Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/TX-95/2931-1		

4. Title and Subtitle	5. Report Date
IMMEDIATE ACTION PROGRAM, HOUSTON ITS PRIORITY CORRIDOR PROGRAM PLAN	October 1995
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Merrell E. Goolsby and William R. McCasland	Research Report 2931-1

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Texas Transportation Institute The Texas A&M University System College Station, Texas 77843-3135	11. Contract or Grant No. Study No. 7-2931

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Texas Department of Transportation Research and Technology Transfer Office P. O. Box 5080 Austin, Texas 78763-5080	Interim: July 1994 - May 1995
	14. Sponsoring Agency Code

15. Supplementary Notes

Research performed in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.

Research Study Title: Development of ITS Priority Corridor Program Plan

16. Abstract

The Houston ITS Priority Corridor is one of four corridors selected by the U.S. Department of Transportation to showcase Intelligent Transportation Systems applications. The Texas Transportation Institute is assisting Houston TranStar, a coalition of four local governments, comprised of the Texas Department of Transportation, Metropolitan Transit Authority, Harris County, and City of Houston, in developing the Houston ITS Priority Corridor Program Plan.

This interim report documents development of the Immediate Action Program. Fourteen immediate action projects, with an estimated total cost of $9,192,500, have been proposed. These projects focus primarily on transportation management and traveler information systems. The final report will develop a 20-year vision for the Houston ITS Priority Corridor, with specific deployment projects identified for the initial 10-year period, of which this Immediate Action Program will be a part.

17. Key Words	18. Distribution Statement
Intelligent Transportation Systems, Traffic Management, Traveler Information Systems	No restrictions. This document is available to the public through NTIS: National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161

19. Security Classif.(of this report)	20. Security Classif.(of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	84	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

IMMEDIATE ACTION PROGRAM
HOUSTON ITS PRIORITY CORRIDOR
PROGRAM PLAN

Interim Report

by

Merrell E. Goolsby, P.E.
Research Engineer
Texas Transportation Institute

and

William R. McCasland, P.E.
Research Engineer
Texas Transportation Institute

Research Report 2931-1
Research Study Number 7-2931
Research Study Title: Development of ITS Priority Corridor Program Plan

Sponsored by the
Texas Department of Transportation
In Cooperation with
U.S. Department of Transportation
Federal Highway Administration

October 1995

TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77843-3135

IMPLEMENTATION STATEMENT

The product of this interim report is a program of early deployment projects for the Houston ITS Priority Corridor. The purpose of establishing the immediate action program is to identify projects for which implementation activities (e.g., approvals, funding, detailed planning, design, construction) can proceed concurrently with the development of the Houston ITS Priority Corridor Program Plan. Fourteen projects have been identified in the Immediate Action Program. These projects have evolved over the period of time since designation of the Houston ITS Priority Corridor and are currently in various stages of the implementation process.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Texas Department of Transportation (TxDOT) or the Federal Highway Administration (FHWA). This report does not constitute a standard, specification, or regulation. It is not intended for construction, bidding, or permit purposes. The engineer in charge of the project was Merrell E. Goolsby, P.E. #29551.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

LIST OF FIGURES

LIST OF TABLES

SUMMARY

The U.S. Department of Transportation (USDOT) designated Houston as one of four ITS Priority Corridors in the United States in 1993. The intent of the Priority Corridor program is to provide testbeds for demonstrating and evaluating concepts and technologies. The ITS program, including Priority Corridors, was an important element of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA).

Each of the four designated corridors is to develop an ITS Priority Corridor Program Plan which identifies projects, schedules, priorities, and estimated funding requirements. This interim report documents the Immediate Action Program for the Houston ITS Priority Corridor and includes a review of existing physical and operational characteristics, resources and needs, and the identification of fourteen immediate action projects.

The Houston ITS Priority Corridor Program Plan will outline a 20-year vision of ITS deployment and will develop a program of projects for a 10-year planning horizon. This Immediate Action Program will be a part of the 10-year program of projects.

The projects selected build upon the existing and evolving ITS core infrastructure of the Corridor, including the Computerized Traffic Management System (CTMS), Automatic Vehicle Identification (AVI) system, Regional Computerized Traffic Signal System (RCTSS), and the Houston TranStar Center.

The projects recommended for the Immediate Action Program, with estimated cost are:

Project	Estimated Cost
CCTV Surveillance System Lease for Astrodome Area	$ 480,000
Development of ITS Priority Corridor Program Plan	400,000
Monitoring Traffic and Transit Conditions and Incident Detection with AVI (Phase 4)	1,830,000
Changeable Lane Assignment System (CLAS) on Frontage Roads	750,000

Public Information/Program Administration	200,000
Truck Monitoring and Warning Systems for Freeway to Freeway Connections	220,000
Real-Time Information Kiosks	750,000
Railroad Grade Crossing Monitoring System	500,000
Automatic Vehicle Locator for Incident Management	100,000
On-Vehicle Navigation/Information Applications	400,000
Monitoring and Information System for Environmental Conditions	500,000
Changeable Lane Assignment System (CLAS) at Arterial Intersections	250,000
Integrated Corridor Transportation Management and Traveler Information System	1,862,500
Washburn Tunnel Traffic Management and Information System	950,000
Total Estimated Cost	$9,192,500

This Immediate Action Program for the Houston ITS Priority Corridor is currently being implemented. Implementation activities are underway for each of the projects and are in various stages of planning, design, and evaluation.

1.0 INTRODUCTION

The U.S. Department of Transportation (USDOT) designated the Houston ITS Priority Corridor as one of only four corridors to showcase Intelligent Transportation Systems (ITS) applications. An ITS Priority Corridor Program Plan is being developed which identifies the 20-year vision for ITS deployment in the Corridor. One of the elements of the Plan is identification of an immediate action program: a set of specific projects for which planning, design, and implementation can proceed while the program plan is being developed and finalized.

This Interim Report provides background information and characteristics of the Corridor, identifies needs and opportunities for ITS deployment, and recommends fourteen projects for early deployment by local agencies. The final plan report will develop a 20-year vision for ITS deployment, which will include identification of recommended 5-year and 10-year projects.

THE INTELLIGENT TRANSPORTATION SYSTEM

Passage of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) introduced a new direction for surface transportation development and operation in the United States. With completion of the Interstate Highway System, ISTEA focuses on multimodal approaches to efficiently utilize existing and upgraded transportation resources to improve safety and reduce congestion.

An important element of ISTEA is the creation of an Intelligent Transportation System (ITS) program which will contribute significantly to meeting the goals of ISTEA. Completion of the Interstate System concluded a historic period of roadbuilding, which involved the largest infrastructure program ever undertaken. However, traffic demand and congestion continue to increase, straining a system which no longer sees commensurate increases in capacity. The overriding concept of ITS is to increase transportation system performance, efficiency, and safety through application of advanced operational and technological applications.

ITS applies advanced and emerging technologies to address the goals adopted for the ITS program, as follows:[1]

- Improve the safety of the Nation's surface transportation system;
- Increase the operational efficiency and capacity of the surface transportation system;
- Reduce energy and environmental costs associated with traffic congestion;
- Enhance present and future productivity;
- Enhance the personal mobility and the convenience and comfort of the surface transportation system; and
- Create an environment in which the development and deployment of ITS can flourish.

National ITS Planning

The U.S. Department of Transportation and ITS America developed strategic plans for ITS development in 1992. These plans outline a strategic program to improve surface transportation operations in the United States. They focus on the premise that increased safety and efficiency are achieved by improving conventional transportation infrastructure with new control information and communications capabilities.

In order to establish a framework for ITS deployment, USDOT and ITS America initiated development of the National ITS Program Plan, with the final draft issued November 1994. The purpose of the National Plan is to:

- Promote shared ITS goals;
- Guide ITS investment decisions;
- Encourage coordination;
- Maintain a focus on deployment; and
- Ensure ITS is intermodal.

[1] National Program Plan for Intelligent Transportation Systems, Final Draft, U.S. Department of Transportation, November 1994.

The National ITS Program Plan will serve as a living document, with annual updates conducted.

ITS User Services

In formulating the ITS program, USDOT developed the concept of "user services" to describe individual ITS tools used by travelers and transportation providers. The resulting twenty-nine user services, grouped into seven related "bundles" are listed in Table 1. These tools can assist transportation agencies in increasing the efficiency of existing facilities, while fostering attainment of environmental goals.

