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16. Abstract

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Operational data will continue to be collected within the study corridors, both monthly and quarterly, throughout a 5-year evaluation period. The collection, and subsequent analysis, of data will allow a before, during and after comparison of freeway operations.

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Evaluation of High-Occupancy Vehicle Priority Treatment Projects:

First Year's Analysis

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Research Report 339-2

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

Sponsored by

State Department of Highways and Public Transportation
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ABSTRACT

This report presents an overview of the study plan for the evaluation of three high-occupancy vehicle facilities currently being constructed in Houston, Texas. Preliminary analyses of data from the first 12 months of the study are presented. These data include park-and-ride demands, travel times and speeds, vehicle and person demands, plus limited accident experience within the three freeway corridors under investigation.

Operational data will continue to be collected within the study corridors, both monthly and quarterly, throughout a 5-year evaluation period. The collection, and subsequent analysis, of data will allow a before, during and after comparison of freeway operations.

SUMMARY

The State Department of Highways and Public Transportation has strongly endorsed high-occupancy vehicle (HOV) priority treatments. The first effort in this regard, the Houston Contraflow Lane (CFL), has proven highly successful from both an operational and a public acceptance standpoint. Subsequent projects, directed to exclusive, physically separated HOV facilities, have reached implementation stage; additional projects are in the planning stage. However, many of the effects of priority treatment are relatively unknown. Therefore, it is important to document and analyze information from the development of these initial HOV priority treatment projects on the Katy (I-10W), North (I-45N) and Gulf (I-45S) Freeways in Houston, Texas.

In June 1983, two of the three study corridors already had construction work underway, and the third had preconstruction work underway. The Gulf Freeway Authorized Vehicle Lane (AVL) construction began as early as

September 1982. The Katy Freeway had its construction ground breaking ceremonies in May 1983, with actual construction on the Freeway beginning in June 1983. The North Freeway preconstruction preparatory work, Phase IA, began in April 1983, but actual construction did not begin until January 1984.

Consequently, a comprehensive comparative "before and after" analysis cannot be made at this early time. Preliminary findings from the first 12 months of data collection and analysis are presented regarding the operational effects of the AVL implementation. At a subsequent time, figures to depict selective operational parameters on the three freeways will be prepared to show the impacts of facility implementation. Accented lines on the figures will indicate both historical trends and projected changes in these operational parameters based upon the institution of the AVL system. Use by high-occupancy vehicles (HOVs) and corresponding passenger throughput in HOVs is expected to increase over time. Likewise, the percentage of total peak-period passenger demand served by HOVs is expected to increase from about 5% to 35% with no significant increase in total vehicles. It is not known whether the extent of modal shift to the AVL from the freeway mainlanes will be significant enough to dramatically enhance freeway operations, as this may possibly be negated by population growth, latent demand, and diversion of traffic. However, this effect, if any, will be noted in future reports.

Operational data will continue to be collected within the study corridors monthly and quarterly throughout the five-year evaluation period. Updates for each freeway will be periodically available and documented in subsequent reports.

IMPLEMENTATION STATEMENT

This project was established to provide continued support to the Texas State Department of Highways and Public Transportation for the implementation of priority treatment techniques for high-occupancy vehicles. Several highway-transit projects have been designed and are under construction, while numerous others are in the conceptual and planning stages. This report documents the first year of a "before and after" evaluation of those projects currently under implementation. The results of the subsequent analyses will be summarized as guidelines for future AVL projects.

DISCLAIMER

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INTRODUCTION

Scope

The tremendous growth experienced in urban areas of Texas in the last decade has caused concern by State and local transportation officials over degradation of mobility. Future growth and economic vitality in the Texas metropolitan regions are in serious jeopardy unless major improvements are implemented in the existing urban transportation system. It would neither be economically nor physically possible to provide enough additional highway capacity through major expansion of the cross section or to expand transit services to serve anticipated demand. Therefore, new and innovative means of freeway system management have been looked to as possible remedies.

One approach to increase roadway capacity and which is strongly endorsed by both the State Department of Highways and Public Transportation and the Metropolitan Transit Authority in Houston is to provide High-Occupancy Vehicle (HOV) priority treatment. The first priority treatment effort, the Houston Contraflow Lane (CFL), has proven operationally successful and has received favorable public acceptance. Several subsequent projects, exclusive, physically separated HOV facilities, have reached the implementation stage with numerous additional projects being in the planning stage. However, many of the short- and long-term effects of priority treatment are relatively unknown. Therefore, it is important to document and analyze information on the implementation of these HOV improvements.

Implementation of three HOV projects on the Katy (I-10W), North (I-45N), and Gulf (I-45S) Freeways in Houston, Texas began in 1982 and will continue through 1987. It is the purpose of this report to present the first year's evaluation of these three projects and the preliminary findings from the data collection and analysis.

Objectives

The objectives of this study are:

1) To formulate a detailed study design for data collection and analysis of HOV projects;

2) To collect continuous operational data before, during, and after project implementation;

3) To monitor all activities during implementation of HOV projects with particular emphasis on the transition of the contraflow lane to an exclusive, physically separated facility;

4) To perform a comprehensive evaluation of the implementation of each specified HOV project; and

5) To develop guidelines for application to future HOV projects.

The detailed study design (Objective #1), along with a summary of the first 6-months of data collection, were documented in a Research Report 339-1 dated March 1984 (1). This report presents additional data and analyses performed in the Houston area in the subsequent 6-month period.

PROJECTS UNDER IMPLEMENTATION

General

Houston, Texas is currently in the process of implementing exclusive, physically separated HOV priority facilities along three major radial freeway corridors. These facilities, referred to as Authorized Vehicle Lanes (AVLs), are located on the:

- Katy Freeway (I-10W)
- North Freeway (I-45N)
- Gulf Freeway (I-45S)

The Katy, North and Gulf AVLs have similar designs with a cross- section of approximately 20 feet. They are single, reversible lanes; traffic will travel inbound toward downtown in the morning and outbound in the afternoon. These lanes are constructed within the existing median of the involved freeways and are protected from other freeway lanes by concrete barriers.

Adequate space is provided for emergencies and breakdowns within the AVL cross section. Access points are limited and controlled. However, each AVL facility differs slightly from the others in design, construction, and operational features. Figure 1 shows the AVL system being implemented on the three freeway corridors now being monitored; each freeway is discussed separately herein.

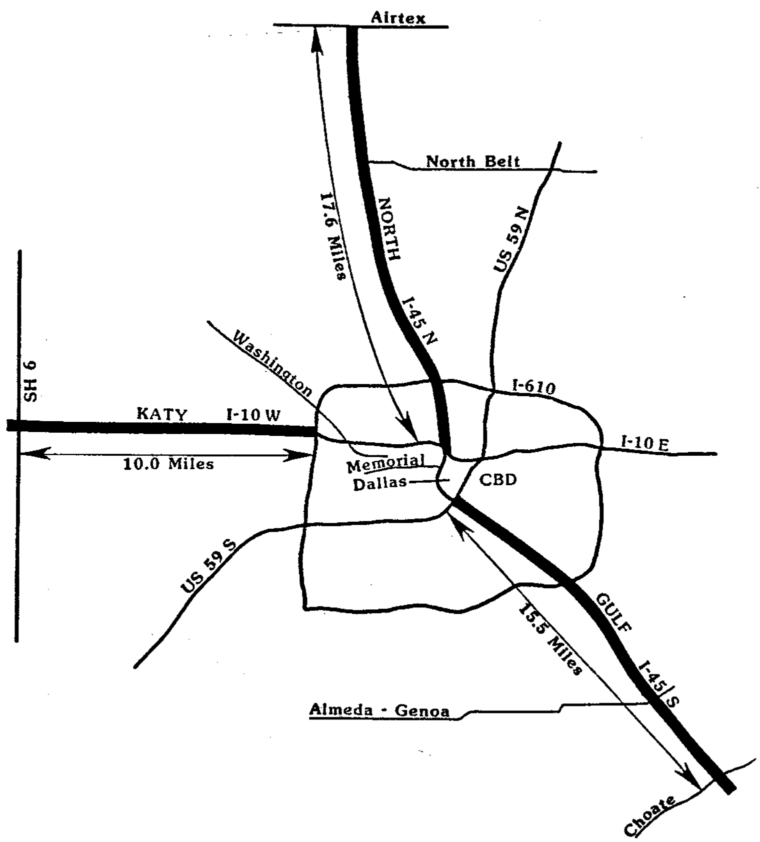


Figure 1: Authorized Vehicles Lanes (AVL's) Under Construction in Houston, Texas

Katy Freeway (I-10W) AVL

The Katy Freeway is a major Interstate highway serving travel demands from western Harris County to various parts of Houston. Traffic volumes have increased at annual rates in excess of 4% throughout the 1970's. Currently, weekday traffic volumes approach 25,000 vehicles per lane; peak-direction flow exceeds 1,900 vehicles per hour per lane (2).

The Katy Freeway AVL will be built and operated in three phases as shown in Figure 2. The first phase is being developed at this time and will stretch five miles from Post Oak (near I-610) to near Gessner. The second phase will extend the AVL another five miles to SH 6 and the third phase will include an interchange at Addicks (SH 6). When fully completed, the Katy AVL will extend 11.5 miles from near I-610 (the West Loop) to Addicks and have intermediate access near Gessner. Construction on the first phase began in June 1983 and is scheduled to be operational in November 1984.

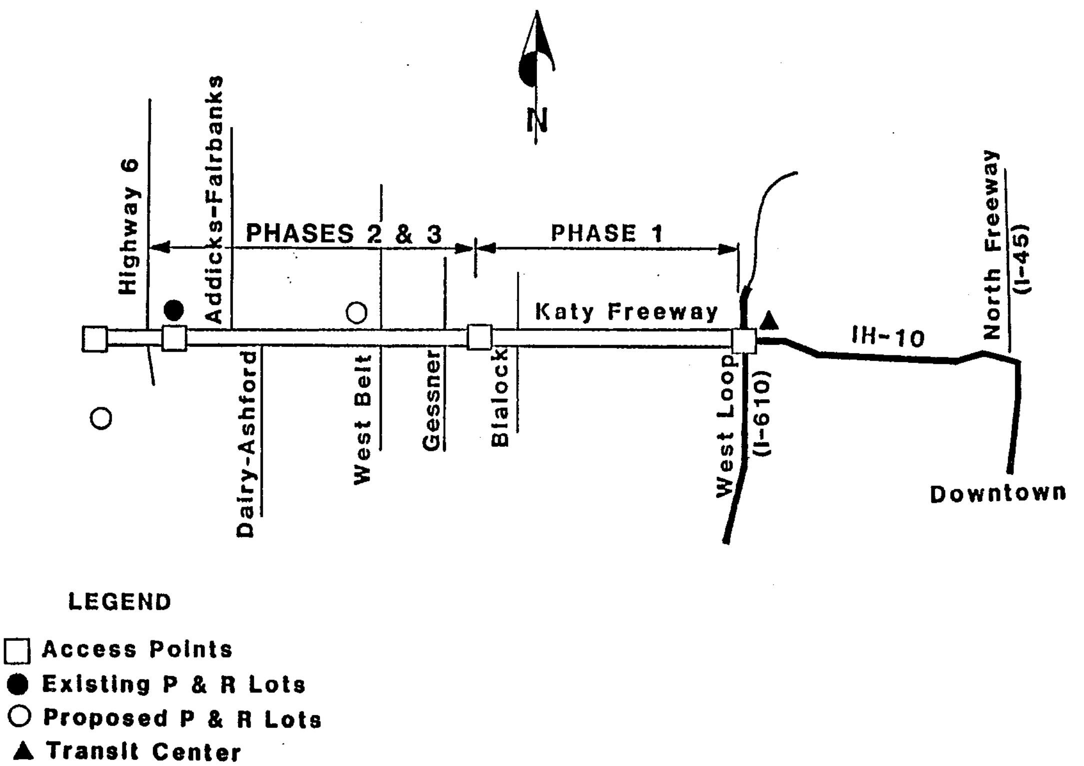


Figure 2: Katy Freeway AVL Phase Construction

At the eastern end, near I-610, a bridge over the westbound freeway mainlanes will connect the AVL to Katy Road at the Post Oak intersection. From this intersection, AVL traffic can turn north or south to reach major employment centers along the West Loop, or continue eastward on Katy Road to downtown. At Gessner, a ramp will provide direct access to and from the freeway mainlanes, and additional ramps will eventually be located at the western end at Addicks.

By 1987, in the peak hour alone, the Katy Freeway AVL is anticipated to accommodate approximately 60 buses and 190 vanpools, or 3,900 persons. Daily ridership is estimated to exceed 15,000 commuters. Peak-hour travel time from the Addicks Park-and-Ride lot to downtown, via the lane, should be reduced from the current 45 minutes to 25 minutes; a reduction of some 20 minutes, or 44% of the peak-hour freeway mainlane travel time (3).

North Freeway (I-45N) AVL

The North Freeway currently carries more than 150,000 vehicles each weekday. Population in the freeway corridor is expected to grow 38% by 1995, with traffic volumes expected to increase accordingly (2).

The AVL will be built and operated in four phases as shown in Figure 3. Phases I and II include both AVL and mainlane construction for 9.6 miles from downtown to North Shepherd. Construction of Phase 1 of the AVL began in January 1984 and is scheduled to be operational in May 1985. Phase III will extend the lane 4.9 miles from North Shepherd to North Belt. Phase IV will continue the AVL an additional 3.1 miles from North Belt to Airtex. Phase III construction is scheduled to begin in August 1985 with a completion date in June 1987. Phase IV construction is anticipated to begin in August 1985 and to end in June 1987.

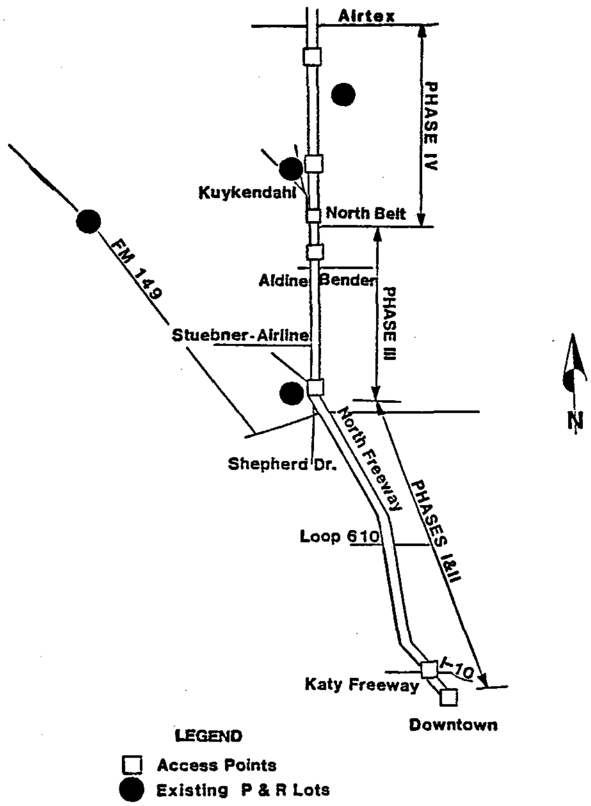


Figure 3: North Freeway AVL, Phase Construction

The North Freeway AVL will be constructed in the median of the freeway and separated from the other mixed-flow traffic lanes by concrete barriers. Since the construction of the AVL is part of the SDHPT work to upgrade and expand the North Freeway to eight lanes, disruption for building the lane will be minimal. The North Freeway AVL should significantly reduce peak hour travel time. When completed, the travel time for AVL users during peak periods is estimated to be half that for current mainlane users. The AVL will significantly increase the person-carrying capacity of the freeway. During its first full year of operation, the North Freeway AVL is expected to benefit 26,000 commuters daily in vanpools and buses (4).

