph)
	Vans	Buses	Carpools			45-50	50-54	54-57	57-60	60-63	63-66		
March 1985													
EB am ¹	70	55	---	17	0	8	30	25	20	12	8	7	57
WB pm ¹	82	58	---	15	2	3	28	30	28	17	11	7	57
June 1986													
EB am	78	59	59	2	0	1	2	3	31	68	49	42	61
WB pm	66	65	65	17	0	7	26	54	44	32	19	14	58

¹Average of data collected on 8 separate days. Refer to Research Report 484-1.

Headways

Although the average operating speeds on the AVL are very near the speed limit, a certain percentage of vehicles are restricted from travelling their desired speed due to slower travelling vehicles in the traffic stream.

Headway data provide an indication of the percent of AVL vehicles having their desired speed reduced due to the presence of other vehicles. As would be expected, with more vehicles operating on the AVL, this percentage has increased (Table 19). Operating conditions of AVL traffic are, for the most part, free flow. However, studies at the entrance and exit to the AVL indicate that speeds of 31% of the AVL traffic may be affected by other vehicles. This percentage has increased from the 15% found in the March 1985 survey. However, the average speed for all vehicles on the AVL has increased from 55 to 56 mph.

Table 19. Percent of AVL Vehicles Having Operating Speed Restricted Due to the Presence of Other AVL Vehicles

Date	Avg. AVL Peak-Hour Volume	Percent With Speed Restricted
March 1985, Before Carpools	82	15%
April 1986, After Carpools	140	31%

Conclusion Pertaining to Evaluation Criterion

Possible changes in AVL operating speed are a criterion for evaluating the success of the carpool experiment. Table 20 summarizes this criterion.

Table 20. Change in Average Travel Time on the AVL, Criterion for Assessing the Success of the Katy AVL Carpool Experiment

Rating ¹	Associated Impact
4. Highly Successful ²	No change.
3. Successful	Average travel speed decreases by no more than 3 mph.
2. Somewhat Unsuccessful	Average travel speed decreases by between 3 mph and 6 mph.
1. Highly Unsuccessful	Average travel speed decreases by more than 6 mph.

¹Of the 6 criteria used to rate the success of the carpool experiment, this criterion is given the third heaviest relative weighting (20% of total).

²The April and June 1986 data fall into this category.

If anything, average travel speed on the AVL has increased slightly. Thus, in terms of this measure, the carpool experiment is considered "highly successful".

VII. MIXED-FLOW TRAFFIC LANES

It is conceivable that allowing carpools onto the AVL could have either a positive or a negative impact on the mixed-flow lanes. If substantial carpool volumes use the AVL, mainlane volumes could be decreased which might improve operations. Conversely, the existing access/egress locations to the AVL are less than desirable. Large volumes entering or exiting the AVL, particularly at the p.m. exit locations, could deteriorate level-of-service on the mainlanes.

Due to natural variability in the traffic stream, it is difficult to precisely quantify changes in mainlane operating speeds. However, the data collected (Tables 21 and 22) suggest that, if anything, mainlane speeds have increased since carpools began to use the AVL. However, it does not appear that this change is a result of carpools using the AVL.

Table 21. Travel Time and Speeds, Freeway Mainlanes, SH 6 to S.P.R.R.
(13.2 miles)

Traffic and Time Period	Avg. Travel Time (min).		Avg. Speed (mph)	
	3/85	7/86	3/85	7/86
A.M. Eastbound				
3-Hour Period, 6-9 a.m.	26.5	19.1	30	42
2-Hour Period, 6:30-8:30 a.m.	30.6	20.9	26	38
P.M. Westbound				
3-Hour Period, 3:15-6:15 p.m.	21.3	19.1	37	41
2-Hour Period, 4:15-6:15 p.m.	24.7	21.1	32	38