Table 1. ITS User Services and Bundles

Bundle	User Services
1. Travel and Transportation Management	1. En-Route Driver Information 2. Route Guidance 3. Traveler Services Information 4. Traffic Control 5. Incident Management 6. Emissions Testing and Mitigation
2. Travel Demand Management	1. Pre-Trip Travel Information 2. Ride Matching and Reservation 3. Demand Management and Operations
3. Public Transportation Operations	1. Public Transportation Management 2. En-Route Transit Information 3. Personalized Public Transit 4. Public Travel Security
4. Electronic Payment	1. Electronic Payment Services
5. Commercial Vehicle Operations	1. Commercial Vehicle Electronic Clearance 2. Automated Roadside Safety Inspection 3. On-Board Safety Monitoring 4. Commercial Vehicle Administrative Processes 5. Hazardous Material Incident Response 6. Commercial Fleet Management
6. Emergency Management	1. Emergency Notification and Personal Security 2. Emergency Vehicle Management
7. Advanced Vehicle Control and Safety Systems	1. Longitudinal Collision Avoidance 2. Lateral Collision Avoidance 3. Intersection Collision Avoidance 4. Vision Enhancement for Crash Avoidance 5. Safety Readiness 6. Pre-Crash Restraint Deployment 7. Automated Highway Systems

Source: National ITS Program Plan, Draft, November 1994.

Core Infrastructure

The Federal Highway Administration (FHWA) considers implementation of a "core infrastructure" to be a necessary ingredient in deploying traffic management and traveler information services. The core infrastructure establishes a foundation upon which ITS deployment by both the public and private sectors can proceed. Development of the core infrastructure is a near-term (and evolutionary) deployment activity lead by the public sector. FHWA has defined core infrastructure in seven elements:[2]

- Regional Multimodal Traveler Information Center;
- Traffic Signal Control System(s);
- Freeway Management System(s);
- Transit Management System(s);
- Incident Management Program;
- Electronic Fare Payment System(s); and
- Electronic Toll Collection System(s).

The Houston area has made significant progress in putting an ITS infrastructure in place. By 1996, a significant portion of the freeway management system will have computerized traffic management systems in place, as well as a central control facility.

THE PRIORITY CORRIDOR PROGRAM

ISTEA established the ITS Corridors Program as part of the ITS Act. In April 1993, USDOT designated four priority corridors to become test beds for ITS deployment. Selection of these priority corridors was based on seven specific criteria:

1. Traffic density.
2. Severe or extreme ozone nonattainment.

[2] Core ITS Infrastructure Elements for Metropolitan Area ATMS/ATIS Deployment, Working Paper by Federal Highway Administration, USDOT, Version 1.7, March 22, 1995.

3. Variety of transportation facilities
4. Inability to significantly expand capacity of existing facilities.
5. Significant mix of passenger, transit, and commercial motor carrier traffic.
6. Complexity of traffic patterns.
7. Potential contribution to implementation of National ITS Plan.

The four chosen priority corridors are:

- Northeast (IH-95) Corridor—Includes a corridor from Maryland to Connecticut, with numerous transportation agencies involved.
- Midwest Corridor—Includes the corridor from Gary, Indiana through Chicago to Milwaukee, Wisconsin.
- Southern California Corridor—Includes IH-10/IH-5 from Los Angeles to San Diego.
- Houston, Texas Corridor—Includes the area surrounding IH-45 and IH-10, essentially including urbanized Greater Houston.

Each of the corridors is unique in terms of area, demographics, transportation system characteristics, and institutional framework.

2.0 THE HOUSTON PRIORITY CORRIDOR

Designation of the Houston ITS Priority Corridor by FHWA provides an opportunity to coordinate advanced transportation programs currently being developed in Houston with the concepts and emerging technologies of ITS.

Houston has been a leader in traffic management for decades. TxDOT developed an operational freeway surveillance and control system in Houston in the mid-1960s on the Gulf Freeway. Subsequent research, development, and design by TxDOT culminated in the 1980s in the Computerized Transportation Management System (CTMS) concept for areawide transportation system management. This concept was merged with the joint TxDOT/METRO Surveillance Communication and Control (SC&C) concept to include development and operation of an extensive system of high occupancy vehicle (HOV) lanes. Further transportation system management planning resulted in a unified, multiagency (TxDOT, Metropolitan Transit Authority, City of Houston, Harris County) control center—the Houston TranStar Center (Center).

Transportation operations staff of the four agencies will occupy the Center when completed in late 1995. The Center will be the focal point for monitoring, operating, and coordinating areawide transportation systems, including:

- HOV (buses, vanpools, carpools) lanes on 161 kilometers (100 miles) of freeway;
- Extensive park and ride facilities;
- Motorist Assistance Program on all area freeways;
- Computerized Traffic Management System (CTMS) for over 370 kilometers (230 miles) of freeways; composed of:
  - vehicle detection systems
  - CCTV
  - changeable message signs
  - highway advisory radio
  - ramp metering

  - interchange signal control
  - fiber optic communications system
- Automatic Vehicle Identification (AVI) on 370 kilometers (230 miles) of freeway;
- Regional Computerized Traffic Signal System (2800 signalized intersections); and
- Emergency management operations.

HOUSTON PRIORITY CORRIDOR

In its designation of the Houston ITS Priority Corridor, FHWA defined the corridor as the area surrounding IH-45 and IH-10. These major urban freeways pass through the Houston area in a north-south and east-west orientation, intersecting near the Central Business District. Local agencies and FHWA consider the corridor to include the Greater Houston area.

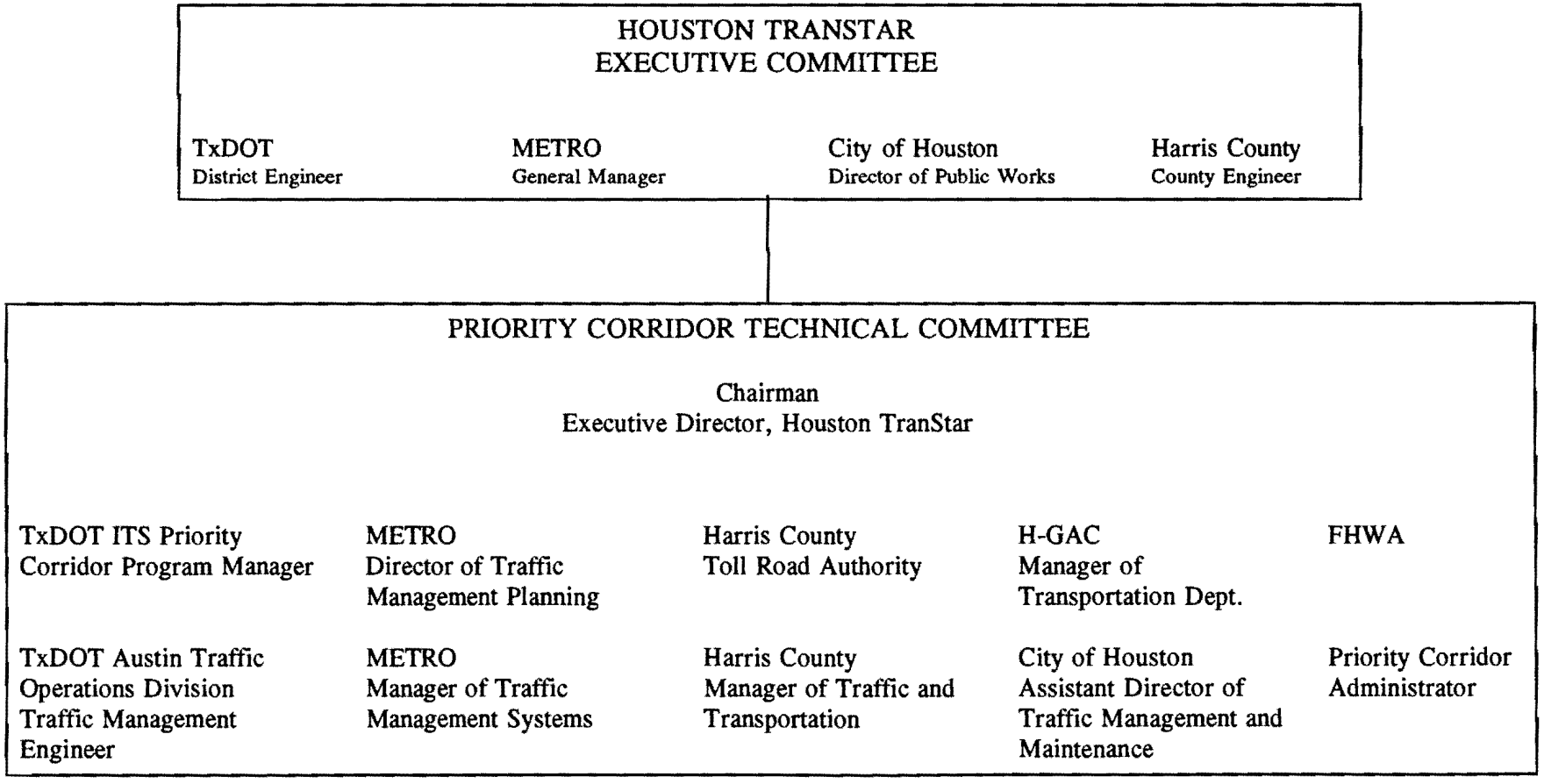
PROGRAM ORGANIZATION

The ITS Partnership Agreement between FHWA and TxDOT established and funded the Houston ITS Priority Corridor Program. The agreement establishes the framework for program development and administration and also recognizes the importance of involvement of other local agencies in management of the corridor. TxDOT, Harris County, City of Houston, and METRO entered into a Memorandum of Understanding to manage and implement the Houston ITS Priority Corridor Program.