Gulf Freeway (I-45S) AVL

Currently, the Gulf Freeway serves some 150,000 vehicles on a typical weekday. Traffic in peak periods exceeds 1,900 vehicles per hour per lane (2).

The AVL will be built and operated in three phases as shown in Figure 4. The first phase stretches five miles from Lockwood Drive to Airport Boulevard. Construction began in 1982 and is scheduled to be completed in February 1986. The second phase will extend the lane 2.5 miles from Lockwood to downtown; this section should open as an interim facility in June 1986. The eight-mile third phase will extend the lane from Airport Boulevard south to Choate Road near Ellington Air Force Base. This phase may be built in segments as traffic demands dictate. The total AVL facility will be 15.5 miles long when completed in late 1986 or 1987.

Four intermediate, grade-separated interchanges will allow direct access to the AVL and connections to other transit facilities. Interchanges at Lockwood, Hobby and Fuqua employ elevated ramps and bridges over the freeway for entry and exit. Construction will include improvements to general traffic freeway ramps and to intersections at several major cross streets.

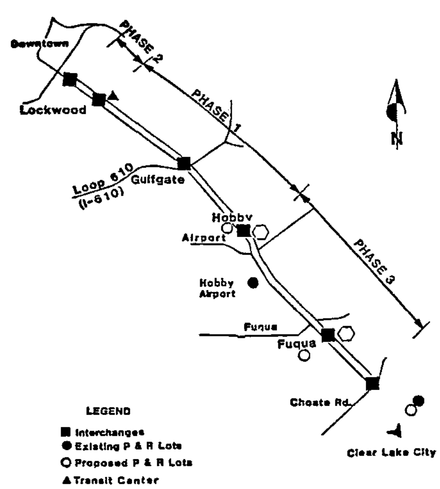


Figure 4. Gulf Freeway AVL, Phase Construction

The Gulf Freeway AVL should significantly reduce peak hour travel time for users of the facility. On the five-mile Phase I section, travel time should be reduced 5 to 10 minutes. When all 15.5 miles are completed, a bus trip on the AVL to downtown should be about 13 minutes, half the current time. The AVL will significantly increase the person carrying capacity of the freeway. About 18,600 daily commuters are expected to travel the lane in vanpools and buses during its first full year of operation. The completed AVL should be able to move some 14,000 commuters per peak-hour in 280 buses and vans (13).

STUDY DESIGN OVERVIEW

Data Base

As outlined in the March 1984 report (1), the following groups of data are being collected along the three Freeway corridors: (1) Park-and-Ride Demands; (2) Peak and Off-Peak Direction Travel Times; (3) Peak Direction Vehicle Volumes and Occupancies; and, (4) Accident Data. The Park-and-Ride data includes the number of vehicles parked in each of the surveyed lots. The travel time surveys include various check points along the study corridors, the weather, light, and pavement conditions at the time of the runs, and the severity of any incidents during the runs. Finally, in the vehicle volume and occupancy survey, mainlane occupancies and volumes by vehicle types are recorded. The frontage road traffic volume is also recorded but not categorized by vehicle type or by occupancy level.

Collection Methodology

Starting in June 1983, Park-and-Ride demands were sampled at two lots on the Gulf, two lots on the Katy, and four lots on the North Freeway as shown in Figure 5. The samples were collected between the morning and the evening peak periods (i.e. after 10:00 a.m. and before 4:00 p.m.). Park-and-Ride demand is represented by the number of vehicles found parked inside the Park-and-Ride lots. The study is not sampling the demand for Park-and-Ride service, but rather the demand for lot space; however, for lots not at capacity, this measure provides a rough estimate of service demand.

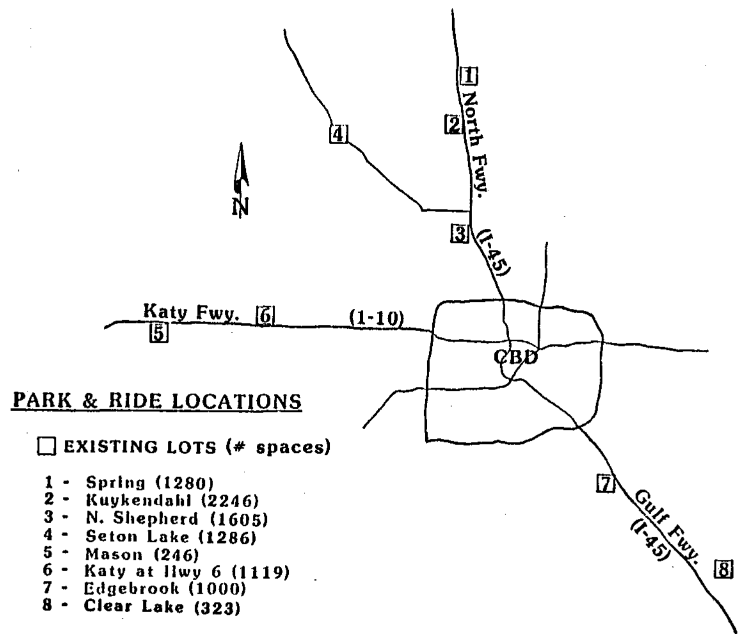


Figure 5: Park-and-Ride Lot Locations Along The Three Study Freeway Corridors

Freeway travel times are sampled on a monthly basis. All travel times are sampled near the middle of each month (i.e., 2nd or 3rd complete week of each month) with a specific day of the week assigned to each freeway. This sampling schedule screens out the daily and weekly variations that may be present and allows monthly change comparisons. On the Gulf Freeway, the travel times from Choate Road to Dallas Street in downtown Houston are being recorded. On the Katy Freeway, travel times are recorded from State Highway 6 to Washington Avenue, just inside Loop I-610. Travel times are recorded from the North Belt to Memorial for the North Freeway. Beginning at 6:00 a.m., travel time runs are begun at 30 minute intervals ending by 11:00 a.m. In the afternoon, also at 30 minute intervals, runs are made between 4:00 p.m. and 8:00 p.m. Beginning and ending checkpoints were previously shown in Figure 1; all checkpoints used in the study are listed in Table 1.

Table 1. Travel Time Check Points

INBOUND					
Gulf		Katy		North	
Milepoint	Cross Street	Milepoint	Cross Street	Milepoint	Cross Street
0.00	Choate Road	0.00	SH 6	0.00	North Belt
2.00	South Belt	1.63	Eldridge	1.70	West Road
4.05	Almeda-Genoa	2.30	Dairy Ashford	2.90	West Mt. Houston
5.35	Edgebrook	3.28	Kirkwood	4.45	North Shepherd
6.25	Airport	4.18	Wilcrest	4.95	Little York
8.15	Howard/Bellfort	4.93	West Belt	5.75	Parker
9.05	Park Place	6.08	Gessner	6.85	Tidwell
10.15	South Loop	6.81	Bunker Hill	7.75	Airline Drive
10.45	Reveille	7.44	Blalock	8.20	Crosstimbers
11.35	Griggs	8.80	Bingle	9.30	North Loop (I-610)
12.10	Wayside	9.62	Wirt	11.00	North Main
13.75	Calhoun	10.19	Antoine	12.20	Hogan St. Overpass
14.50	Scott	10.64	Silber	13.10	Memorial
15.30	Dowling	11.56	West Loop		
16.85	Dallas	12.81	Washington		

OUTBOUND					
Gulf		Katy		North	
Milepoint	Cross Street	Milepoint	Cross Street	Milepoint	Cross Street
0.00	Dallas	0.00	Washington	0.00	Memorial
1.55	Dowling	1.25	West Loop	0.90	Hogan St. Overpass
2.35	Scott	2.17	Silber	2.10	North Main
3.10	Calhoun	2.62	Antoine	3.80	North Loop (I-610)
4.75	Wayside	3.19	Wirt	4.90	Crosstimbers
5.5	Griggs	4.01	Bingle	5.35	Airline Drive
6.4	Reveille	5.37	Blalock	6.25	Tidwell
6.7	South Loop	6.00	Bunker Hill	7.35	Parker
7.8	Park Place	6.73	Gessner	8.15	Little York
8.7	Howard/Bellfort	7.83	West Belt	8.65	North Shepherd
10.6	Airport	8.63	Wilcrest	10.80	West Mt. Houston
11.5	Edgebrook	9.53	Kirkwood	11.40	West Road
12.8	Almeda-Genoa	10.51	Dairy Ashford	13.10	North Belt
14.85	South Belt	11.18	Eldridge		
16.85	Choate Road	12.81	SH 6		

Freeway vehicle volumes and occupancies are being sampled on a quarterly schedule at the following locations: (1) Gulf Freeway at Monroe, (2) Katy Freeway at Bunker Hill, and (3) North Freeway at Little York. Volumes are counted for 15 minute intervals on a lane-by-lane basis between 6:00-10:00 a.m. and between 4:00-7:00 p.m. These counts, like the Park-and-Ride and the travel time surveys, have also been conducted in the 2nd and 3rd week of each month, with the same specific day of the week being assigned to each freeway corridor. Surveyors are stationed in the peak directions in either the outer separation between the freeway and the frontage road or at sites on the other side of the frontage road. A surveyor is assigned to each peak direction lane on the freeway, and one surveyor is assigned to the frontage road. The surveyor counting the frontage road is also responsible for the contraflow volumes in North Freeway corridor. Surveyors record both the total number of vehicles and the occupancies of each vehicle type. The vehicle and occupancy classifications are listed in Table 2.

Table 2. Vehicle and Occupancy Categories

Vehicle Categories	Occupancy Categories
Pickups/Passenger Cars	1 2 3 4+
Vans	1-3 4-6 7+
Buses	Empty 1/4 full 1/2 full 3/4 full Full

Accident data, available from SDHPT, is obtained for the three freeway corridors under investigation. The number of accidents occurring in a given time period, in combination with freeway distances and average daily traffic (ADT), allows the computation of accident rates for the different highways. These rates are expressed in terms of accidents per 100 million vehicle miles of travel.

Analysis Techniques

Throughout the course of the study, regression techniques are applied to all groups of data. The resulting regression models allow the investigation of the statistical relationships between the variables of interest. They are used to determine the magnitude and significance of changes in travel times, Park-and-Ride lot demands, person volumes that may be attributed to the operation of AVL projects, and accident rates experienced during construction versus before and after rates. Additionally, the Tukey Multiple Comparison procedure is used to compare the relative degrees of success of the various different combinations of design features (1).

Park-and-Ride demand levels are regressed on three factors: (1) time; (2) CFL operation; and, (3) AVL operation. Time is subdivided by month. The time variable simply estimates the general trend of the observed Park-and-Ride demands. The regression relationships are used to project demand levels forward in time.

Travel speeds are regressed on: (1) the extent of construction work; (2) the configuration used for construction; (3) the weather conditions; (4) the lighting conditions; (5) the pavement conditions; (6) the severity of accidents or incidents; (7) the reduction of lane widths; (8) the operation of the transitway in the corridor; and, (9) the time of day. Since speed is a function of both distance and travel time, regression is applied to speed and then the results converted to travel time. The travel time variables and their values are listed in Table 3.

Table 3. Travel Time Variables

Weather (W): 0 = Clear 1 = Overcast 2 = Light Rain or Drizzle 3 = Heavy Rain	Extent of Construction Work: 0 = 0% of corridor length 1 = 25% of corridor length 2 = 50% of corridor length 3 = 75% of corridor length 4 = 100% of corridor length
Light Conditions (L): 0 = Normal Daylight 1 = Dark or Twilight 2 = Sunglare 3 = Fog	Lane Width Reduction: 0 = No lane width narrowing 1 = Lanes narrowed
Pavement Conditions (P): 0 = Dry 1 = Wet 2 = Ice, Snow or other extreme slickness	Number of Lanes Removed: 0 = No lanes removed in any section 1 = 1 lane removed in any section 2 = 2 lanes removed in any section 3 = 3 lanes removed in any section
Incidents (1): 0 = None 1 = Minor (off-road) (No appreciable impact on speed) 2 = Major (lane blockage, etc.) (Significant impact on speed)	

Vehicle volumes and occupancies will undergo a similar regression analysis once an adequate data base is established. Four variables are to be examined: (1) the total vehicle volume; (2) the total person volume; (3) the overall average occupancy rate; and, (4) the HOV contribution to each of the preceding three variables. The regression procedure is performed because of interest in any significant increases or decreases in volumes and occupancies resulting from the implementation of AVLs on the Katy and Gulf Freeways, and the upgrading from CFL to AVL on the North Freeway. Finally, the Tukey Multiple Comparison procedure is employed to identify any statistically significant, as well as any practically significant differences between the volume changes resulting from the three different transitway treatments.

Tables and plots illustrating relevant statistics are available to supplement the statistical tests. For the Park-and-Ride demand, tables display the monthly demand levels for each of the lots as well as for the entire corridor. The plots will graphically illustrate the general trends in the corridor's Park-and-Ride demands as compared to its capacity. Tables summarize the average peak-period and peak-hour travel times along with speeds, total travel times, and average travel speeds. Graphs illustrate the changes that the average speeds and the total times have experienced each month. The extent of the AVL construction/road surface renovation is indicated on these monthly curves to illustrate the impact (if any) that the construction has on freeway travel time for non-AVL users. Tables for the volume study summarize peak period and peak hour vehicle volumes, person volumes, HOV percent of vehicle volume, HOV percent of person volume, and overall vehicle occupancy rates in the peak directions. The accompanying graphs fall into three basic categories: (1) vehicle and person volumes; (2) HOV percent of vehicle and person volumes; and, (3) overall occupancy rates by vehicle type.

PRELIMINARY RESULTS

Overview

At the beginning of this study in June 1983, two of the three study corridors already had AVL construction work underway; the third was being prepared for construction. The Gulf Freeway transitway construction was underway as early as September 1982. The North Freeway preconstruction preparatory work (Phase IA) began in April 1983, but actual construction did not begin until January 1984. Table 4 presents the anticipated construction schedule for the three freeways.