Table 22. Average Speeds on the Katy Freeway Mainlanes

Date, Direction, Time	Average Speed in MPH							
	Section 1		Section 2		Section 3		Section 4	
	3/85	7/86	3/85	7/86	3/85	7/86	3/85	7/86
Eastbound, A.M.								
6:00	54	54	55	51	55	59	55	55
6:15	46	56	49	51	50	55	54	60
6:30	31	51	33	42	39	51	49	55
6:45	26	43	26	35	34	43	54	53
7:00	22	42	22	30	28	55	54	--
7:15	20	36	16	28	22	30	54	53
7:30	18	32	18	18	21	25	52	55
7:45	18	36	17	20	22	28	54	51
8:00	33	48	28	23	26	30	54	55
8:15	30	54	21	36	26	31	56	57
8:30	39	55	30	51	28	34	55	57
8:45	53	55	37	56	33	46	56	53
Westbound, P.M.								
3:00	58	53	60	51	66	44	55	59
3:15	57	55	57	48	58	49	55	54
3:30	48	55	53	49	54	51	57	51
3:45	56	55	49	46	58	54	53	53
4:00	56	53	50	52	60	36	55	58
4:15	48	60	44	49	41	30	55	58
4:30	49	55	35	46	34	29	54	51
4:45	42	41	28	35	28	31	44	48
5:00	42	37	25	31	24	22	46	44
5:15	48	47	22	27	22	22	46	41
5:30	35	53	20	25	19	20	49	45
5:45	47	49	21	32	25	21	42	45
6:00	58	49	28	32	32	25	50	52

Note: Section 1 a.m. and Section 4 p.m. = SH 6 to West Belt AVL entrance.

Section 2 a.m. and Section 3 p.m. = West Belt AVL Entrance to Gessner AVL ent.

Section 3 a.m. and Section 2 p.m. = Gessner AVL entrance to Post Oak

Section 4 a.m. and Section 1 p.m. = Post Oak to S.P.R.R.

However, it should be noted in reviewing Tables 21 and 22 that travel time data collected in March 1985 are being compared to travel time data collected in July 1986. This inconsistency was the result of difficulties in scheduling the data collection effort.

The data do suggest that travel time savings on the AVL are less than they were in 1985. To further check this finding, additional travel time data were collected in September 1986, after 2+ carpools were allowed onto the transitway.

The differences in average speeds between AVL and non-AVL traffic are not as large as in the "before" study (March 1985). The poor economy and the construction projects are factors that contribute to a current reduction in peak-period traffic and resultant congestion. The survey taken in July 1986 had the added factors of reduced demands because of school and vacation traffic. The survey taken in September 1986 included the shift of approximately 1600 carpool vehicles in the three-hour peak from the mainlanes of the freeway to the AVL.

Even though transitway volumes in the a.m. in September are 175% greater than March 1985, travel time savings are only about 20% greater (Tables 23 and 24). This no doubt helps to explain the slower than expected growth in transitway volumes. However, projections continue to call for increases in freeway volumes in the future.

Conclusion Pertaining to Evaluation Criteria

Changes in freeway speeds and travel times are a criterion for evaluating the success of the carpool experiment. Table 25 summarizes this criterion.

Table 23. Eastbound AM Travel Time Savings for Katy AVL Users,
May 1985 and September 1986

Time of Day	Time Saved by AVL (minutes)		AVL Person Volume		Travel Time Saved (person minutes)	
	5/85	9/86	5/85	9/86	5/85	9/86
6:00 a.m.	-1.8	-3.2	90	150	-162	-480
6:15	-0.9	-3.1	152	211	-137	-654
6:30	1.8	-2.9	66	508	119	-1,473
6:45	4.3	0.7	466	677	2,004	474
7:00	7.0	4.2	288	897	2,016	3,767
7:15	11.3	4.9	358	844	4,045	4,136
7:30	11.3	5.5	218	949	2,463	5,220
7:45	11.5	5.3	166	691	1,909	3,662
8:00	8.3	5.0	238	563	1,975	2,815
8:15	7.2	3.3	188	465	1,354	1,535
8:30	5.6	1.7	90	302	504	513
8:45	0.9	-0.1	60	302	54	-30
9:00	-0.1	-1.8	60	11	-6	-380
3 Hr. Total			2,380	6,559	16,138	19,485
2 Hr. Total			1,988	5,594	15,885	20,136