The organizational structure for the Houston ITS Priority Corridor Coalition is shown in Figure 1. Top management members of the four coalition agencies comprise the Executive Committee. This committee, which also directs the Center, has overall management responsibility for the corridor program and its implementation.

The Technical Committee is responsible for the technical direction of the corridor program development, administration, and implementation. This committee played a key role in developing the Priority Corridor Program Plan and the individual deployment projects. In addition, this committee will guide deployment of these projects.

Figure 1. Organization of Houston ITS Priority Corridor Coalition



ITS CORRIDOR PROGRAM PLAN

Each of the four designated corridors is to develop a vision of ITS applications to be undertaken in the corridor. The ITS Corridor Program Plan for each corridor will identify projects, schedules, priorities, and estimated funding requirements. ITS Corridor Program Plans are to be consistent with national needs and the National Program Plan.

The Houston ITS Priority Corridor Program Plan will outline a 20-year vision of ITS deployment and will develop a program of specific deployment projects for five- and ten-year planning horizons.

Interim Report

Early activities in the corridor planning process involved a review of existing transportation system characteristics, identification of needs and opportunities, and definition of early action projects. Development of this Immediate Action Program permits implementation activities to proceed while the planning process continues. This early identification of projects also fulfilled programming and budgeting needs of TxDOT and USDOT for the Priority Corridors Program. This interim report serves to document existing system characteristics and the projects identified by the consortium of local governments to serve as the immediate action program.

3.0 EXISTING CORRIDOR CONDITIONS

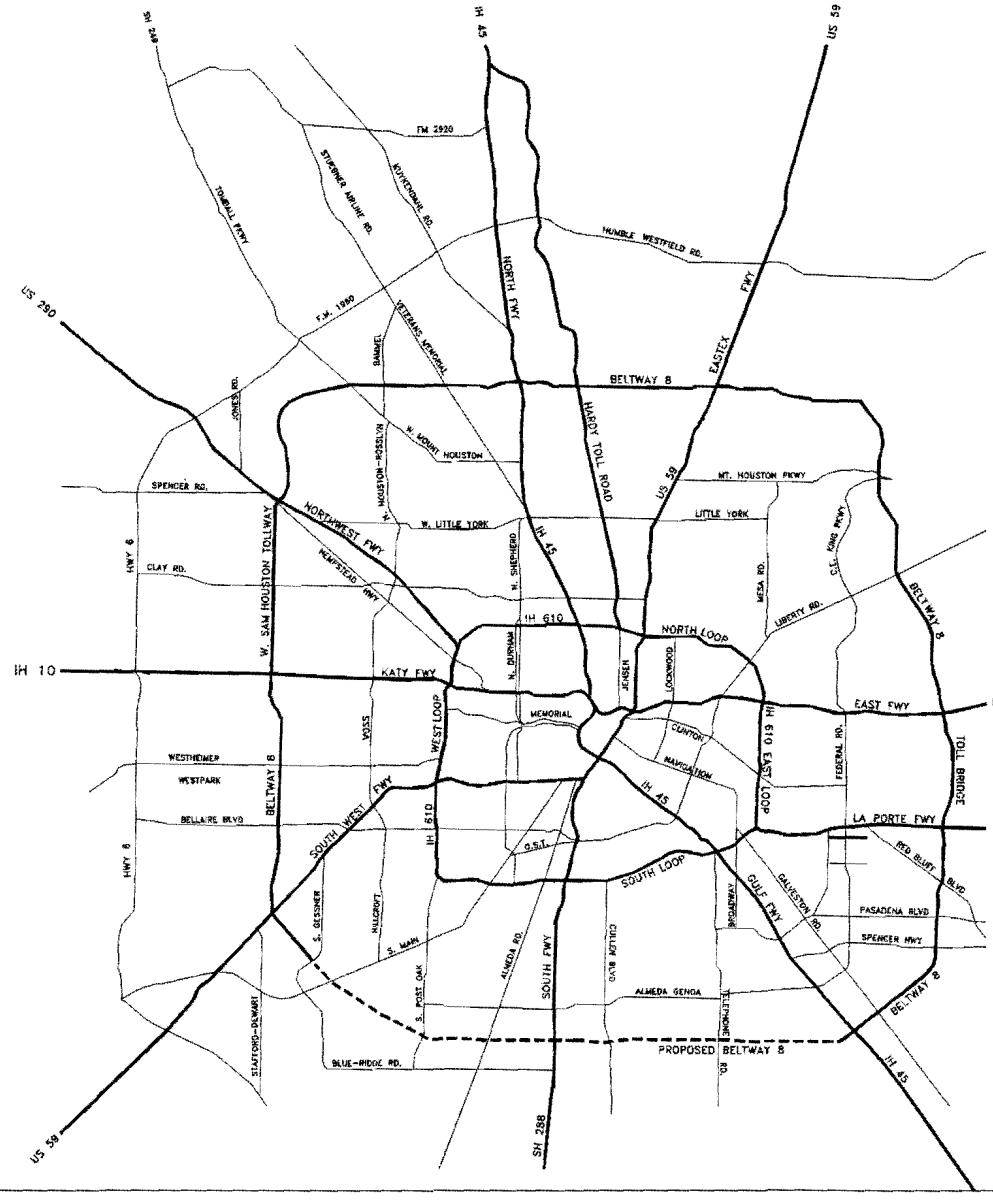
This chapter provides an overview of existing transportation facilities and resources in the corridor and overall descriptive measures of current traffic and transit operations. This review of existing corridor characteristics provides background and input in assessing the deployment potential of ITS technologies and applications.

In addition, this documentation provides a baseline upon which to measure and assess the overall impact of ITS program deployment. However, operational measures described in this chapter are broad in nature and intended to provide a snapshot of areawide conditions. Evaluation studies of individual deployment projects will include collection and analysis of operational data. Corridor characteristics include both physical and operational measures for the roadway system and public transportation.

ROADWAY SYSTEM CHARACTERISTICS

An extensive freeway and arterial system serves the Houston area, as illustrated in Figure 2. Nine radial (from the IH-610 Loop) freeways, a circumferential loop, and a beltway comprise the freeway system. The system also includes two toll roads: the Hardy Toll Road and the Sam Houston Toll Road (a portion of Beltway 8). The Sam Houston Toll Road will be extended to comprise the mainlanes of Beltway 8 for most of its length. The freeway system focuses on the Central Business District and also serves other major activity centers (Figure 3).

Physical characteristics, as well as representative daily traffic volumes, of area freeways are summarized in Table 2. Freeways typically have six to ten main lanes, with access provided by slip ramps which connect with parallel continuous frontage roads. Houston area freeways are typically developed with continuous frontage roads, generally over their entire length. This provides operational flexibility, particularly when the mainlanes experience incidents or congestion.