Table 4: Construction Schedule for Houston's AVL System (as of June 7, 1984)

Freeway	Total Length	Start of Construction	Estimated Operational Date
Katy (I-10)	10.0 miles	June 1983	November 1984[1]
North (I-45N)	17.6 miles	January 1984	December 1984[2]
Gulf (I-45S)	15.5 miles	September 1982	February 1986[3]

[1]Phase 1: Post Oak to Gessner (5 miles).
[2]Phases 1 and 2: Downtown to North Shepherd (9.6 miles)
[3]Phase 1: Lockwood to Airport Boulevard (5 miles)

All three study corridors, at the present time, are heavily involved in actual AVL construction. The Katy Freeway is near to completion of its first phase extending from Post Oak/West Loop to Gessner. In order to facilitate the freeway resurfacing and transitway construction without decreasing the number of lanes available to serve Katy Freeway traffic demands, an extensive program of traffic management was implemented along the Katy corridor construction work zones. This traffic management program included lane narrowing and restriping, use of the emergency shoulder for through traffic, and selective ramp closures. The Gulf Freeway has been undergoing construction mostly around the vicinity of the Lockwood Interchange. Until January 1984, work on the North Freeway consisted primarily of the relocation of signing, lighting and guard railing from the median. The North Freeway has had a highly successful HOV contraflow lane for more than five years. Special measures were necessary to perpetuate priority transit ridership during the period of time when the freeway would be undergoing rehabilitation and AVL construction. METRO arranged to have the HOVs operate within the barrier protected median strip where construction was ongoing. This barrier protected segment extends 6.1 miles from Downtown to Airline and is augmented by a median contraflow/concurrent flow segment extending an additional 3.5 miles from Airline to North Shepherd. The segment operates contraflow in the morning and concurrent flow in the afternoon.*

The Katy, Gulf, and North Corridors are all very different, whether in operational characteristics or in functional circumstances. However, all three are experiencing high degrees of traffic congestion and the resulting unacceptable levels of service. Installation of median AVLs may improve mobility in all three corridors.

Park-and-Ride Parking Demand

Figure 6 illustrates the variations in Park-and-Ride Demand for each of the freeway corridors on a monthly basis (June 1983 through May 1984). All three corridors, in general, exhibit small rates of change per month. Long term trend estimates are difficult to project since only 12 months of data are available. Any conclusions drawn at this time would lack reliability Since construction is actively underway in all three corridors. However,

*Due to median pavement problems, mainlane contraflow operation was resumed on July 19, 1984.

once the AVLs become operational, large increases in park-and-ride demand are anticipated.

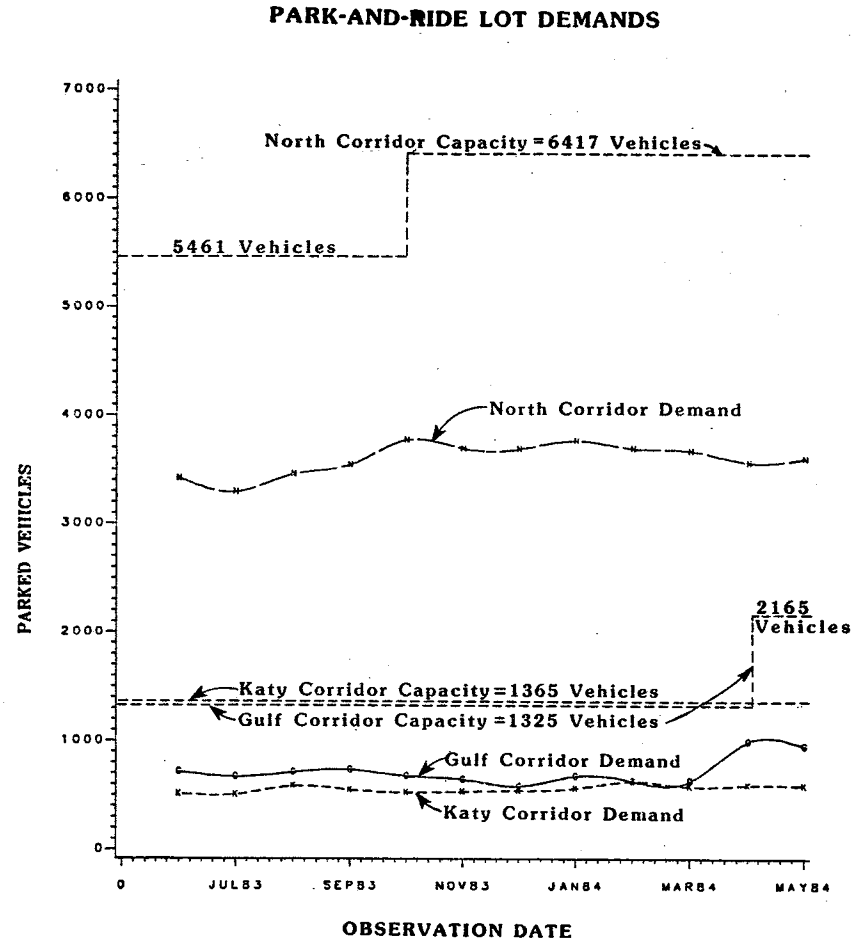


Figure 6: Park-and-Ride Parking Demands in The Three (3) Freeway Corridors

Table 5 summarizes the observed parking demand for all Park-and-Ride lots in the three freeway corridors. On a monthly basis, the total observed demand in all corridors ranged from 4,467 to 5,162 parked vehicles and averaged 4,883 vehicles.

Table 5: Park-and-Ride Parking Demands

	Freeway Corridor			
Date	Gulf	Katy	North	Total
June 83	716	513	3419	4648
July 83	668	506	3293	4467
Aug 83	709	583	3457	4749
Sep 83	733	549	3546	4828
Oct 83	676	527	3772	4975
Nov 83	644	533	3696	4943
Dec 83	583	542	3691	4816
Jan 84	676	565	3768	5009
Feb 84	632	628	3698	4958
Mar 84	630	580	3676	4886
Apr 84	996	595	3570	5161
May 84	957	589	3605	5151
Monthly Average	718	559	3599	4883

Tables 6, 7 and 8 present the parked vehicle demand for the individual Park-and-Ride sites in the Katy, North and Gulf Freeway corridors, respectively. As shown in Table 6, demand for the two Park-and-Ride sites along the Katy Freeway ranged from 506 to 628 and averaged 559 parked vehicles. Demand appears to be increasing very slightly with most of the gains being made at the SH 6 lot; the Mason Lot has been operating close to its capacity of 246 vehicles since the beginning of this study one year ago. Monthly demand in the North corridor for the available parking at the four sites varied from 3,293 to 3,772 and averaged 3,599 vehicles as shown in Table 7. Demand on the North Corridor also appears to be increasing. The two largest Park-and-Ride lots on the North Corridor, the North Shepherd and the Kuykendahl lots, have been maintaining a fairly constant demand level at roughly one-half their operating capacities. The two smaller lots located further north and further west of the North Freeway have accounted for almost all of the increases observed on the North Corridor Park-and-Ride demand. Total demand for the two sites in the Gulf corridor, summarized in Table 8, varied on a

Table 6: Katy Corridor Park-and-Ride Demand

Date	Site Location		Total Katy
	Mason Road	State Highway 6	
Jun 83	220	293	513
Jul 83	209	197	506
Aug 83	235	348	583
Sep 83	212	337	549
Oct 83	196	331	527
Nov 83	201	332	533
Dec 83	215	327	542
Jan 84	208	357	565
Feb 84	232	396	628
Mar 84	214	366	580
Apr 84	250	345	595
May 84	236	353	589
Monthly Average	219	340	559

monthly basis from 583 to 996 parked vehicles and averaged 877 vehicles for the 12-month study period. The Gulf Corridor Park-and-Ride demand was holding fairly steady with a possible decreasing trend evident until April 1984. With the opening of the new Clear Lake Park-and-Ride lot on the Gulf Corridor, demand jumped by more than 360 vehicles between March and April 1984.

Travel Times/Travel Speeds

This section of the report presents the observed freeway travel times and corresponding speeds for each of the three freeway corridors: (1) Katy (I-10W); (2) North (I-45N); and, (3) Gulf (I-45S). Both directions of travel (inbound and outbound) are investigated for the AM and PM peak periods and peak hour.

Katy (I-10) Freeway

Figure 7 presents the travel times (in minutes) observed on the Katy Freeway from SH 6 to Washington, a distance of 12.8 miles. Similarly, Figure 8 shows the travel speeds in miles per hour (MPH) for the same section of freeway during the same time periods.

Table 7: North Corridor Park-and-Ride Demand

Date	Site Location				Total North
	North Shepherd	Kuykendahl	Spring	Seton Lake	
Jun 83	824	1379	741	475	3419
Jul 83	801	1296	790	406	3293
Aug 83	833	1325	826	473	3457
Sep 83	803	1342	861	540	3546
Oct 83	853	1453	859	607	3772
Nov 83	852	1426	875	543	3696
Dec 83	833	1387	840	631	3691
Jan 84	851	1397	884	636	3768
Feb 84	800	1448	870	580	3698
Mar 84	829	1382	813	652	3676
Apr 84	709	1432	852	577	3570
May 84	795	1372	846	592	3605
Monthly Average	815	1387	838	559	3599

Table 8: Gulf Corridor Park-and-Ride Demand

Date	Site Location		Total Gulf
	Edgebrook	Clear Lake	
Jun 83	546	170	716
Jul 83	511	157	668
Aug 83	555	154	709
Sep 83	581	152	733
Oct 83	540	136	676
Nov 83	530	114	644
Dec 83	487	96	583
Jan 84	509	167	676
Feb 84	498	134	632
Mar 84	124	506	630
Apr 84	554	442	996
May 84	544	413	957
Monthly Average	498	220	718