Table 24. Westbound PM Travel Time Savings for Katy AVL Users,
May 1985 and September 1986

Time of Day	Time Saved by AVL (minutes)		AVL Person Volume		Travel Time Saved (person minutes)	
	5/85	9/86	5/85	9/86	5/85	9/86
3:00 p.m.	-1.7	-0.7	0	0	0	0
3:15	-0.9	-0.6	0	0	0	0
3:30	-1.0	0.5	120	138	-120	110
3:45	-0.8	-0.2	158	203	-126	-41
4:00	-2.0	-1.2	164	424	-328	-509
4:15	1.2	0.4	248	471	298	188
4:30	3.5	1.9	324	611	1,134	1,161
4:45	7.4	3.4	330	597	2,442	2,030
5:00	10.0	4.8	122	503	1,220	2,414
5:15	10.4	6.8	374	899	3,890	6,113
5:30	13.6	8.8	198	699	2,693	6,151
5:45	10.5	6.3	166	510	1,743	3,213
6:00	6.7	3.8	60	286	402	1,087
6:15	-0.3	3.0	120	395	-36	1,185
3 Hr. Total			2,384	5,312	13,212	23,102
2 Hr. Total			1,882	4,500	13,822	23,354

Table 25. Change in Person Delay to Mixed-Flow Traffic, Criterion for Assessing the Success of the Katy AVL Carpool Experiment

Rating ¹	Associated Impact
4. Highly Successful ²	No change or a decrease in total delay
3. Successful	Delay increase by less than 5%
2. Somewhat Unsuccessful	Delay increases by 5% to 10%
1. Highly Unsuccessful	Delay increases by more than 10%

¹Of the six criteria used to rate the success of the carpool, experiment, this criterion is given the fourth heaviest total rating (15%).

²The April-June 1986 data fall into this category.

In terms of this evaluation factor or measure of effectiveness, the carpool experiment is considered "highly successful". Factors other than the presence of the AVL, such as the downturn in the economy, are having a greater impact on mixed-flow traffic than is the presence of an AVL.

VIII. AVL BREAKDOWN DATA

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

Metro AVL operating data have been analyzed for the period from October 29, 1984 through May 21, 1986. These data are summarized in Table 26.

For the period since carpools began operating on the AVL, total vehicle breakdowns have been 14% greater (33 versus 29 disabled vehicles) than they would of had there been no carpool operation on the AVL. While carpools represent over 40% of total vehicles on the AVL, they constitute 12% of the total disabled vehicles that have occurred since the AVL was opened to carpools. At current carpool volumes and breakdown rates, one carpool breakdown would be expected to occur every 2 months. Interviews with Metro staff responsible for operating the AVL indicate that all disabled carpools have been able to pull to the side of the AVL and have not blocked through traffic.

Conclusion Pertaining to Evaluation Criterion

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

The data suggest that breakdowns have increased by 14% due to carpool utilization of the AVL; this equates to "somewhat unsuccessful". However, given the low frequency of carpool breakdowns and the fact that the breakdowns have not blocked the through lane, a "successful" conclusion is assumed for this criterion.

Table 26. Vehicle Breakdown Rates, Katy Freeway AVL

Vehicle Group	Time Period	
	10/29/84-5/21/86	4/1/85-5/21/86 ²
No. of Disabled Vehicles, Total	37	33
Buses	29	25
Vans	4	4
Carpools	4	4
No. of Towed Vehicles, Total ³	9	9
Buses	6	6
Vans	0	0
Carpools	3	3
Vehicle Miles of Travel (VMT), Total	843,190	709,040
Buses	283,770	236,920
Vans	358,610	271,310
Carpools	200,810	200,810
VMT/Disabled Vehicles, Total	22,788	21,486
VMT/Disabled Bus	9,785	9,477
VMT/Disabled Van	89,652	67,827
VMT/Disabled Carpool	50,202	50,202
VMT/Towed Vehicle, Total	93,687	78,782
VMT/Towed Bus	47,295	39,486
VMT/Towed Van	----	----
VMT/Towed Carpool	66,936	66,936

¹Operating period from inception of AVL.