HOUSTON AREA FREEWAYS AND PRINCIPAL ARTERIALS

LEGEND

FREEWAYS

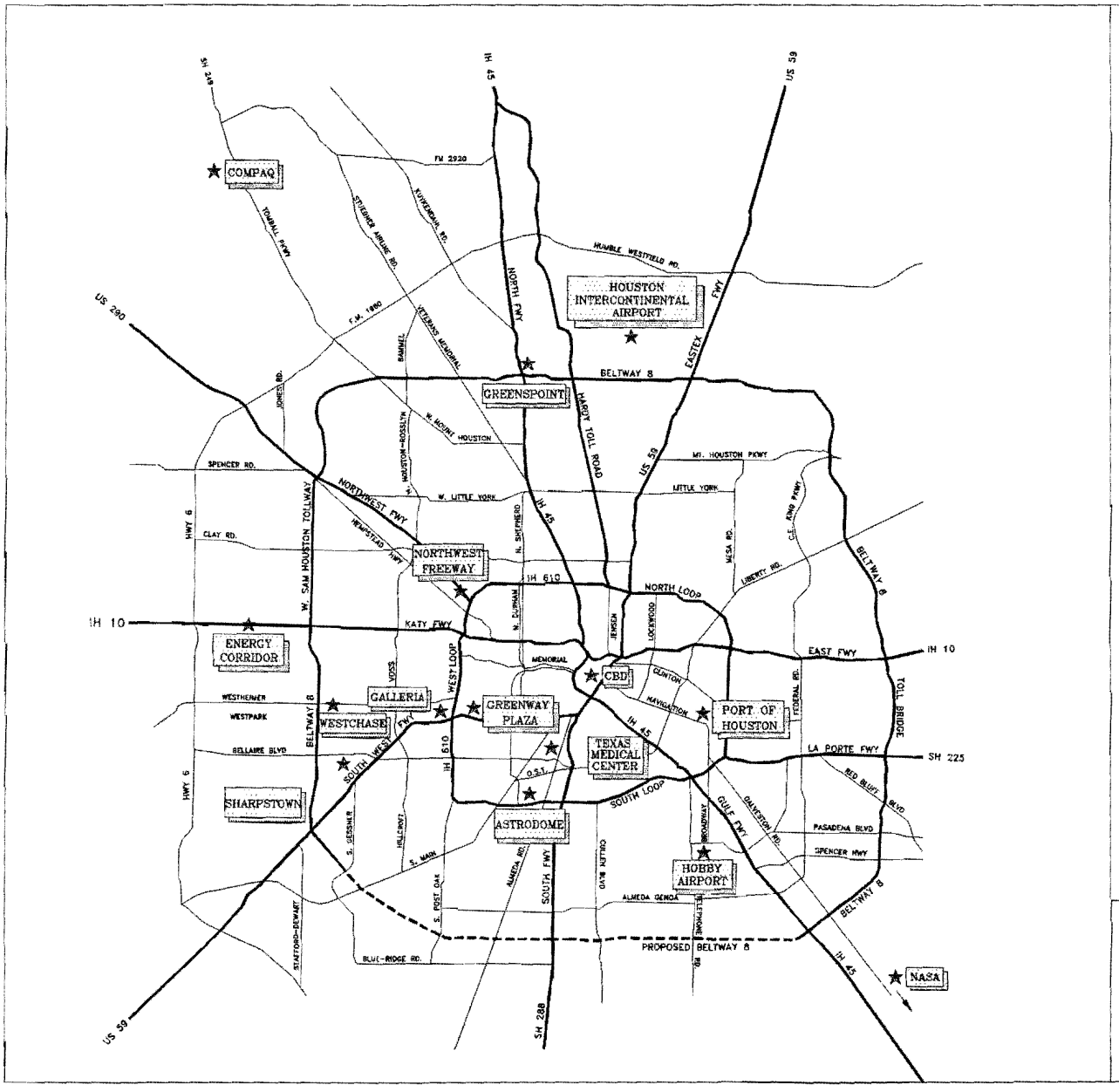
PRINCIPAL ARTERIALS

SCALE

1 2 3 4 5 MILES

N

FIGURE 2



MAJOR ACTIVITY CENTERS

LEGEND

ACTIVITY CENTERS

SCALE 1 2 3 4 5 MILES

N

FIGURE 3

Table 2. Corridor Freeway Characteristics

Freeway Corridor	Freeway Segment	Cross Section At Count Location		Traffic[1] Volume	Count Location (Cross Street)
		No. Lanes By Direction	HOV Status	ADT	
IH-45N North Freeway	FM 1960 to Beltway 8	3 Main 2 Front	No HOV	123,620	South FM 1960
	Beltway 8 to IH-610N	4 Main 2 Front	1 HOV	206,940	North Shepherd
	IH-610 N to CBD	4 Main 3 Front	1 HOV	192,290	Link Road
U.S. 290 Northwest Freeway	FM 1960 to Sam Houston Tollway	3 Main 3 Front	1 HOV	107,340	FM 529
	Sam Houston Tollway to IH-610N	4 Main 3 Front	1 HOV	171,840	Antoine
IH-10W Katy Freeway	SH 6 to Sam Houston Tollway	3 Main 2 Front	1 HOV	175,480	Kirkwood
	Sam Houston Tollway to IH-610W	3 Main 3 Front	1 HOV	204,820	Gessner
	IH-610W to CBD	5 Main No Front	No HOV	191,320	Taylor
U.S. 59S Southwest Freeway	SH 6 to Sam Houston Tollway	3 Main 3 Front	No HOV	114,090	Harris/Fort Bend County Line
	Sam Houston Tollway to IH-610W	6 Main 2 Front	1 HOV	188,970	Westpark
	IH-610W to CBD	5 Main No Front	No HOV	232,080	Montrose
SH 288 South Freeway	SH 6 to IH-610S	4 Main 2 Front	No HOV	76,680	Bellfort
	IH-610S to CBD	4 Main 2 Front	No HOV	154,870	Southmore
IH-45S Gulf Freeway	SH 6 to Beltway 8	3 Main 2 Front	No HOV	96,890	Nasa Road 1
	Beltway 8 to IH-610S	3 Main 2 Front	1 HOV	147,370	Edgebrook
	IH-610S to CBD	4 Main 3 Front	1 HOV	196,550	Wayside
IH-10E East Freeway	Beltway 8 to IH-610E	4 Main 2 Front	No HOV	116,700	West Beltway
	IH-610E to CBD	4 Main 2 Front	No HOV	147,750	Waco
U.S. 59N Eastex Freeway	FM 1960 to Beltway 8	2 Main 2 Front	No HOV	99,090	Rankin
	Beltway 8 to IH-610N	3 Main 2 Front	No HOV	134,630	Bennington
	IH-610N to CBD	3 Main 3 Front	No HOV	123,090	Lorraine

[1] TxDOT Houston District Traffic Map, 1991.

TxDOT, along with METRO, is currently implementing a Computerized Traffic Management System (CTMS) on 372 kilometers (231 miles) of area freeways as illustrated in Figure 4. This freeway corridor management system has two separate, but integrated subsystems: mainlane freeway traffic management and HOV surveillance, communications, and control. A control center for the CTMS and other area transportation management operations is also under construction and will be completed in late 1995.

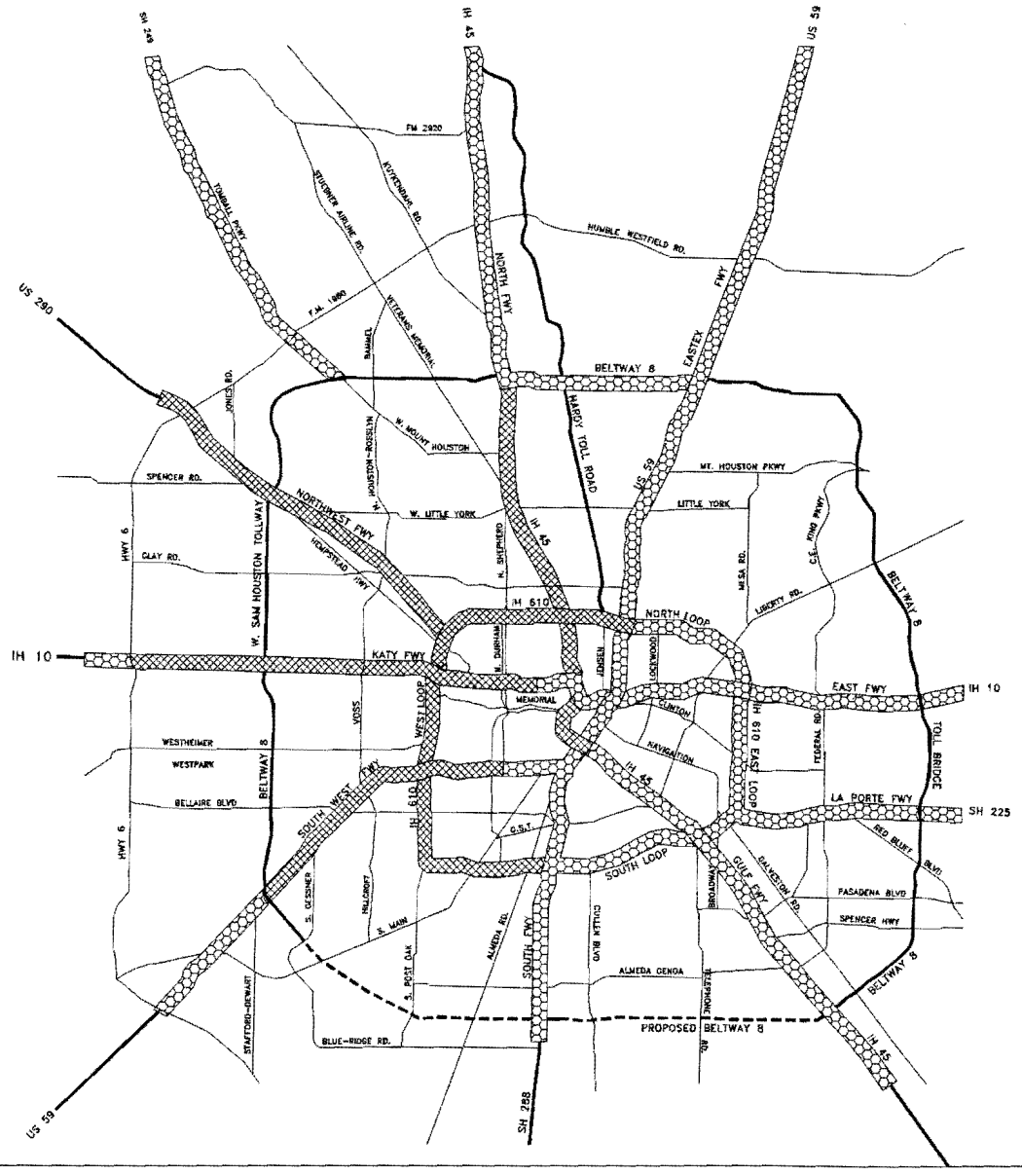
Staff of TxDOT, METRO, Harris County, and the City of Houston will occupy the Center. This staff will operate the surveillance, control, communications, and traveler information systems and respond to incidents, emergencies, and other operational needs.