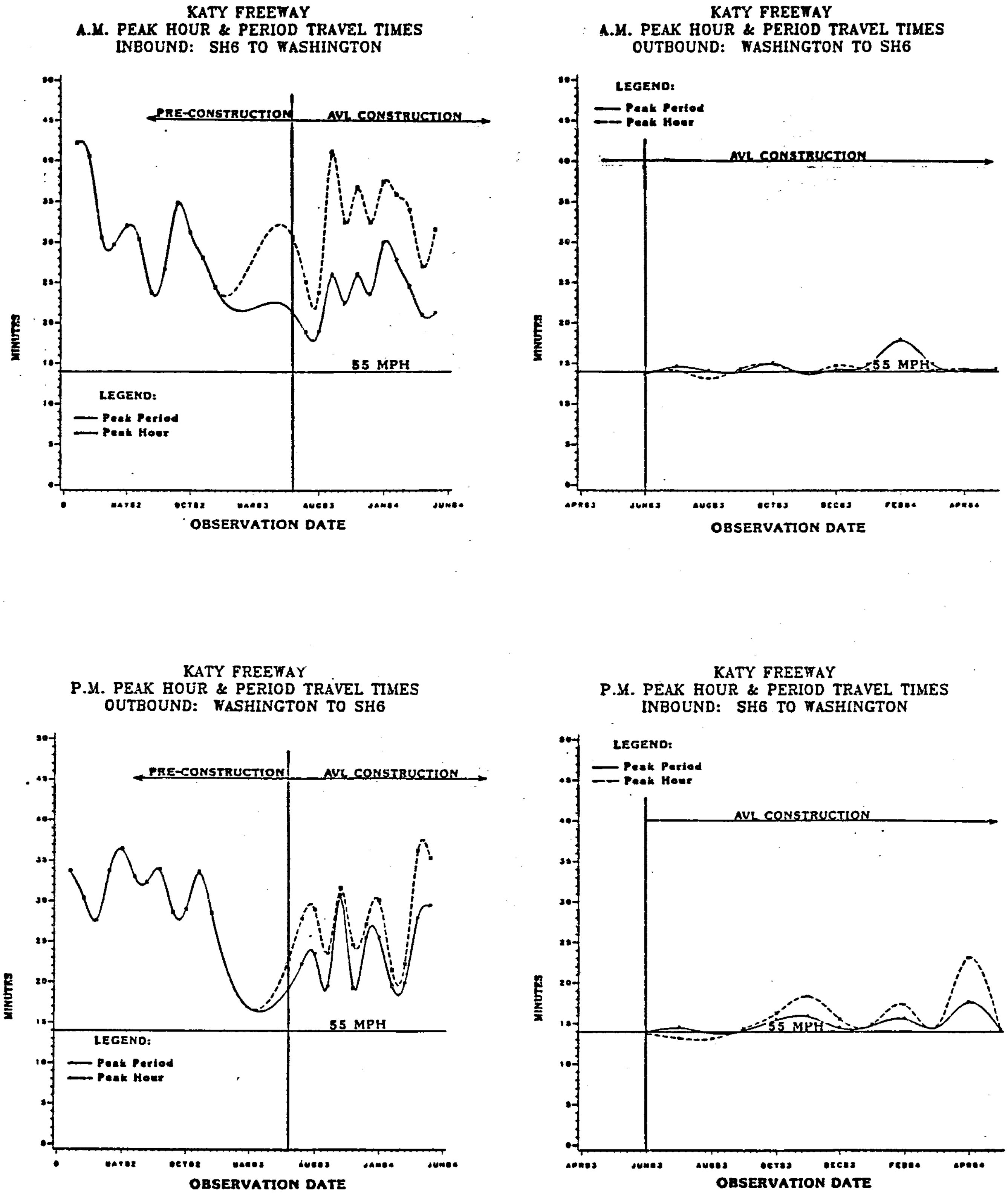


Figure 7: Katy Freeway Total Travel Times

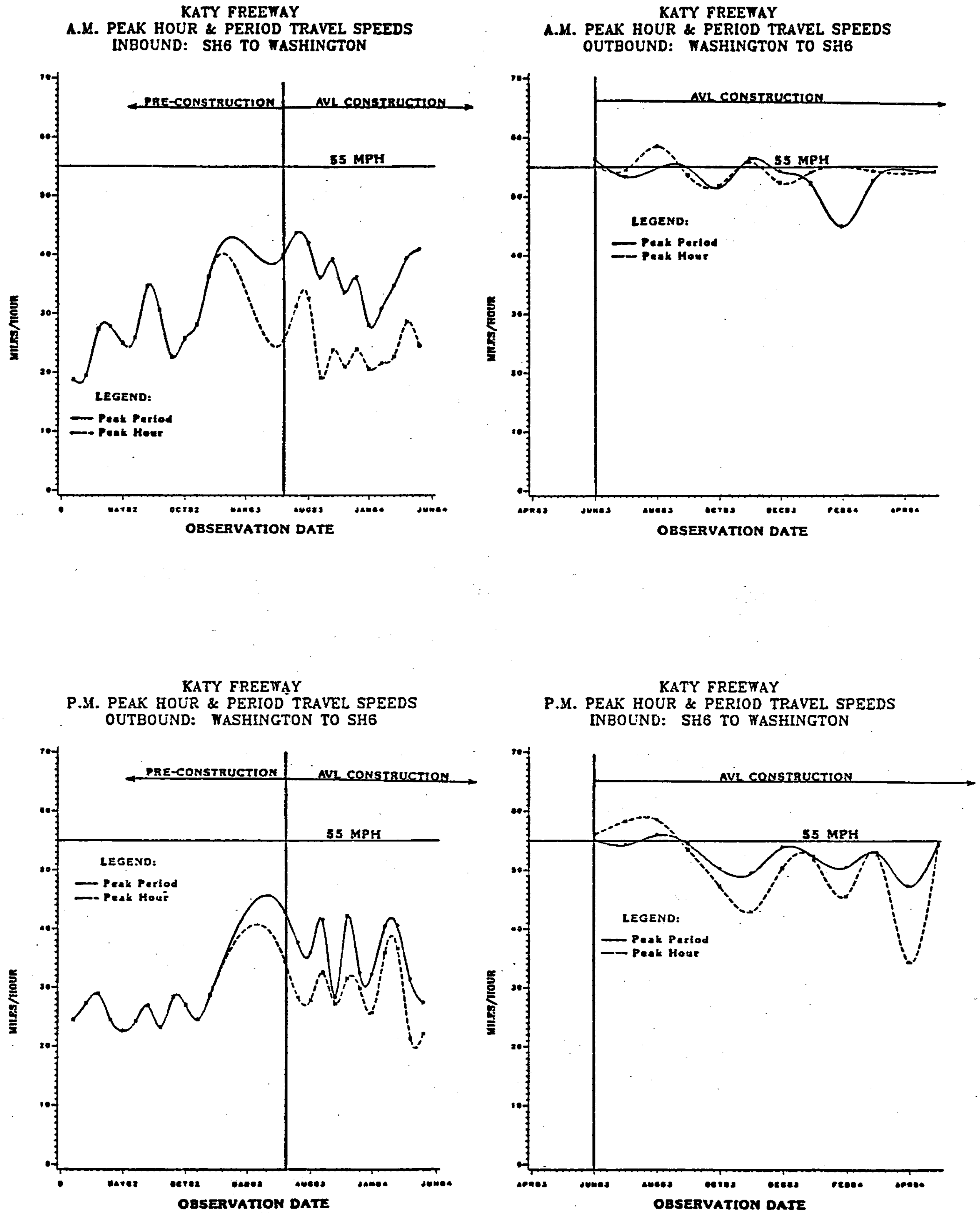


Figure 8: Katy Freeway Overall Travel Speeds

Table 9 summarizes the average travel times, by month, for the Katy Freeway which corresponds to the previous graph (Figure 7). Likewise Table 10 presents the average travel speeds observed on the freeway (shown in Figure 8). In addition to the Texas Transportation Institute (TTI) data collected since June 1983, it has also been possible to obtain peak-period, peak-direction travel time and speed data from the SDHPT. These additional times and speeds are in Figures 7 and 8 and in Tables 9 and 10. That data goes back as far as January 1982 and extends through December 1982. The Katy Freeway study length is 12.81 miles. A car traveling at 55 MPH over this distance would have a travel time of 14.0 minutes. As shown in Figure 7, the off-peak direction travel times are near 14.0 minutes, but both peak direction travel times exceed this mark considerably. The 12-month average for the morning outbound direction is 14.6 minutes and 14.9 minutes for the afternoon off-peak direction. Both averages lie above the free-flow time but not by a substantial amount.

As illustrated in Figure 8, both the AM and PM peak directional speeds appear higher after the start of construction than before. However, considerable variation exists from month to month. The inbound morning speeds varied from 28 mph to 44 mph and averaged 37 mph for the 12-month period after construction started. In 1982, prior to construction, the speeds ranged from 19 to 36 mph and averaged 27 mph for the AM, inbound peak. The traffic management program involving the use of the emergency shoulder for through traffic and selective ramp closures may be credited for this improvement in freeway mainlane travel speeds during construction. Table 11 presents the speed comparisons for both AM and PM peak periods in the peak directions.

Table 9: Peak Period Travel Times for the Katy (I-10) Freeway Corridor (Minutes)

Date	Direction and Time			
	AM Inbound	AM Outbound	PM Outbound	PM Inbound
Jan 82	42.1	--	33.7	--
Feb 82	40.4	--	30.3	--
Mar 82	30.5	--	27.6	--
Apr 82	29.6	--	33.7	--
May 82	31.9	--	36.4	--
Jun 82	30.3	--	33.0	--
Jul 82	23.7	--	32.3	--
Aug 82	26.6	--	33.9	--
Sep 82	34.8	--	28.6	--
Oct 82	31.1	--	29.0	--
Nov 82	28.0	--	33.5	--
Dec 82	24.4	--	28.5	--
Jan 83	--	--	--	--
Feb 83	--	--	--	--
Mar 83	--	--	--	--
Apr 83	--	--	--	--
May 83	--	--	--	--
Jun 83	21.4	13.7	19.2	14.0
Jul 83	18.8	14.6	22.2	14.5
Aug 83	18.9	14.1	23.4	13.8
Sep 83	25.9	14.0	19.4	14.1
Oct 83	22.4	15.0	30.7	15.4
Nov 83	26.0	13.7	19.3	15.9
Dec 83	23.5	14.2	25.5	14.4
Jan 83	29.9	14.8	25.5	14.7
Feb 84	27.7	17.8	19.5	15.5
Mar 84	24.5	14.9	19.9	14.5
Apr 84	21.0	14.1	27.9	17.6
May 84	21.1	14.3	29.5	14.2

Note: AM Peak Period is 6:30 a.m. - 9:30 a.m.
PM Peak Period is 4:00 p.m. - 7:00 p.m.

Table 10: Peak Period Travel Speeds for the Katy (I-10) Freeway Corridor (MPH)

Date	Direction and Time			
	AM Inbound	AM Outbound	PM Outbound	PM Inbound
Jan 82	19	--	24	--
Feb 82	19	--	27	--
Mar 82	27	--	29	--
Apr 82	28	--	24	--
May 82	25	--	23	--
Jun 82	26	--	24	--
Jul 82	35	--	27	--
Aug 82	31	--	23	--
Sep 82	23	--	28	--
Oct 82	26	--	27	--
Nov 82	28	--	25	--
Dec 82	36	--	29	--
Jan 83	--	--	--	--
Feb 83	--	--	--	--
Mar 83	--	--	--	--
Apr 83	--	--	--	--
May 83	--	--	--	--
Jun 83	40	56	43	55
Jul 83	44	53	38	54
Aug 83	42	55	36	56
Sep 83	36	55	41	54
Oct 83	39	51	28	50
Nov 83	33	56	42	49
Dec 83	36	54	32	54
Jan 83	28	52	32	52
Feb 84	31	45	40	50
Mar 84	35	52	40	53
Apr 84	39	54	31	47
May 84	41	54	27	54

Note: AM Peak Period is 6:30 a.m. - 9:30 a.m.
PM Peak Period is 4:00 p.m. - 7:00 p.m.

Table 11: Comparison of Monthly Speeds on the Katy (I-10) Freeway for Peak Periods; Before and During the AVL Construction

	AM Peak Period (Inbound)		PM Peak Period (Outbound)	
	Before	During	Before	During
Speed Range:				
Low	19 mph	28 mph	23 mph	27 mph
High	36 mph	44 mph	29 mph	43 mph
Average (Mean) Speed	27 mph	37 mph	26 mph	36 mph

Note: A.M. Peak Period is 6:30 a.m. - 9:30 a.m.
P.M. Peak Period is 4:00 p.m. - 7:00 p.m.

North (I-45N) Freeway

Figures 9 and 10 show the travel times and speed, respectively, for the 13.1 mile study section of the North Freeway. The study length with free-flow, 55 mph travel would require a time of 14.3 minutes. The 12 months of travel time data plotted in Figure 9 exhibits a scatter from 16 to 30 minutes with an average of 23.7 minutes in the morning inbound direction. This average time translates to 9.4 minutes of delay incurred by the average peak direction morning non-contraflow driver. The afternoon, outbound direction mainlane travel times with an average of 24.1 minutes have also shown a scatter similar to the morning peak data, ranging from 18 to 29 minutes. In Figure 10, the 12-month average speed for the morning inbound traffic is 38 mph. The afternoon 12-month average outbound corridor speed is 35 mph, 20 mph less than the legal speed limit.

Tables 12 and 13 present the average monthly travel times and speeds, respectively, observed on the North Freeway. On the average, during the 12-month study period, the off-peak direction moves some 9 mph to 13 mph faster than the peak-direction flow. The speed ranges and average speeds are summarized in Table 14.

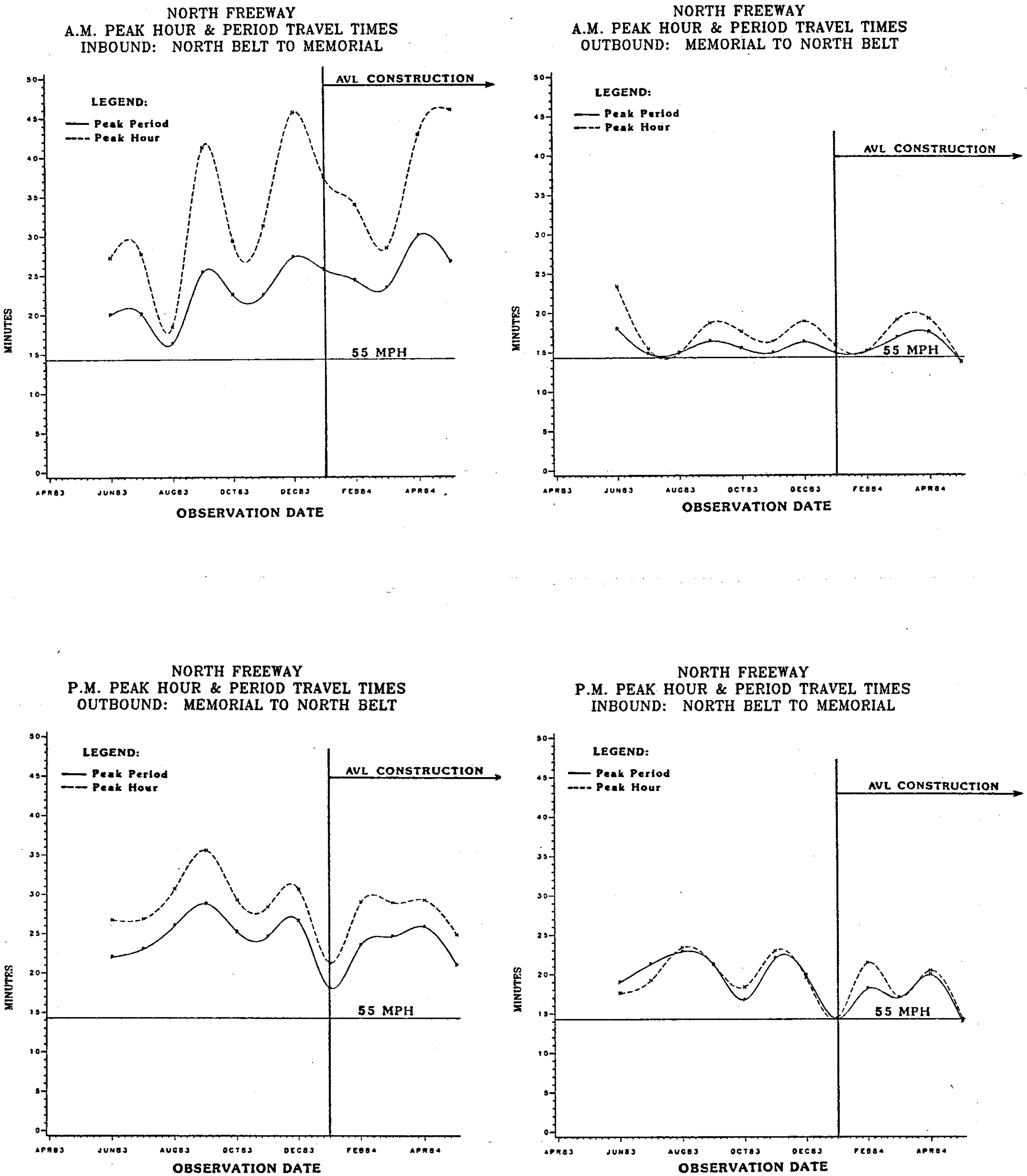
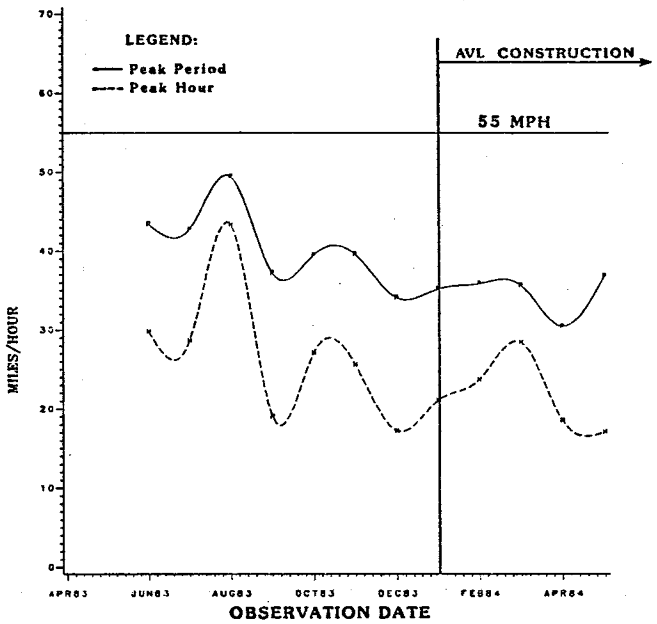
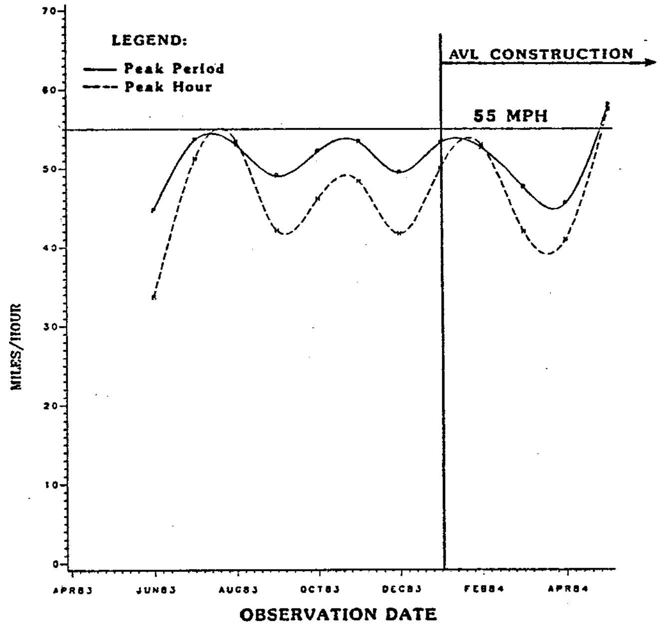