²Operating period from when carpools allowed onto AVL.

³Towed vehicles are a subset of disabled vehicles.

IX. AUTHORIZATION AND ENFORCEMENT COSTS

Allowing carpools onto the AVL could increase costs for both enforcement and vehicle authorization. The Director of Transportation Programs at Metro was requested to address these concerns; her response is presented below.

Administrative Costs Incurred to Authorize Carpools

No additional staff has been necessary to maintain an efficient authorization system. Carpool and vanpool authorizations for both the Katy and North Transitways are handled by two information operators on the CarShare/VanShare staff. These operators spend about 20% of their time performing vehicle and driver authorizations. These tasks have become a part of the staff's job responsibilities.

The Metro computer system file format for vanpool information was easily adapted to carpool information. All carpool vehicle and driver information is on computer and is easily retrieved.

As carpools are authorized on other Metro transitways, an additional staff person may be necessary to authorize drivers and vehicles. This staff person will be necessary to handle the increased demand. Metro will not be projecting any additional staff for carpool/vanpool authorizations during FY 87.

Increase In Enforcement Costs

Currently, Metro does not have permanent enforcement stations on the Katy AVL or North AVL. 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 AVL has resulted in an increase in traffic violations on the AVL resulting in changes in modes of enforcement; however, costs have not been affected at the present time. These violations have related to non-compliance to the three (3) person carpool rule, speeding and other vehicle violations.

Conclusion Pertaining to Evaluation Criterion

It appears that the marginal impact on authorization and enforcement due to AVL carpool utilization has been minimal. In regard to this criterion, the carpool experiment is judged to be "successful".

X. CONCLUSIONS

A summary of the evaluation of the individual criterion is shown in Table 27. Based on that evaluation, as of April 1986 the Katy carpool experiment is judged to be between "somewhat unsuccessful" and "successful". If numerical values are assigned to the possible outcomes (with "highly successful" = 4; "successful" = 3; "somewhat unsuccessful" = 2; and "highly unsuccessful" = 1), the weighted value for the carpool experiment is 2.62. A value of 2.5 is midway between "successful" and "somewhat unsuccessful".

All of the individual criterion, with the exception of the non-user perception of Katy AVL utilization, were rated as at least "successful". However, the non-user perception of utilization, which is the single most important criterion and the primary reason for allowing carpools onto the AVL, is judged to be "highly unsuccessful". If AVL volumes were to increase sufficiently to alter the non-user perception of underutilization, it is reasonable to assume that other evaluation criteria would be adversely impacted. Further monitoring of the Katy carpool experiment will identify impacts of increased AVL carpool volumes.

Table 27. Overall Evaluation of Katy AVL Carpool Experiment 12 Months After Carpools Were Allowed Onto the AVL

Criterion	Relative Weighting	Conclusion Pertaining to Experiment	Relevant Data
1. Change in Person Movement on the AVL Directly Attributable to Carpooling	25%	Between "Successful" and "Somewhat Unsuccessful"	<ul style="list-style-type: none"> ● AVL person movement increased by 10% due to carpooling
2. Non-User Perception of Katy AVL Utilization	30%	"Highly Unsuccessful"	<ul style="list-style-type: none"> ● Over 90% of non-users feel the AVL is not sufficiently utilized.
3. Change in Travel Time on the AVL	20%	"Highly Successful"	<ul style="list-style-type: none"> ● If anything, average speeds on the AVL have increased.
4. Change in Delay to Mixed-Flow Traffic	15%	"Highly Successful"	<ul style="list-style-type: none"> ● No change was detected.
5. Increase in Frequency of AVL Break-downs	5%	"Successful"	<ul style="list-style-type: none"> ● Breakdowns increased by 14% due to carpooling; the number of breakdowns was small and none blocked the AVL
6. Increase in Authorization and Enforcement Costs	5%	"Successful"	<ul style="list-style-type: none"> ● Marginal increase in costs due to carpools has not been substantial.
TOTAL	100%	Between "Somewhat Unsuccessful" and "Successful"	