METRO, Harris County, and the City of Houston are developing an advanced traffic signal system which will provide coordinated control over most of the Greater Houston area. The Regional Computerized Traffic Signal System (RCTSS) will modernize and coordinate 2800 traffic signals in a staged implementation program, shown in Figure 5.

PEAK PERIOD FREEWAY OPERATIONS

The freeway system is a key element in satisfying the mobility needs of the region. Freeways and associated HOV lanes create high capacity travel corridors which carry a high proportion of the area's vehicle trips. The highest travel demands occur during the peak morning and evening periods when work-related trips are predominant.

Travel speeds reflect the level of service of freeway operations. Table 3 summarizes average peak hour travel speeds for primary freeway sections. It should be noted that these are average speeds over freeway sections several kilometers (miles) long, and significant speed differences may exist in these aggregated sections. Generalized peak hour levels of service for these freeway sections are also shown in Table 3. Levels of service of E or F are considered unacceptable for peak period operations.



COMPUTERIZED TRANSPORTATION MANAGEMENT SYSTEM (CTMS) DEVELOPMENT

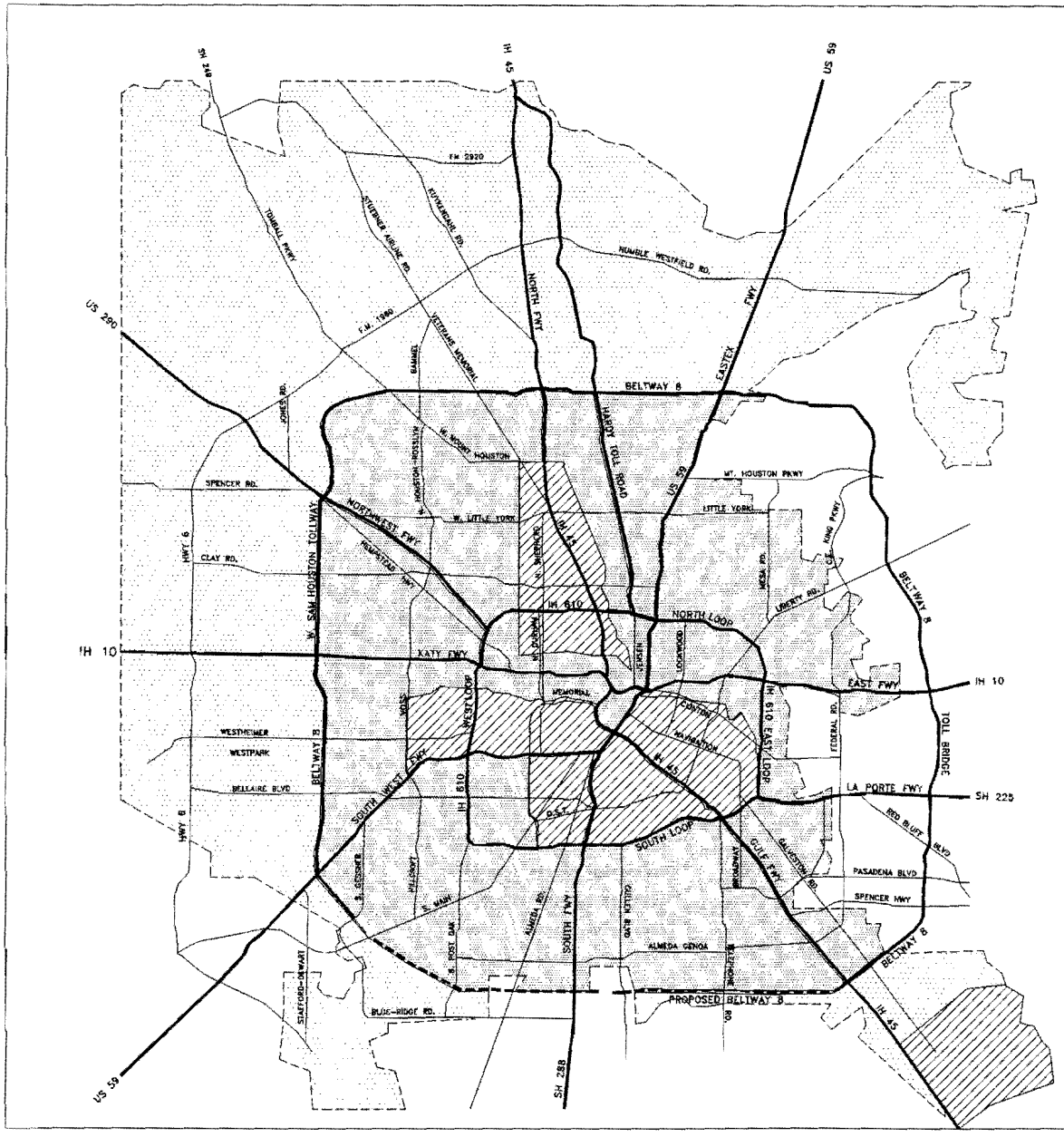
LEGEND

- UNDER CONSTRUCTION
- PLANNED

SCALE 1 2 3 4 5 MILES

N

FIGURE 4



REGIONAL COMPUTERIZED TRAFFIC SIGNAL SYSTEM (RCTSS)