Figure 9: Katy Freeway Total Travel Times

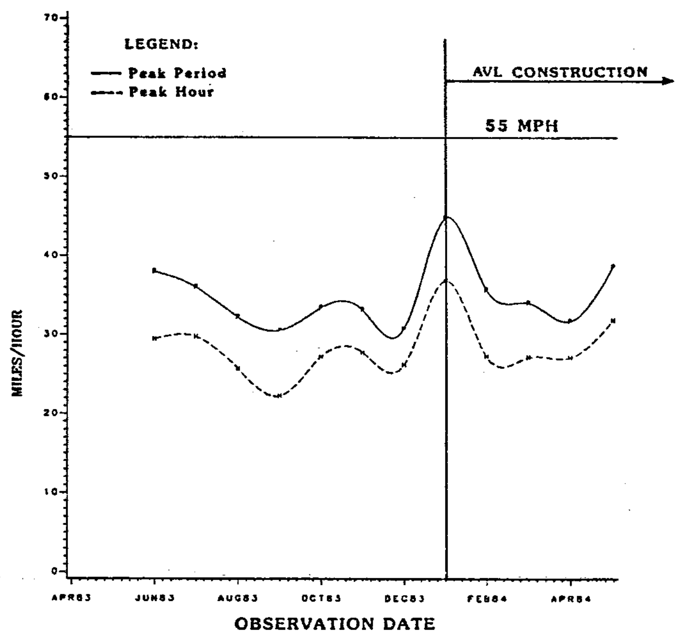
NORTH FREEWAY
A.M. PEAK HOUR & PERIOD TRAVEL SPEEDS
INBOUND: NORTH BELT TO MEMORIAL



NORTH FREEWAY
A.M. PEAK HOUR & PERIOD TRAVEL SPEEDS
OUTBOUND: MEMORIAL TO NORTH BELT



NORTH FREEWAY
P.M. PEAK HOUR & PERIOD TRAVEL SPEEDS
OUTBOUND: MEMORIAL TO NORTH BELT



NORTH FREEWAY
P.M. PEAK HOUR & PERIOD TRAVEL SPEEDS
INBOUND: NORTH BELT TO MEMORIAL

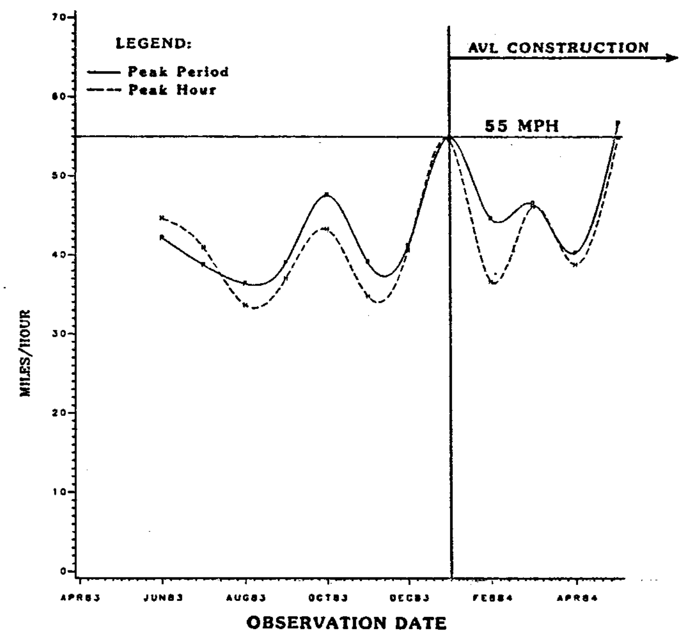


Figure 10: North Freeway Overall Travel Speeds

Table 12: Peak Period Travel Times for the North (I-45N) Freeway Corridor (Minutes)

Date	Direction and Time			
	AM Inbound	AM Outbound	PM Outbound	PM Inbound
Jun 83	20.0	18.0	22.0	19.0
Jul 83	20.1	14.8	23.0	21.3
Aug 83	16.3	14.9	26.0	22.9
Sep 83	25.4	16.4	28.8	21.2
Oct 83	22.5	15.5	25.2	16.7
Nov 83	22.5	14.9	24.6	22.0
Dec 83	27.3	16.2	26.7	19.9
Jan 83	25.7	14.9	18.1	14.3
Feb 84	24.3	15.0	23.6	18.1
Mar 84	23.4	16.8	24.7	17.0
Apr 84	30.0	17.4	25.9	19.9
May 84	26.6	13.6	21.0	13.9
Monthly Average	23.7	15.7	24.1	18.8

Table 13: Peak Period Travel Speeds for the North (I-45N) Freeway Corridor (MPH)

Date	Direction and Time			
	AM Inbound	AM Outbound	PM Outbound	PM Inbound
Jun 83	43	45	38	42
Jul 83	43	54	36	39
Aug 83	49	53	32	36
Sep 83	37	49	31	39
Oct 83	39	52	33	48
Nov 83	40	53	33	39
Dec 83	34	49	31	41
Jan 83	35	53	45	55
Feb 84	36	53	36	45
Mar 84	36	48	34	47
Apr 84	30	45	32	40
May 84	37	58	39	57

North Freeway Contraflow Lane Transition

The upgrading of the North Freeway Contraflow Lane (CFL) to an AVL design is being monitored for its impact on the off-peak direction travel times and speeds. The off-peak direction traffic on the North Freeway has had to cope with one less lane than was originally allocated to it. Since August 1979, the North Freeway has had a CFL operating during both the morning and afternoon peak periods. This reduction in roadway capacity, combined with the continued growth of travel demand in the off-peak directions, has resulted in deterioration of the morning and afternoon off-peak direction travel times and speeds for the North Freeway as previously illustrated in Figures 9 and 10.

The morning outbound and afternoon inbound travel times have risen above the free flow mark of 14.3 minutes in most of the survey months. The average time from June 1983 through May 1984 was 15.7 to 18.8 minutes in the off-peak direction; some 1.4 to 4.5 minutes more than the hypothetical time of 14.3 minutes. This average delay trend confirms that the contraflow operation cannot continue to take a lane from the off-peak direction traffic indefinitely without continued degradation of service.

As was shown in Table 14, the morning outbound lanes are operating relatively smoothly with an average speed of 51 mph. The afternoon inbound lanes have not coped with the loss of capacity as well as has the morning outbound lanes. The afternoon inbound traffic has a 12-month average speed of 44 mph; some 11 mph less than the speed limit. Looking at the first 7 months of data, you see the p.m. (off-peak) inbound is not operating much better than the a.m. inbound which is a peak direction. However, after January when the CFL was put onto the median, p.m. inbound speeds increased an average of 8 mph from the previous 7 months. Even a cursory examination of the off-peak direction travel times and speeds strongly indicates that upgrading the North Freeway CFL to an AVL is a very desirable improvement.

Table 14: Average Monthly Travel Speeds on The North Freeway for Peak Periods (June 83-May 84)

	AM Peak Period		PM Peak Period	
	Inbound	Outbound	Outbound	Inbound
Speed Range:				
Low	30	45	31	36
High	49	58	45	57
Average (Mean) Speed	38	51	35	44

Gulf (I-45S) Freeway

Figures 11 and 12 show the travel times and speeds, respectively, for the 16.8-mile study section on the Gulf Freeway for the 12-month period from June 1983 through May 1984. Given free flow (55 mph) conditions, 18.4 minutes would be required to travel the total distance being investigated. The 12-month average travel time in the peak direction is 24.0 minutes during the morning and 22.4 minutes in the afternoon. This represents an average delay per vehicle of some 4 to 6 minutes during the peak periods traveling in the peak directions.

Table 15 presents the monthly travel times observed on the Gulf Freeway, while Tables 16 and 17 summarize the derived travel speeds. The Gulf Freeway operates extremely well in the off-peak directions during both the morning and afternoon periods. Over the 12-month study period, the average off-peak flow was 56 mph to 57 mph. When compared to the other two freeway corridors (Katy and North), the Gulf Freeway provides the highest level-of-service during the peak periods; average speeds in the peak directions are only 8 to 10 miles below the legal speed limit.

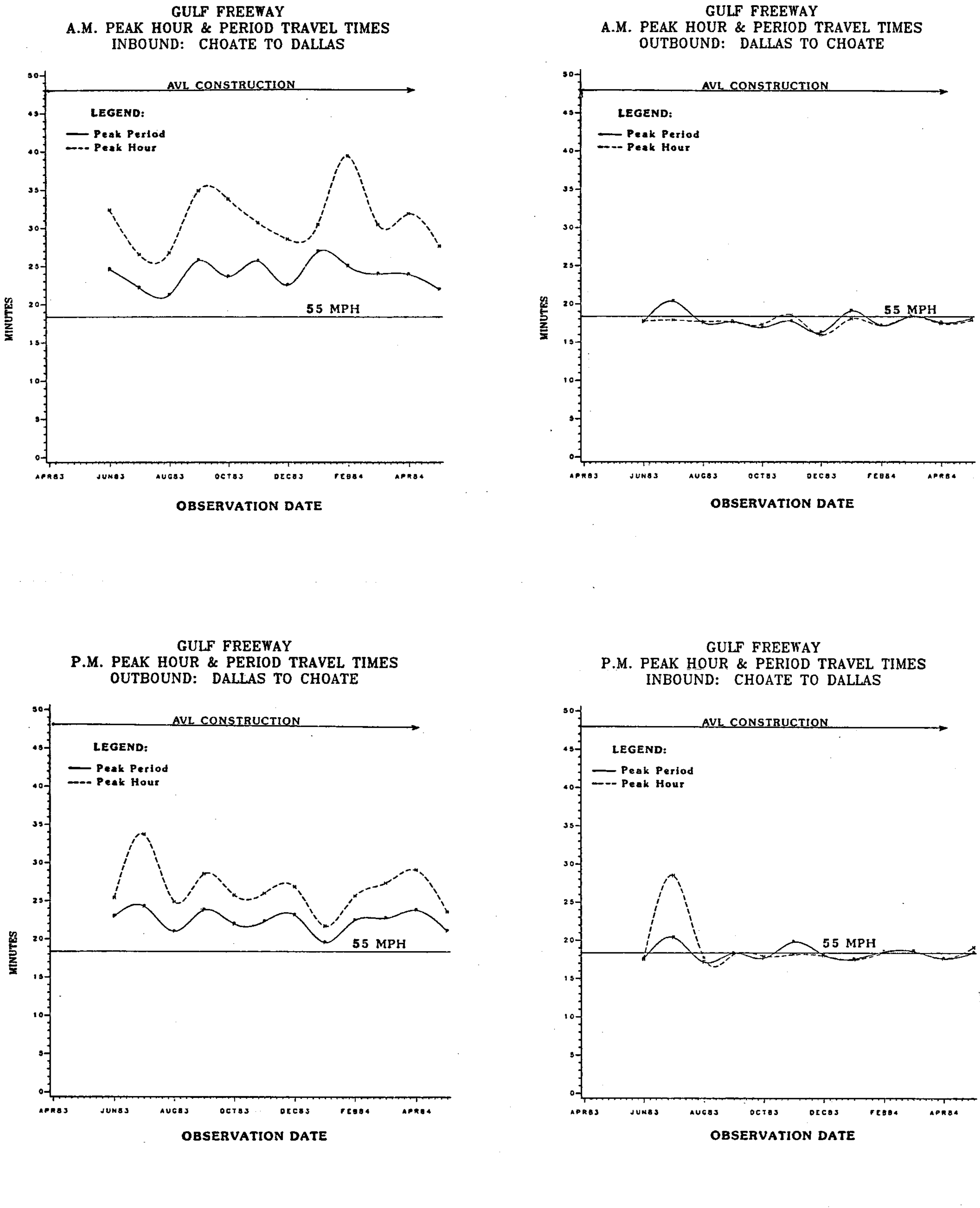


Figure 11: Gulf Freeway Total Travel Times

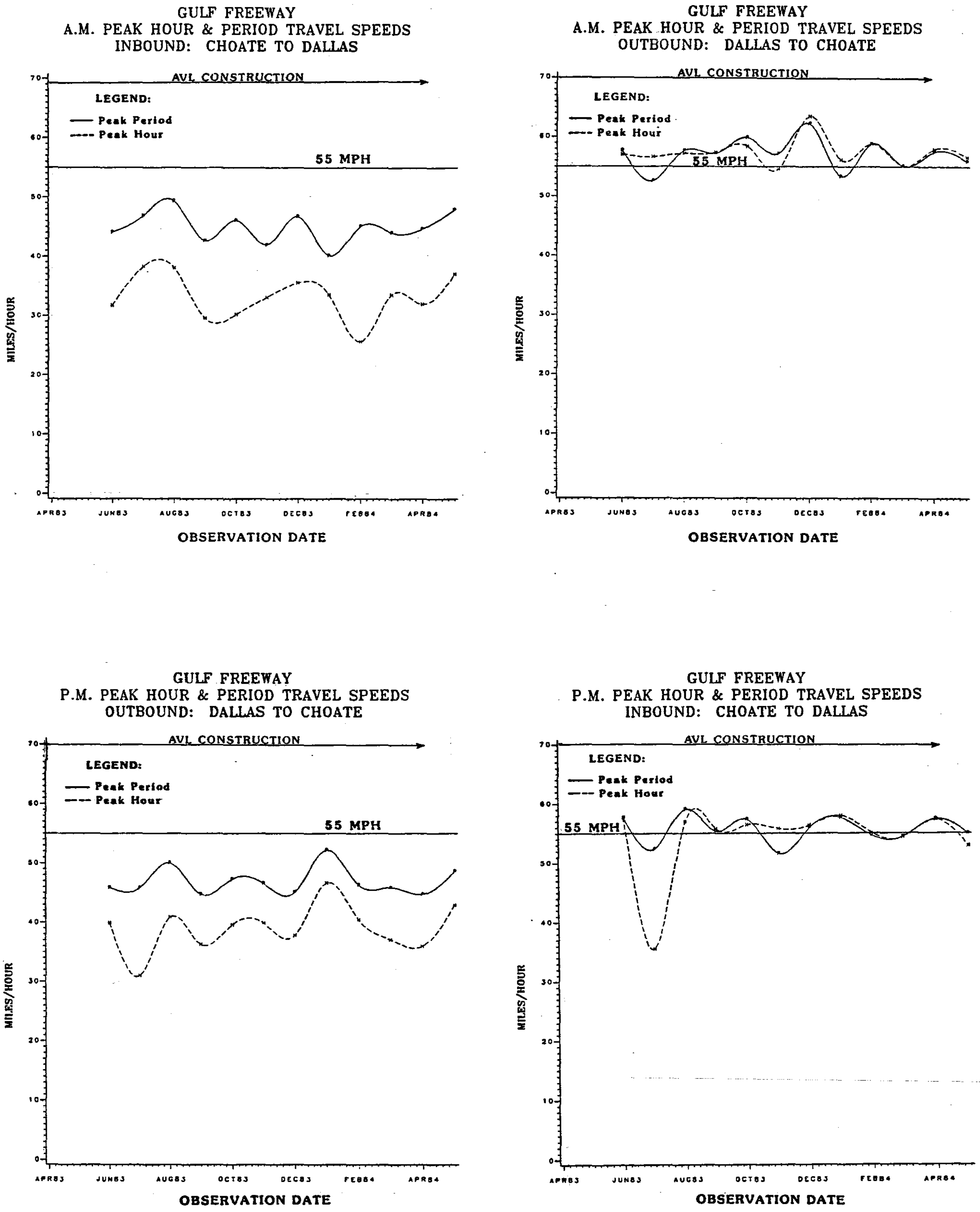


Figure 12: Gulf Freeway Overall Travel Speeds

Table 15: Peak Period Travel Times for the Gulf (I-45S) Freeway Corridor (Minutes)

Date:	Direction and Time			
	AM Inbound	AM Outbound	PM Outbound	PM Inbound
Jun 83	24.6	17.6	23.0	17.6
Jul 83	22.2	20.3	24.3	20.4
Aug 83	21.2	17.6	21.0	17.1
Sep 83	25.7	17.7	23.8	18.3
Oct 83	23.6	16.9	22.0	17.7
Nov 83	25.7	17.7	22.3	19.8
Dec 83	22.5	16.3	23.2	18.2
Jan 84	26.9	19.1	19.6	17.6
Feb 84	25.1	17.2	22.5	18.5
Mar 84	24.0	18.4	22.7	18.6
Apr 84	24.0	17.6	23.8	17.6
May 84	22.0	18.1	21.1	18.4
Average Times	24.0	17.9	22.4	18.3

Table 16: Peak Period Travel Speeds for the Gulf (I-45S) Freeway Corridor (MPH)

Date	Direction and Time			
	AM Inbound	AM Outbound	PM Outbound	PM Inbound
Jun 83	44	58	46	58
Jul 83	47	53	46	52
Aug 83	49	58	50	59
Sep 83	43	57	45	55
Oct 83	46	60	47	57
Nov 83	42	57	47	52
Dec 83	47	62	45	56
Jan 83	40	53	52	58
Feb 84	45	59	46	55
Mar 84	44	55	46	54
Apr 84	45	57	45	57
May 84	48	56	49	55

Table 17: Average Monthly Travel Speeds on The Gulf (I-45S) Freeway for Peak Periods (June 83-May 84)

	AM Peak Period		PM Peak Period	
	Inbound	Outbound	Outbound	Inbound
Speed Range:				
Low	40	53	45	52
High	49	62	52	59
Average (Mean) Speed	45	57	47	56

Vehicle and Person Volumes

Unlike the Park-and-Ride and the Travel Time Surveys, the Volume Survey is being conducted on a quarterly basis. The preliminary look at the volumes occurred in June 1983; quarterly sampling began in August 1983. Consequently, only five data points are available. The following analysis consists of three parts for each freeway and each peak period: (1) an analysis of the vehicle and person volumes; (2) an analysis of HOV contributions to overall vehicle and person volumes; and, (3) an analysis of the resulting occupancy levels.

Katy (I-10) Freeway

The vehicle volumes for the 3-hour morning and afternoon peak periods are shown in Tables 18 and 19, respectively. Generally speaking, between 11,000 and 15,000 vehicles were observed using the freeway facility during the observation periods. HOV vehicles recorded in the traffic stream constituted between .73% and .85% of the total volume during the peak period. Traffic demand throughout the peak period remained fairly constant; some 36% to 37% of the total 3-hour volume was accounted for during the peak hour within the two peak periods. However, during the morning period (6:30 a.m. to 9:30 a.m.), over 50% of all HOV traffic was observed during the peak hour; this was not the case in the afternoon, when only 34% of HOV demand occurred in the peak hour.

Table 18: Observed Vehicle Volumes on the Katy (I-10) Freeway; Morning peak Period (6:30 a.m.-9:30 a.m.) Inbound

Date	HOV Vehicles			Non-HOV Vehicles	Total
	Vanpool	Bus	Total		
June 1983	54	20	74	11,519	11,593
August 1983	29	23	52	10,827	10,879
November 1983	32	29	61	10,789	10,850
February 1984	65	17	82	11,071	11,153
May 1984	101	34	135	10,950	11,085
Average (mean)	56	25	81	11,031	11,112

Table 19: Observed Vehicle Volumes on the Katy (I-10) Freeway; Afternoon Peak Period (4:00 a.m.-7:00 p.m.) Outbound

Date	HOV Vehicles			Non-HOV Vehicles	Total
	Vanpool	Bus	Total		
June 1983	38	29	67	12,315	12,382
August 1983	46	31	77	11,293	11,370
November 1983	76	40	116	14,583	14,699
February 1984	111	45	156	14,604	14,760
May 1984	98	33	131	10,609	10,740
Average (mean)	74	36	109	12,681	12,790

Tables 20 and 21 present the peak period person demand observed using the Katy Freeway during the morning and afternoon, respectively. Even though HOV traffic only constitutes a very small proportion of total vehicle demand (.73% to .85%), the person demand served by HOVs amounts to 7.8% during the morning and 10.2% during the afternoon. Vehicle occupancies for HOV traffic were 11 to 13 times greater than for non-HOV traffic as shown in Table 22. Some 70% of the HOV person demand is served by buses with the other 30% carried in vanpools.

Table 20: Observed Person Volumes on the Katy (I-10) Freeway; Morning Peak Period (6:30 a.m.-9:30 a.m.) Inbound

Date	HOV Vehicles			Non-HOV Vehicles	Total
	Vanpool	Bus	Total		
June 1983	286	689	975	13,057	14,032
August 1983	212	866	1078	13,012	14,090
November 1983	184	794	978	12,700	13,678
February 1984	386	651	1037	12,894	13,931
May 1984	420	922	1342	12,505	13,847
Average (means)	298	784	1082	12,834	13,916

Table 21: Observed Person Volumes on the Katy (I-10) Freeway; Afternoon Peak Period (4:00 p.m.-7:00 p.m.) Outbound

Date	HOV Vehicles			Non-HOV Vehicles	Total
	Vanpool	Bus	Total		
June 1983	284	941	1225	15,550	16,775
August 1983	416	1311	1727	14,558	16,285
November 1983	568	1285	1853	17,985	19,838
February 1984	826	1518	2344	17,754	20,098
May 1984	565	1295	1860	13,201	15,061
Average (means)	532	1270	1802	15,809	17,611

Table 22: Average Peak Period Vehicle Occupancies for the Katy (I-10) Freeway; Persons Per Vehicle

Period	HOV Traffic			Non-HOV Traffic	Total Traffic
	Vanpools	Buses	All		
AM Inbound	5.32	31.36	13.36	1.16	1.25
PM Outbound	7.19	35.28	16.53	1.25	1.38

North (I-45N) Freeway

Table 23 presents the vehicle volumes for the a.m. (inbound) period while Table 24 shows the volumes recorded for the p.m. (outbound) period on the North Freeway. When compared to the Katy Freeway, the North Freeway contains a relatively high percentage of HOVs in the overall traffic stream: between 2.6% in the morning and 3.4% in the afternoon (less than 1% of the traffic on the Katy Freeway was classified as HOV). Almost all of these HOVs travel in the North Freeway CFL. Both HOV and non-HOV traffic was fairly evenly distributed through the morning peak period. However, over 50% of all HOV traffic was observed during the peak hour (4 p.m. - 5 p.m.) during the afternoon period.

Table 23: Observed Vehicle Volumes on the North (I-45N) Freeway; Morning Peak Period (6:30 a.m.-9:30 a.m.) Inbound

Date	HOV Vehicles			Non-HOV Vehicles	Total
	Vanpool	Bus	Total		
June 1983	187	103	290	11,012	11,302
August 1983	173	102	275	10,720	10,995
November 1983	172	98	270	13,269	13,539
February 1984	218	116	334	11,451	11,785
May 1984	220	131	351	10,024	10,375
Average (mean)	194	110	304	11,295	11,599

Table 24: **Observed Vehicle Volumes on the North (I-45N) Freeway; Afternoon Peak Period (4:00 p.m.-7:00 p.m.) Outbound**

Date	HOV Vehicles			Non-HOV Vehicles	Total
	Vanpool	Bus	Total		
June 1983	239	133	372	12,694	13,066
August 1983	271	123	394	10,307	10,701
November 1983	281	144	425	13,459	13,884
February 1984	294	176	470	12,889	13,359
May 1984	311	138	449	11,035	11,484
Average (mean)	279	143	422	12,077	12,499

Tables 25 and 26 show the peak-period person demand observed on the North Freeway during the morning and afternoon, respectively. The person demand served by HOVs amounts to approximately 30% in both the afternoon and morning peak periods. Approximately 70% of the HOV persons are served by buses, with the remainder carried in vanpools.

Table 25: **Observed Person Volumes on the North (I-45N) Freeway; Morning Peak Period (6:30 a.m.-9:30 a.m.) Inbound**

Date	HOV Vehicles			Non-HOV Vehicles	Total
	Vanpool	Bus	Total		
June 1983	1782	3631	5413	13,335	18,748
August 1983	1442	3442	4884	12,911	17,795
November 1983	1164	2906	4070	15,131	19,201
February 1984	2100	4446	6546	13,312	19,858
May 1984	1875	5248	7123	11,893	19,016
Average (mean)	1673	3935	5607	13,316	18,924

Table 26: Observed Person Volumes on the North (I-45N) Freeway; Afternoon Peak Period (4:00 p.m.-7:00 p.m.) Outbound

Date	HOV Vehicles			Non-HOV Vehicles	Total
	Vanpool	Bus	Total		
June 1983	1506	2297	3803	17,121	20,924
August 1983	2190	3761	5951	13,632	19,583
November 1983	2354	3541	5895	17,154	23,049
February 1984	2756	4889	7645	15,715	23,360
May 1984	2673	5525	8198	14,295	22,493
Average (mean)	2296	4003	6298	15,583	21,882

The average vehicle occupancies for the 12-month study period are summarized in Table 27. As evidenced by the overall occupancies (1.63 to 1.75 ppv) in the corridor, the HOV traffic makes significant improvement in the person-carrying capacity of the freeway facility. Sufficient data does not yet exist to draw conclusions as to trends in HOV use resulting from the AVL construction.

Table 27: Average Peak Period Vehicle Occupancies for the North (I-45N) Freeway; Persons Per Vehicle

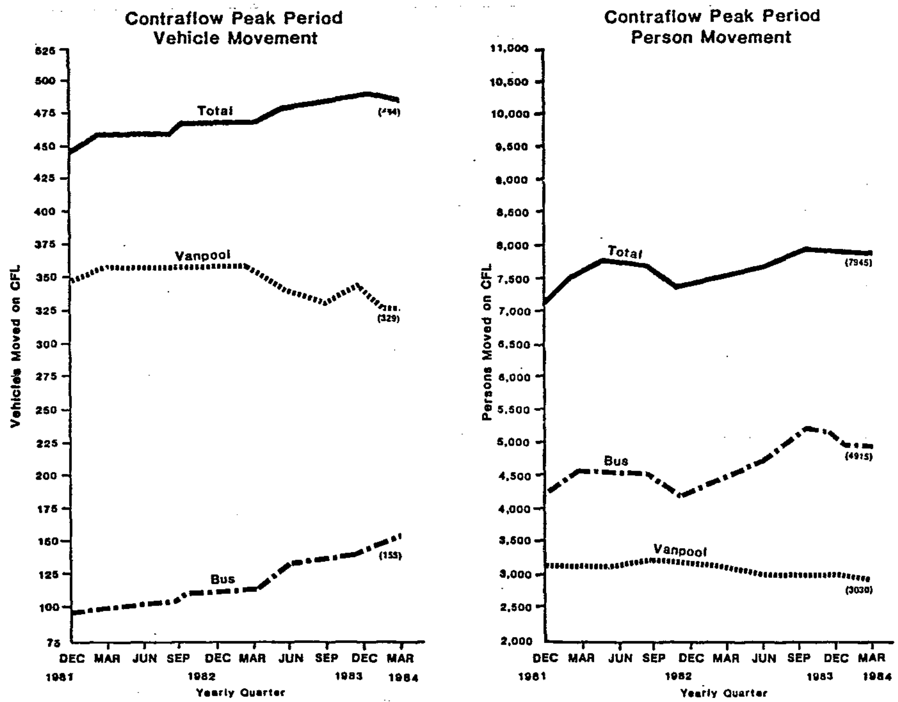
Period	HOV Traffic			Non-HOV Traffic	Total Traffic
	Vanpools	Buses	All		
AM - Inbound	8.62	35.77	18.44	1.18	1.63
PM - Outbound	8.23	27.99	14.92	1.29	1.75

North Freeway Contraflow Lane Transition

The Houston contraflow lane (CFL) operates from 6:00 to 8:30 in the morning and from 4:00 to 6:30 in the afternoon. Unfortunately, these time periods do not exactly coincide with the Texas Transportation Institute (TTI) count times. Consequently, to obtain CFL volumes and occupancy levels from the Houston Metropolitan Transit Authority (7). The vehicle volumes and classifications (i.e. van or bus) were obtained by matching the output from mechanical vehicle count devices with actual bus schedules. The occupancy levels were derived from actual head counts by the bus operators and by quarterly spot checks of vanpool occupancies. In the instances where only daily figures were available from METRO, the total volumes were halved based upon the assumption that morning and afternoon HOV volumes tend to be very similar. People going downtown by bus or vanpool in the morning usually return by the same mode in the afternoon.

As shown in Figure 13, total CFL vehicle volumes have remained relatively stable over the 2-year plus period. Bus vehicles have shown a gradual increase over time, whereas the number of vanpools has decreased slightly. These volumes are based upon CFL operating periods (6:00-8:30 a.m. and 4:00-6:30 p.m.). Although CFL volumes have been stable for some time, growth is anticipated with further economic recovery and AVL construction.

Figure 13 also presents the person movement observed on the contraflow lane between December 1981 and March 1984. Looking at both the person volume and vehicle volume shown in the figure, recent average occupancy of all CFL vehicles amounts to 16.42 persons per vehicle. Average bus occupancies are 31.71 while vanpool occupancies are 9.21 persons per vehicle.



SOURCE: Metropolitan Transit Authority, METRO: Houston, Texas.

Figure 13: Contraflow Operation on the North (I-45) Freeway; December 1981 Through March 1984

Table 28 presents morning vehicle and person volumes observed on the CFL while Table 29 presents the afternoon volumes. Again, this vehicle and person data is obtained from METRO surveys.

Table 30 summarizes the computed vehicle occupancies from the mean averages for the 10 months presented (June 1983 through march 1984). As can be seen, little difference exists between morning and afternoon vehicle occupancies on the CFL facility. Again, these numbers were obtained from METRO for CFL operation during the time periods of 6:00 a.m. to 8:30 a.m. and 4:00 p.m. to 6:30 p.m.; as such, they may not coinside with the previously summarized peak-period figures.