LEGEND

- IN DESIGN/CONSTRUCTION
- IN ENGINEERING
- FUTURE EXPANSION

SCALE 1 2 3 4 5 MILES

N

FIGURE 5

Table 3. Peak Hour Freeway Speeds and Levels of Service

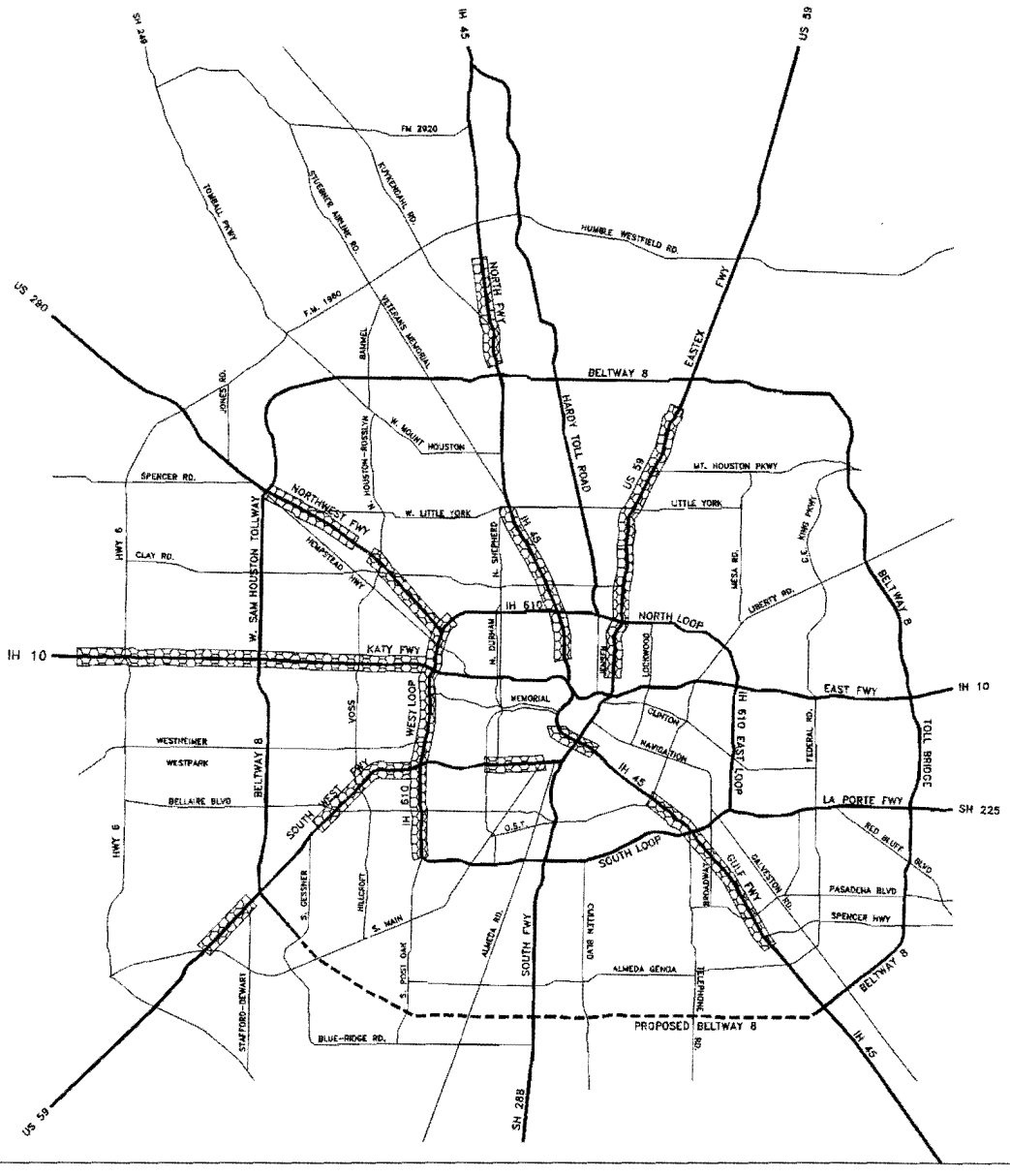
Freeway Corridor	Freeway Segment	Average Speed—KPH (MPH) In Peak Direction		LEVEL OF SERVICE[3] IN PEAK DIRECTION	
		AM Peak[1] Hour	PM Peak[2] Hour	AM Peak[1] Hour	PM Peak[2] Hour
IH-45N North Freeway	Airtex to Beltway 8	55 (34.2)	65 (40.6)	E	E
	Beltway 8 to IH-610N	65 (40.4)	59 (36.5)	E	E
	IH-610N to CBD	68 (42.1)	62 (38.3)	E	E
U.S. 290 Northwest Freeway	FM 1960 to Sam Houston Tollway	97 (60.2)	92 (57.4)	A	B
	Sam Houston Tollway to IH-610N	56 (34.6)	56 (34.5)	E	E
IH-10W Katy Freeway	SH 6 to Sam Houston Tollway	52 (32.6)	68 (42.0)	E	E
	Sam Houston Tollway to IH-610W	36 (22.3)	49 (30.4)	F	E
	IH-610W to CBD	83 (51.4)	91 (56.4)	D	C
U.S. 59S Southwest Freeway	U.S. 90A to Sam Houston Tollway	70 (43.4)	50 (31.2)	E	E
	Sam Houston Tollway to IH-610W	70 (43.7)	66 (41.0)	E	E
	IH-610W to CBD	75 (46.6)	61 (37.6)	D	E
IH-45S Gulf Freeway	FM 1959 to Beltway 8	86 (53.3)	80 (49.8)	D	D
	Beltway 8 to IH-610S	56 (35.0)	43 (26.6)	E	F
	IH-610S to CBD	70 (43.6)	59 (36.6)	E	E
U.S. 59N Eastex Freeway	FM 1960 to Beltway 8	77 (47.6)	77 (47.7)	D	D
	Beltway 8 to IH-610N	59 (36.9)	68 (42.5)	E	E
	IH-610N to CBD	54 (33.8)	83 (51.4)	E	D
IH-610W West Loop Northbound	Braes Bayou to U.S. 59S	80 (49.8)	91 (56.6)	D	C
	U.S. 59S to Buffalo Bayou	87 (53.9)	28 (17.7)	D	F
	Buffalo Bayou to U.S. 290	91 (56.6)	65 (40.2)	C	E
IH-610W West Loop Southbound	U.S. 290 to Buffalo Bayou	51 (31.5)	54 (33.3)	E	E
	Buffalo Bayou to U.S. 59S	87 (53.9)	42 (25.9)	D	F
	U.S. 59S to Braes Bayou	95 (58.9)	88 (54.4)	B	C

Source: Texas Transportation Institute, 1993.
[1] AM Peak Hour is 7:00 a.m.—8:00 a.m.
[2] PM Peak Hour is 5:00 p.m.—6:00 p.m.
[3] Based on Highway Capacity Manual.

Peak period congestion and queuing occur, to varying degrees, on each of the freeways, as shown in Figure 6 (morning peak period) and Figure 7 (evening peak period). Sections which experienced travel speeds less than 56 kilometers per hour (35 miles per hour) during the peak period are defined as congested sections.

HIGH OCCUPANCY VEHICLE (HOV) FACILITIES

METRO and TxDOT have developed an extensive system of HOV lanes, primarily located in freeway medians. METRO buses (operating from park and ride lots or as fixed route express buses), vanpools, and carpools utilize these facilities. The HOV system currently has