Table 28: Observed Vehicle and Person Volumes on the Contraflow Lane (North Freeway Corridor); Morning Peak Period (6:00 a.m.-8:30 a.m.) Inbound

Date	HOV Vehicles			HOV Persons		
	Vanpool	Bus	Total	Vanpool	Bus	Total
June 1983	342	128	470	2970	4622	7592
July 1983	NA	128	NA	NA	4599	NA
August 1983	NA	128	NA	NA	4335	NA
September 1983	331	128	459	2974	4338	7812
October 1983	344	144	488	3092	4981	8073
November 1983	352	144	496	3165	4951	8116
December 1983	NA	NA	NA	NA	NA	NA
January 1984	325	NA	NA	2994	NA	NA
February 1984	NA	NA	NA	NA	NA	NA
March 1984	328	158	486	3021	5014	8035
Average (mean)	337	137	480	3036	4691	7926

Source: Metropolitan Transit Authority; Houston, Texas

Table 29: Observed Vehicle and Person Volumes on the Contraflow Lane (North Freeway Corridor); Afternoon Peak Period (4:00 p.m.-7:00 p.m.) Outbound

Date	HOV Vehicles			HOV Persons		
	Vanpool	Bus	Total	Vanpool	Bus	Total
June 1983	342	128	470	2970	4622	7592
July 1983	NA	128	NA	NA	4599	NA
August 1983	NA	128	NA	NA	4335	NA
September 1983	331	128	459	2974	4838	7812
October 1983	339	143	482	3044	4910	7954
November 1983	337	143	480	3022	4826	7848
December 1983	NA	NA	NA	NA	NA	NA
January 1984	325	NA	NA	2994	NA	NA
February 1984	NA	NA	NA	NA	NA	NA
March 1984	330	153	483	3039	4817	7856
Averages (means)	334	136	475	3007	4707	7812

Source: Metropolitan Transit Authority; Houston, Texas

Table 30: Average Peak Period Vehicle Occupancies for the Contraflow Lane (North Freeway Corridor); Persons per Vehicle

Period	Occupancies for:		
	Vanpools	Buses	All HOVs
AM Inbound	9.01	34.23	16.52
PM Outbound	9.00	34.61	16.45

Gulf (I-45S) Freeway

Vehicle volumes for the morning inbound period on the Gulf Freeway are presented in Table 31. The afternoon, outbound volumes for the study are shown in Table 32. HOVs only constitute some .65% to .72% of the total volume of traffic in the peak periods; this low percentage is similar to the HOV proportion on the Katy Freeway. Over 60% of all morning HOV traffic was observed during the peak hour within the 3-hour study period. Non-HOV traffic was fairly evenly distributed during the 6:30 to 9:30 a.m. time period.

Table 31: Observed Vehicle Volumes on the Gulf (I-45S) Freeway; Morning Peak Period (6:30 a.m.-9:30 a.m.) Inbound

Date	HOV Vehicles			Non-HOV Vehicles	Total
	Vanpool	Bus	Total		
June 1983	32	21	53	11,658	11,711
August 1983	38	28	66	11,296	11,362
November 1983	79	37	116	12,684	12,800
February 1984	55	50	105	11,988	12,093
May 1984	12	29	41	10,731	10,772
Average (mean)	43	33	76	11,671	11,748

Table 32: **Observed Vehicle Volumes on the Gulf (I-45S) Freeway; Afternoon Peak Period (4:00 p.m.-7:00 p.m.) Outbound**

Date	HOV Vehicles			Non-HOV Vehicles	Total
	Vanpool	Bus	Total		
June 1983	35	39	74	13,167	13,241
August 1983	20	32	52	9,486	9,538
November 1983	103	41	144	15,864	16,008
February 1984	88	32	120	12,612	12,732
May 1984	36	26	62	11,252	11,314
Average (mean)	56	34	90	12,476	12,567

Tables 33 and 34 summarize the peak-period person demands observed on the Gulf Freeway during the morning and afternoon, respectively. Some 10.2% of the persons traveling in the morning period are in HOV's; 9.3% of the afternoon person demand was observed in buses or vanpools. Between 77% to 82% of HOV person movement is supplied by buses in the Gulf Corridor. Over 67% of the HOV person demand was observed during the peak hour within the morning peak period.

Table 33: **Observed Person Volumes on the Gulf (I-45S) Freeway; Morning Peak Period (6:30 a.m.-9:30 a.m.) Inbound**

Date	HOV Vehicles			Non-HOV Vehicles	Total
	Vanpool	Bus	Total		
June 1983	300	850	1150	13,776	14,916
August 1983	256	1178	1434	13,859	15,293
November 1983	458	1333	1791	15,053	16,844
February 1984	322	1801	2123	13,874	15,997
May 1984	66	1298	1364	12,769	14,133
Average (mean)	280	1292	1572	13,866	15,439

Table 34: **Observed Person Volumes on the Gulf (I-45S) Freeway; Afternoon Peak Period (4:00 p.m.-7:00 p.m.) Outbound**

Date	HOV Vehicles			Non-HOV Vehicles	Total
	Vanpool	Bus	Total		
June 1983	202	1055	1257	17,908	19,165
August 1983	196	998	1194	12,446	13,640
November 1983	670	1760	2430	19,456	21,886
February 1984	612	1450	2062	15,621	17,683
May 1984	169	961	1130	13,471	14,601
Average (mean)	370	1245	1615	15,780	17,395

The average vehicle occupancies for the 12-month study are summarized in Table 35. The HOVs in the Gulf corridor carry, on an average, between 14 to 17 times the number of persons in a non-HOV category.

Table 35: **Average Peak Period Vehicle Occupancies for the Gulf (I-45S) Freeway; Persons Per Vehicle**

Period	HOV Traffic			Non-HOV Traffic	Total Traffic
	Vanpools	Buses	All		
AM Inbound	6.51	39.15	20.68	1.19	1.31
PM Outbound	6.61	36.62	17.94	1.26	1.38

OPERATIONAL AND SAFETY IMPACTS OF AVL CONSTRUCTION

General

Given the early stages of AVL construction on the North (I-45N) Freeway and the Gulf (I-45S) Freeway, analysis of operational and safety impacts are not yet possible. The SDHPT accident files, in combination with other data, will be assessed by freeway segment and time period corresponding to construction phases in subsequent work for these two freeways. However, preliminary analysis has been accomplished for the Katy (I-10) Freeway Corridor and is presented herein.

The institution of a high-occupancy facility into the median requires special retrofit construction processes which constrain freeway sections already serving high volumes of traffic. Minimizing the adverse traffic impacts associated with this type of construction is a primary concern. Construction on the first such median transitway in Houston was begun in June 1983 on a 5.0 mile section of the Katy Freeway which should be completed in October 1984. As this was the initial effort of a planned 63-mile network of transitways to be constructed in a similar fashion, it is important to measure and understand the operational and safety impacts on mixed flow traffic resulting from the transitway construction. This section of the report presents the results of an evaluation of the operational and safety impacts associated with the retrofit construction of an Authorized High-Occupancy Vehicle Lane into the median of the Katy Freeway (I-10W) in Houston, Texas. Operational measures studied include travel speeds as a measure of travel time delay, traffic volumes as a measure of travel demand served, and lane distributions as a measure of driver reaction to reduced lane widths. Safety is assessed through an analysis of reported accidents associated with various work area segments and time periods of construction.

Katy (I-10) Freeway

Extensive residential and commercial development has occurred and is continuing along the Katy Freeway corridor as far west as Brookshire, a distance of 35 miles from downtown Houston. Throughout the 1960's much of the Katy Freeway was upgraded to interstate standards. Today the interstate facility is a 10-lane freeway from downtown Houston to Loop IH-610 and an 8-lane freeway for a short distance of two miles to the west of IH-610. Further to the west, the Katy Freeway is a 6-lane facility until it reaches the City of Katy at which time it drops to a 4-lane freeway; a distance of some 23 miles to the west of Loop IH-610.

Increasing development, combined with depressed levels of mobility, justify the need for a high occupancy, priority transportation facility within the Katy Freeway corridor. The Texas State Department of Highways and Public Transportation and the Metropolitan Transit Authority of Harris County jointly initiated technical and funding efforts to expedite implementation of the Katy Freeway Transitway.

The Katy Freeway Transitway is being constructed in the median of the freeway and will be separated from general traffic lanes by concrete median barriers (CMB). The facility will be reversible (operating inbound in the morning and outbound in the evening), will include an emergency breakdown shoulder along most portions, and will be designed to accommodate buses, vanpools and other authorized high occupancy vehicles.

Construction of the Katy Freeway Transitway was combined with the rehabilitation of the freeway pavement to minimize traffic disruption and project cost. The AVL work will be completed in two major phases as shown in Figure 14. The individual segment limits and corresponding lengths for Phase 1 are given in Table 36 as taken from the construction plans (9). Also presented in the table are measured 1981-1983 average daily traffic (ADT) for

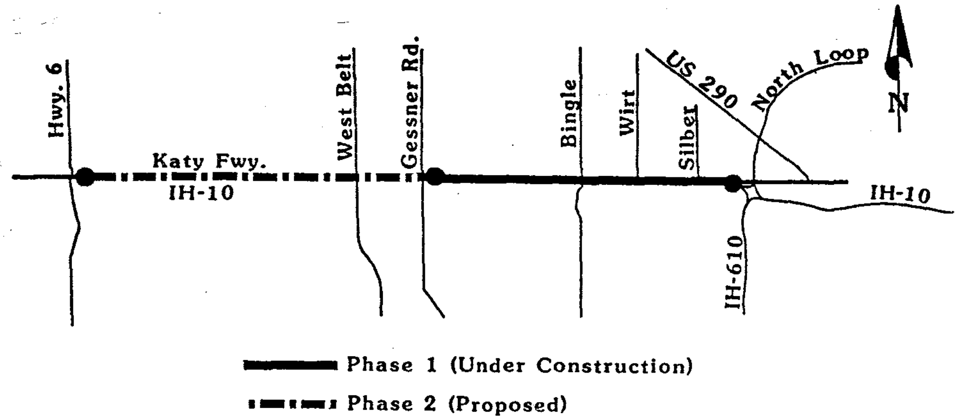


Figure 14: Katy Transitway Project Phases

each section (10). Work was sequenced independently within each segment to allow retrofit construction of the transitway. The work areas were developed in the median and to the inside and outside areas of the freeway mainlane cross section. Traffic was routed around the work areas, in narrow lanes varying from 10 to 11 feet in width with no shoulders on either the inside or the outside. Temporary concrete median barriers protected and separated the work areas from freeway traffic. Typical work area cross sections on the Katy Freeway are shown in Figure 15.

Table 36: Katy Freeway Transitway Project Construction Segments

Number	Length	Limits	1981	1982	1983
1	1.26 miles	West Belt to Bunker Hill	118,000	135,000	136,270
2	1.44 miles	Bunker Hill to Echo	156,000	167,000	161,090
3	1.95 miles	Echo to Bingle	156,830*	161,050*	165,270
4	0.89 miles	Bingle to Wirt	140,410*	143,975*	147,540
5	0.83 miles	Wirt to IH-610	179,000	186,000	192,190

*Estimated - No data available

Source: References (9) and (10)

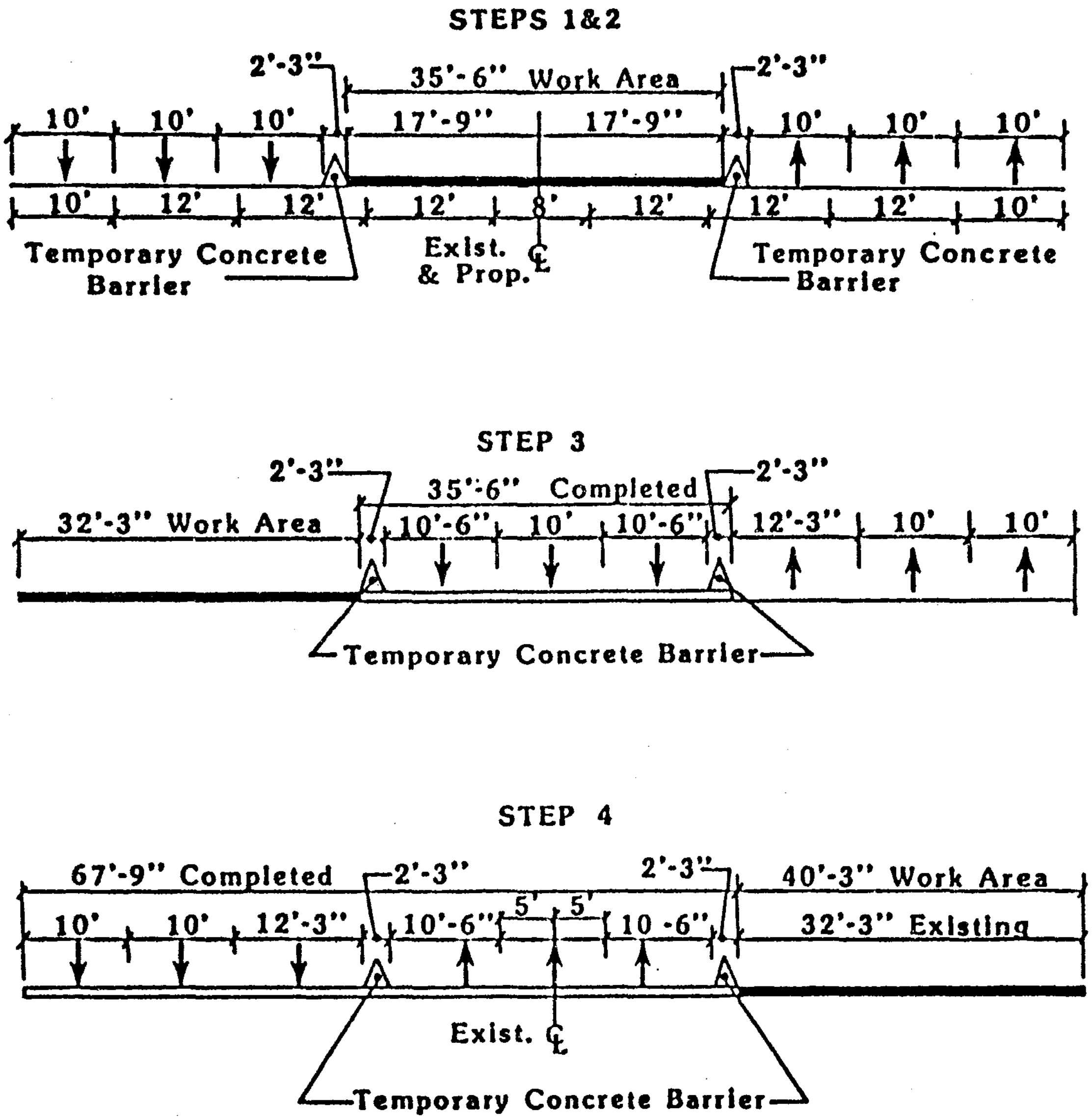


Figure 15: Typical Work Area Cross-Section On Katy Freeway (Looking West)

The impacts of retrofitting the transitway into the median of the Katy Freeway were categorized as either operational or safety related. Operational measures studied included: (1) speeds (as a measure of travel time delay); (2) traffic volumes at sites along the length of the Katy Freeway Transitway project representative of the various construction segments (as a measure of demand served); and, (3) lane distributions (as a measure of driver reaction to reduced lane widths). Safety was assessed through an analysis of reported accidents associated with various work segments and time periods of construction. All operational data was collected manually during both peak periods (morning and evening) and during off peak periods (midday and nighttime). The data was sorted by direction -- either eastbound (a.m. peak direction) or westbound (p.m. peak direction). Standard measuring techniques for recording vehicular volumes and speeds were employed. No data was recorded under aberrant operating (accident, breakdown) or environmental (rain, fog) conditions.

The operational and safety data for each segment under construction was compared to the data for each segment one year prior to construction. The changes were then evaluated using a paired "t" test. The speed and accident data were compared for identical segments and for equal time periods before and during construction. The chi-square test for independence was applied to the variables associated with free-flow lane volume distribution conditions to determine the statistical significance of the observed by-lane volume distribution between full width and narrowed lane cross-sections.

Operational Impacts

The difference between speed profiles prior to and during construction was tested for statistical significance. Segment 5 in the morning, segments 2 and 4 in the evening, and the overall peak-hour, peak-direction differences between pre- and during construction travel speeds are significant at the 5% level as shown in Table 37. However, of these five statistically significant differences, only the morning speed differences indicate a negative impact due to construction. On an average, segment 5 speeds decreased by almost 14 mph with a standard error of 1.65 mph in the morning during construction as opposed to one year earlier. Overall, the morning eastbound speeds decreased by an average 3 mph with a standard error of 1.29 mph during construction; however, this small decrease is not practically significant.

Table 37: T-Tests of Differences in Speeds for Pre- vs. During Construction Conditions

Time and Direction:	Segment	Sample Size	Mean Diff.*	Std. Dev.	Std. Err.	T	PR>T
Morning Eastbound	1	8	-1.02	2.58	0.91	-1.12	0.300
	2	5	-1.27	5.58	2.60	-0.49	0.651
	3	3	+1.16	2.71	1.56	0.74	0.534
	4	2	-2.42	6.47	4.58	-0.53	0.690
	5	3	-13.70	2.86	1.65	-8.31	0.014**
	Overall	21	-2.71	5.90	1.29	-2.11	0.048**
Afternoon Westbound	1	8	+6.24	11.29	3.99	1.56	0.162
	2	5	+6.02	3.07	1.37	4.38	0.012**
	3	3	+2.58	2.80	1.62	1.60	0.251
	4	2	+4.33	0.28	0.20	22.05	0.029**
	5	3	+3.95	5.11	2.95	1.34	0.312
	Overall	21	+5.16	7.2	1.57	3.28	0.004**

*(During speeds) - (Pre speeds)
**Statistically significant at the 5% level

Average peak-period speeds during the first stages of narrow lane construction were compared to observations made during the later stages of narrow lane construction. As only two of the segments have undergone more than one construction step, only two of the five segments may be tested.

Neither of the differences in operating speed in each segment or throughout the construction length is significant at the 5% level as shown in Table 38.

Table 38: T-tests of Differences in Speeds for Beginning vs. Ending Construction Conditions

Time and Direction	Segment	Sample Size	Mean Diff*	Std. Dev.	Std. Err.	T	PR>T
Morning Eastbound	1	4	1.54	4.89	2.45	0.63	0.575
	2	3	-5.44	17.38	12.29	-0.44	0.735
	3	1	-2.89	-	-	-	-
	4	1	-7.20	-	-	-	-
	5	1	2.42	-	-	-	-
	Overall	9	-1.38	7.84	2.61	-0.53	0.612
Afternoon Westbound	1	4	3.12	5.60	2.80	1.11	0.346
	2	2	3.73	5.15	3.64	1.02	0.492
	3	1	1.73	-	-	-	-
	4	1	-0.73	-	-	-	-
	5	1	-0.32	-	-	-	-
	Overall	9	2.29	4.24	1.41	1.62	0.143

*(Ending speeds) - (Beginning speeds)

Finally, operating speeds prior to construction (with the full width lanes plus emergency shoulders) were compared to initial construction operating speeds as well as to later construction operating speed (both with reduced lane widths and no emergency shoulders). The results are presented in Tables 39 and 40. Only one difference in operating speed between pre- and beginning construction speeds was statistically significant at the 5% level. The traffic in segment 5 in the morning eastbound direction experienced an average decrease of more than 15 mph during the first stages of narrow lane construction. Overall, operating speeds did not change significantly during the initial institution of narrow lane work areas. As for the differences

Table 39: T-tests of Differences in Speeds for Pre vs. Beginning Construction Conditions

Time and Direction	Segment	N	Mean Speed	Std. Dev.	Std. Err.	T	PR>T
Morning Eastbound	1	4	-0.42	3.50	1.75	-0.24	0.826
	2	3	-2.36	7.95	4.59	-0.51	0.658
	3	2	2.34	2.53	1.79	-1.30	0.417
	4	1	2.15	-	-	-	-
	5	2	-15.31	0.84	0.59	-25.81	0.025**
	Overall	12	-2.71	7.28	2.10	-1.29	0.224
Afternoon Westbound	1	4	4.26	11.71	5.86	0.73	0.519
	2	3	5.20	3.54	2.04	2.55	0.126
	3	2	2.10	3.78	2.67	0.79	0.576
	4	1	4.52	-	-	-	-
	5	2	1.97	5.36	3.79	0.52	0.694
	Overall	12	3.78	6.74	1.94	1.94	0.078

* (Beginning speeds) - (Pre speeds)
**Statistically significant at the 5% level

Table 40: T-tests of Differences in speeds for Pre vs. Ending Construction Conditions

Time and Direction	Segment	Sample Size	Mean Speed	Std. Dev.	T	PR>T
Morning Eastbound	1	4	-1.63	1.55	-2.10	0.126
	2	2	0.36	0.37	1.36	0.404
	3	1	-1.18	-	-	-
	4	1	-7.00	-	-	-
	5	1	-10.47	-	-	-
	Overall	9	-2.72	3.74	-2.18	0.061
Afternoon Westbound	1	4	8.21	12.25	1.34	0.272
	2	2	7.26	2.77	3.70	0.168
	3	1	3.55	-	-	-
	4	1	4.13	-	-	-
	5	1	7.91	-	-	-
	Overall	9	7.00	7.78	2.70	0.027**

* (Ending speeds) - (Pre speeds)
**Statistically significant at the 5% level

between pre- and ending construction operating speeds, shown in Table 40, no negative speed differentials were statistically significant at the 5% level.

Total vehicle volumes at sites with representative construction cross-sections for morning, evening, noon, and nighttime periods were recorded. Volumes at capacity during peak periods approach an average of 1750 vehicles per hour per lane at the locations sampled. This exceeds the theoretical service volume of 1680 vehicles per hour per lane as calculated to reflect the influence of the indicated geometric restrictions to basic capacity (11).

Information regarding free flow vehicle lane distribution sorted by: (1) inside/middle/outside lane; (2) day/night time period; (3) narrowed/full lane widths; and, (4) total/truck only vehicles was analyzed. All chi-square tests for total vehicles as well as for trucks only indicate that lane distribution is not independent of either time period (day vs night) or cross-sectional width (narrowed vs full). The following effects are noteworthy:

(1) During daytime off-peak operation, there is little difference in lane distribution of total vehicles. However, there is a shift of approximately 20 percent from the inside lane to the middle lane by trucks within the narrow lane construction cross-section over that observed in the full-width cross-section.

(2) During nighttime operations, there is a shift of approximately 13 percent from the inside to the middle lane by total vehicles within the narrow lane construction cross-section as opposed to lane distribution in the full width cross-section. There was also a shift of approximately 10 percent from the inside to the outside lane by trucks within the narrow lane construction cross-section over a full-width normal cross-section.

There was little difference in middle lane distribution of trucks between cross-sections.

Safety Impacts

Total accident experience was noted within the limits of the construction project by segment for equal comparison time periods prior to and during construction. These recorded values were related to segment length and to the measured average daily traffic previously listed in Table 36. This allowed the data to be converted to accident rates (accidents per 100 million vehicle miles) that lend themselves to be statistically analyzed for significance of change (12). Tables 41 through 44 present the impact on safety of the transitway construction as measured by the changes in accident rates. Three changes in accident rates were statistically significant at the 5% level. The overall accident rate between pre- and during construction increased by 4.9 accidents per 100 million vehicle miles with a standard error of 22 accidents per 100 million vehicle miles. The segment 3 accident rate increased by 80 accidents per 100 million vehicle miles between the pre- and the during construction time periods with a standard error of 27 accidents per 100 million vehicle miles. Finally, between the pre- and the beginning construction time periods, the overall accident rate increased by 82 accidents per 100 million vehicle miles with a standard error of 3 accidents per 100 million vehicle miles. Amidst this discussion of significant changes it is important to notice one difference which is not statistically significant. The mean difference in accident rates between the pre- and the ending construction time periods is not significant at the 5% level.

Table 41: Pre vs. During Construction Accident Rates Differences

Segment	Sample Size	Mean Diff*	Std. Dev.	Std. Err.	T	PR>T
1	9	15.05	66.20	22.07	0.68	0.515
2	7	54.27	133.43	50.43	1.08	0.323
3	5	79.52	60.82	27.20	2.92	0.043**
4	3	131.76	110.33	63.70	2.07	0.175
5	6	25.35	204.34	83.42	0.30	0.774
Overall	30	48.68	121.62	22.20	2.19	0.037**

*(During Accident Rates) - (Pre-Accident Rates)
**Statistically significant at the 5% level

Table 42: Beginning vs. Ending Construction Accident Rate Difference

Segment	Sample Size	Mean Diff*	Std. Dev.	Std. Err.	T	PR>T
1	5	14.11	97.03	43.39	-0.33	0.761
2	4	44.50	78.00	39.00	-1.14	0.337
3	3	66.60	34.02	19.64	-3.39	0.077
4	2	164.36	34.79	24.60	6.68	0.095
5	3	71.98	39.07	22.56	-3.19	0.086
Overall	17	19.74	96.06	23.30	-0.85	0.409

*(Ending Accident Rates - (Beginning Accident Rates)

Table 43: Pre vs. Beginning Construction Accident Rate Differences

Segment	Sample Size	Mean Diff*	Std. Dev.	Std. Err.	T	PR>T
1	4	44.75	43.72	21.86	2.05	0.133
2	3	49.37	202.64	117.00	0.42	0.714
3	2	117.64	64.90	45.89	2.56	0.237
4	1	21.14	-	-	-	-
5	3	159.68	114.71	31.81	2.16	0.164
Overall	13	81.68	114.71	31.81	2.57	0.025**

*(Beginning Accident Rate) - (Pre-Accident Rates)
**Statistically significant at the 5% level

Table 44: T-tests of Differences in Accident Rates for Pre- vs. Ending Construction Conditions

Segment	Sample Size	Mean Diff*	Std. Dev.	Std. Err.	T	PR>T
1	5	-8.71	75.70	33.90	-0.26	0.810
2	4	57.94	90.49	45.25	1.28	0.290
3	3	54.10	53.57	30.93	1.75	0.220
4	2	187.08	77.40	54.73	3.42	0.181
5	3	-108.75	184.44	106.49	-1.02	0.415
Overall	17	23.44	124.01	30.08	0.447	

*(Ending Accident Rates) - (Pre-Accident Rates)

Overview of Construction Impacts

The results of this study suggest the following conclusions:

(1) transitway construction, as instituted with a detailed traffic control involving many ramp closures, has not appreciably decreased operating speeds.

(2) the geometric restrictions imposed by transitway construction have not adversely affected freeway volumes to the extent that current highway capacity theory would predict.

(3) the institution of narrowed lane cross-sections and reduced lateral clearances on the inside and the outside lanes along the transitway construction areas has resulted in a higher percentage of trucks, as well as total vehicles, using the middle freeway lane; and,

(4) traffic safety was adversely impacted during the beginning of each step in the transitway construction sequence. However, as time passed, drivers were able to adjust to the traffic diversions and highway geometric restrictions that accompanied transitway construction.

Retrofitting an HOV facility into the median of an existing freeway is a difficult and potentially hazardous task. In Houston, the narrow lane cross-sections that were instituted along the transitway construction areas raised fears of drastically reduced speeds and increased accidents. However, the detailed control plan for management of traffic on the Katy Freeway during AVL construction has effectively confronted the problem and minimized the operational and safety impacts resulting from transitway retrofit construction.

SUMMARY

The three AVL projects are all currently undergoing extensive AVL construction and freeway resurfacing. The Katy project began in June 1983, the North project in January 1984, and the Gulf project in September 1982. Consequently, only the North corridor has "before construction" data collected in this study. The "before" data for the Katy Freeway was obtained from the Texas State Department of Highways and Public Transportation. To date, no "before" data has been obtained for the Gulf corridor. Consequently, the analysis for the Gulf corridor involves only a description of operational effects observed during AVL construction and roadway resurfacing conditions. The analyses for the Katy and the North Freeways (or projects) both include "before" and "during" information. However, since only the Katy project has progressed far enough to provide enough "during" data, only the Katy Freeway has undergone a comparative analysis of the operational and safety characteristics of the freeway between before and during AVL construction.

Park-and-ride demands in all three corridors have been increasing slightly. The Gulf corridor in particular experienced an increase in demand of more than 360 vehicles when the new expanded Clear Lake Park-and-Ride lot was opened on April 2, 1984. The Spring and the Seton Lake Park-and-Ride lots on the North corridor also experienced a growth in demand close to 100 vehicles per lot. The slight growth in demand experienced in the Katy corridor is almost entirely attributable to the SH 6 lot, probably because the Mason lot is, and has been, operating near capacity since the beginning of this study.

Travel times and speeds for all three corridors have fluctuated erratically since the beginning of this study. No distinct trends nor

characteristics are as yet evident in the collected data. Only the Katy Freeway travel speeds were compared to a time period one year prior to the commencement of AVL construction. The results of this pre-/during comparison indicate that, if anything, the AVL construction and its associated traffic management and control plan that involved selected ramp closures on the Katy Freeway has improved freeway mainlane travel speeds.

With only five months of volume data collected to date, no reliable statements may be made concerning any trends in the data. Generally speaking, vehicle volumes on the Katy Freeway averaged about 11,000 in the morning peak period and close to 13,000 in the afternoon peak period. Person volumes averaged 14,000 in the morning and 17,500 in the afternoon on the Katy Freeway. The North Freeway averaged about 11,500 vehicles in the morning and 12,500 vehicles in the afternoon peak periods with person volumes of 19,000 in the morning and 22,000 in the afternoon. Although HOV's comprised less than 1% of the peak period vehicle volumes on the Katy and the Gulf Freeways, they made up more than 6% of the peak period person volumes. On the North Freeway, with the opeational CFL, HOVs comprised about 3% of the vehicle volume and close to 30% of the person volume. Once the AVL's are operational, the Gulf and the Katy may be expected to experience HOV volumes comparable to those observed on the North Freeway CFL.

An overall assessment of the operational and safety impacts of the Katy AVL construction project has indicated that the freeway's operational characteristics have been affected only minimally by the construction project and its associated geometric restrictions. Neither travel speeds nor traffic volumes experienced the declines that were feared. Traffic did exhibit a greater affinity for the middle freeway lane, but the total vehicle volumes did not decline during peak periods as current highway capacity would predict. Finally, drivers did require time to adjust to the changing traffic routings within the freeway cross-section, but within a month after the implementation of each construction step, accident rates were no longer significantly different from accident rates one year before the AVL construction began.

Operational and safety data will continue to be collected within the study corridors monthly and quarterly throughout the five year evaluation period. Updates for each freeway will be provided as required.

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