RECURRENT FREEWAY CONGESTION AM PEAK PERIOD

LEGEND

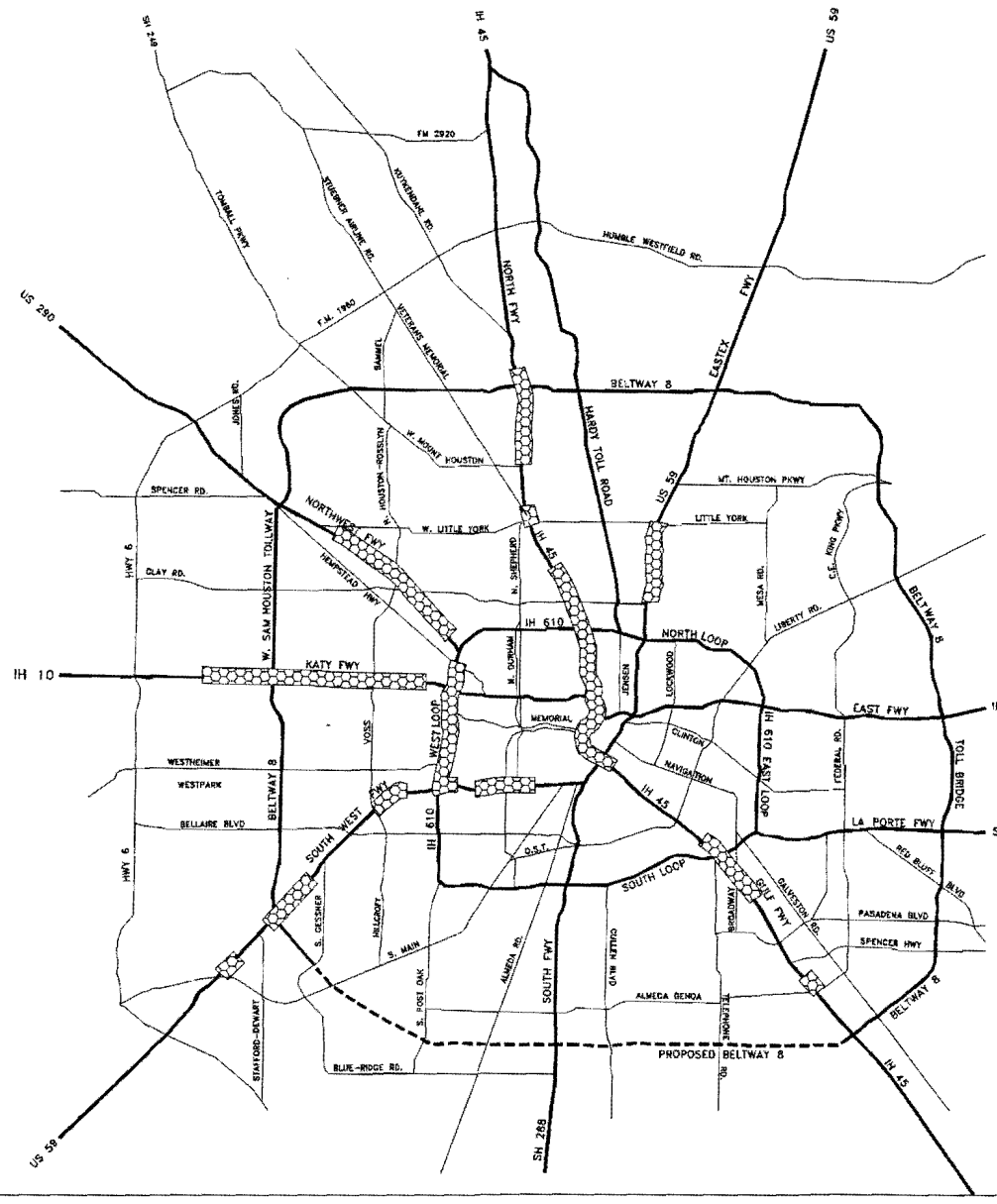
RECURRENT CONGESTION IN PEAK FLOW DIRECTION

SCALE

1 2 3 4 5 MILES

N

FIGURE 6



RECURRENT FREEWAY CONGESTION PM PEAK PERIOD

LEGEND

RECURRENT CONGESTION IN PEAK FLOW DIRECTION

SCALE

1 2 3 4 5 MILES

N

FIGURE 7

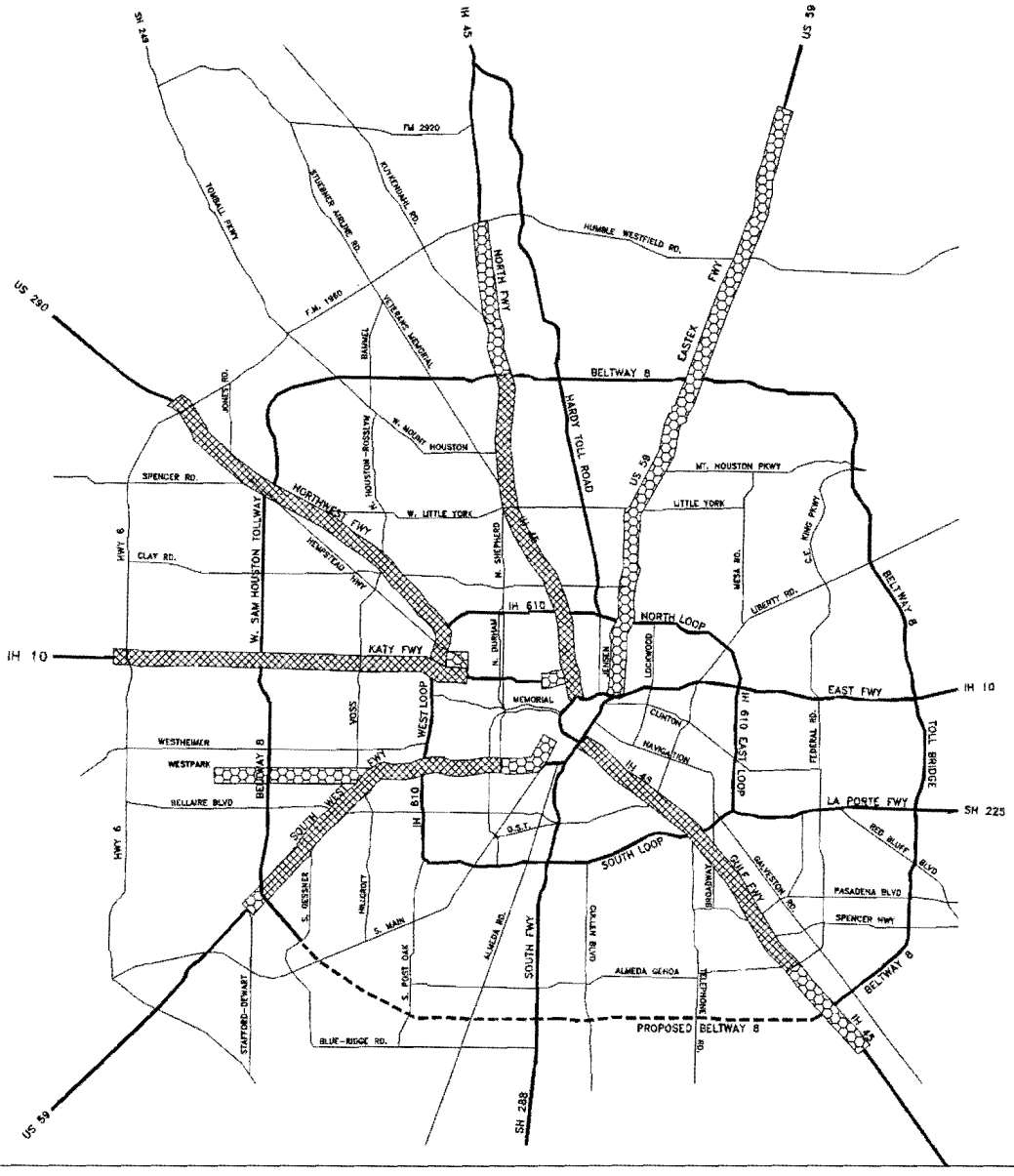
103 kilometers (64 miles) of one-lane, reversible HOV lanes in operation; 34 kilometers (21 miles) under construction, and 31 additional kilometers (19 additional miles) planned, for an ultimate system of 167 kilometers (104 miles), as shown in Figure 8. METRO operates approximately 830 peak period bus trips daily on the HOV lanes, as summarized in Table 4.

Table 5 provides a detailed summary of average daily HOV lane operation. The HOV lane system provides over 77,000 person-trips per day. Historical HOV lane usage is illustrated in Figure 9. This chart shows the staged development since 1979 of the HOV lane system, and the increasing number of persons and vehicles served.

PUBLIC TRANSPORTATION SERVICE

METRO is the region's transit agency, serving a significant portion of Harris County and a portion of Fort Bend County. A countywide election in 1978 created METRO. The election also approved a one-cent sales tax to partially fund the system. METRO is more than a transit system, with a broader transportation role which includes developing and operating HOV facilities, park and ride lots, local and express transit service, and paratransit service for the disabled. In addition, METRO participates in the operation of a motorist assistance program (MAP), is developing a regional traffic signal system, and assists local governments in building arterial streets through its regional mobility projects.

METRO operates a fleet of over 1,200 transit coaches on 3,220 kilometers (2,000 miles) of routes in its 3,315 square kilometer (1,280 square mile) service area. Annual ridership for the METRO system exceeds 60 million passenger trips. Much of METRO's fixed route service is oriented to the Central Business District, although METRO also operates crosstown, circulator, and shuttle routes. METRO's paratransit service, METROLIFT, serves the mobility needs of the disabled. More than 700,000 passenger trips are made annually on the 98 van METROLIFT system. Thirteen transit centers (four regional, nine neighborhood) provide opportunities for transferring between routes, as well as serving major activity centers. Existing and planned transit centers are shown in Figure 10.



HIGH OCCUPANCY VEHICLE LANE FACILITIES

LEGEND

- OPERATIONAL
- PLANNED/UNDER CONSTRUCTION

SCALE

1 2 3 4 5 MILES

N

FIGURE 8

Table 4. Transit Service Utilizing HOV Lanes

HOV Lane	Transit Route	Type of Service	HOV Lane Entry Point	AM Peak Period[1] Inbound		PM Peak Period[2] Outbound	
				Total Number of Buses in Period	Average Number of Buses Per Hour	Total Number of Buses in Period	Average Number of Buses Per Hour
Katy HOV Lane (IH-10W)	Wilcrest	Express	Gessner	8	2	8	2
	Memorial	Express	Gessner	19	5	21	6
	West Belt	Park-and-Ride	Gessner	13	4	12	3
	Kingsland	Park-and-Ride	Eldridge	14	4	19	5
	Addicks	Park-and-Ride	Addicks	29	8	30	9
	Uptown/Post Oak	Park-and-Ride	Eldridge	11	3	12	3
North HOV Lane (IH-45N)	IAH	Express	North Belt	11	3	11	3
	North Shepherd	Park-and-Ride	North Shepherd	15	4	19	5
	Kuykendahl	Park-and-Ride	North Belt	36	10	37	11
	Spring	Park-and-Ride	North Belt	24	7	25	7
	FM 1960	Park-and-Ride	North Belt	7	2	8	2
	Seton Lake	Park-and-Ride	North Shepherd	22	6	24	7
	North Shepherd/ Texas Medical Center	Park-and-Ride	North Shepherd	4	1	4	1
Gulf HOV Lane (IH-45S)	South Belt	Express	Broadway	7	2	7	2
	Edgebrook	Park-and-Ride	Broadway	20	6	22	6
	Bay Area	Park-and-Ride	Broadway	24	7	26	7
Northwest HOV Lane (U.S. 290)	Northwest Station	Park-and-Ride	Northwest Station	25	7	26	7
	W. Little York	Park-and-Ride	W. Little York	8	2	7	2
	Pinemont	Park-and-Ride	Pinemont	9	3	8	2
Southwest HOV Lane (U.S. 59S)	Harwin	Express	Hillcroft	23	7	22	6
	Fondren	Express	Hillcroft	15	4	17	5
	West Loop	Park-and-Ride	West Loop	16	5	16	5
	Westwood	Park-and-Ride	Westwood	17	5	17	5
	Alief	Park-and-Ride	Westwood	14	4	16	5
	West Bellfort	Park-and-Ride	West Bellfort	12	3	12	3

[1] AM Peak Period is 6:00 a.m.—9:30 a.m.
[2] PM Peak Period is 3:30 p.m.—7:00 p.m.

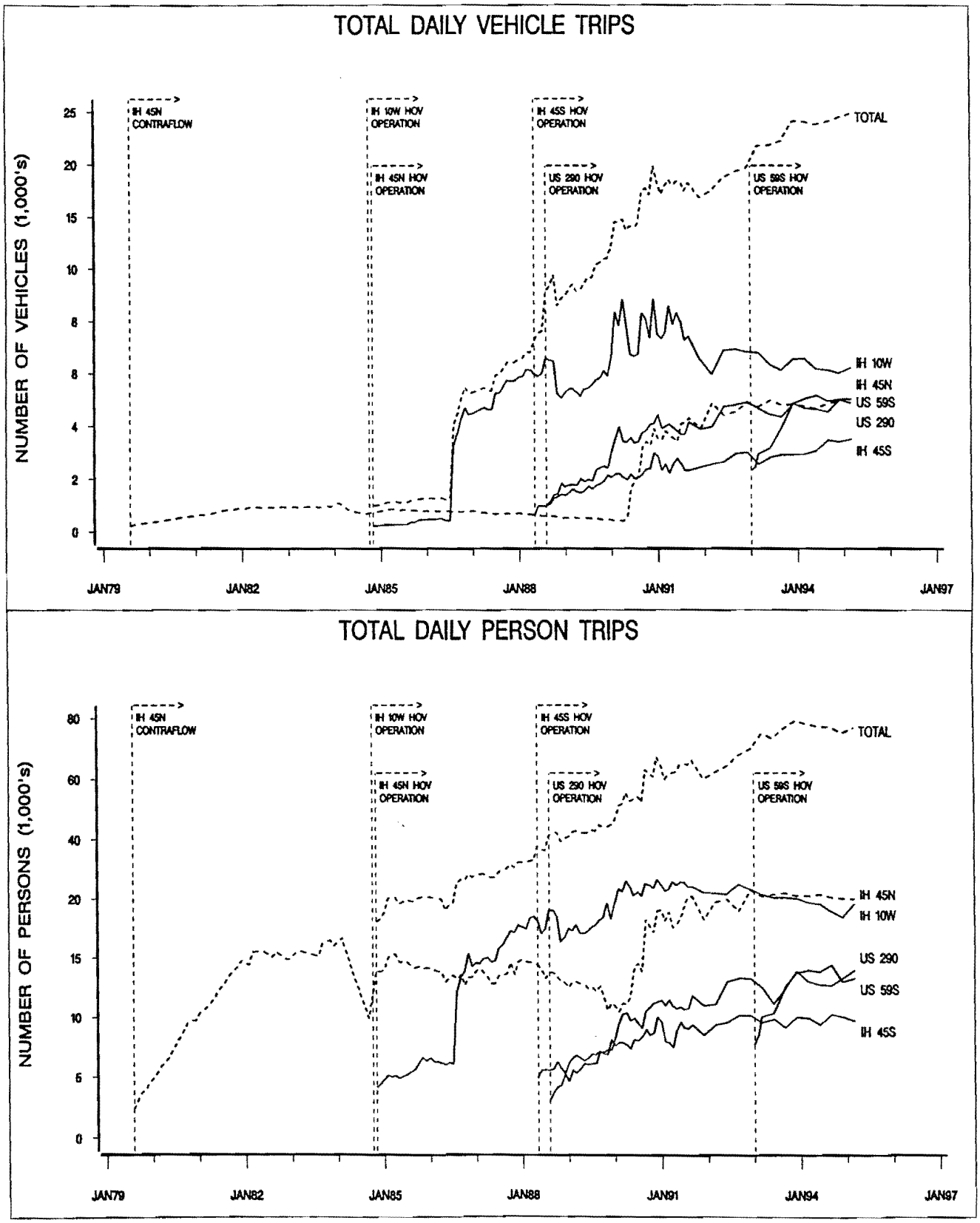
Table 5. High Occupancy Vehicle Lane Daily Operation

	Katy HOV Lane		North HOV Lane		Gulf HOV Lane		Northwest HOV Lane		Southwest HOV Lane		Total HOV Lane	
	Vehicles	Persons	Vehicles	Persons	Vehicles	Persons	Vehicles	Persons	Vehicles	Persons	Vehicles	Persons
AM PEAK HOUR[1]												
Buses	30	1,365	59	2,395	28	780	18	960	19	650	154	6,150
Vanpools	9	81	34	303	16	116	9	81	5	39	73	620
Carpools	757	1,800	1,153	2,394	766	1,601	1,606	3,280	1,220	2,515	5,502	11,590
Motorcycles	4	4	0	0	3	3	4	4	4	4	15	15
Total	800	3,250	1,246	5,092	813	2,500	1,637	4,325	1,248	3,208	5,744	18,375
AM PEAK PERIOD[2]												
Buses	79	2,920	123	4,620	56	1,290	40	1,905	49	1,370	347	12,105
Vanpools	26	204	86	726	30	210	18	156	20	159	180	1,455
Carpools	2,377	5,296	2,174	4,546	1,442	3,005	2,622	5,328	2,227	4,600	10,842	22,775
Motorcycles	12	12	7	7	6	6	8	8	5	5	38	38
Total	2,494	8,432	2,390	9,899	1,534	4,511	2,688	7,397	2,301	6,134	11,407	36,373
PM PEAK HOUR[1]												
Buses	26	1,210	57	2,275	19	710	20	1,015	25	660	147	5,870
Vanpools	59	193	43	347	24	204	11	103	15	155	152	1,002
Carpools	870	1,905	984	2,046	814	1,752	1,044	2,164	1,130	2,365	4,842	10,232
Motorcycles	5	5	3	3	2	2	0	0	0	0	10	10
Total	960	3,313	1,087	4,671	859	2,668	1,075	3,282	1,170	3,180	5,151	17,114
PM PEAK PERIOD[3]												
Buses	72	3,215	118	4,320	43	1,370	38	1,955	64	1,350	335	12,210
Vanpools	132	483	93	716	38	313	19	161	39	356	321	2,029
Carpools	2,210	4,818	2,067	4,299	1,573	3,367	1,945	4,074	2,319	4,848	10,114	21,406
Motorcycles	15	15	4	4	2	2	4	4	3	3	28	28
Total	2,429	8,531	2,282	9,339	1,656	5,052	2,006	6,194	2,425	6,557	10,798	35,673
TOTAL DAILY												
Buses	151	6,135	241	8,940	99	2,660	78	3,860	113	2,720	682	24,315
Vanpools	158	687	179	1,442	68	523	37	317	59	515	501	3,484
Carpools	5,905	12,750	4,684	9,731	3,358	7,058	4,773	9,814	4,868	10,092	23,588	49,445
Motorcycles	27	27	11	11	8	8	12	12	8	8	66	66
Total	6,241	19,599	5,115	20,124	3,533	10,249	4,900	14,003	5,048	13,335	24,837	77,310

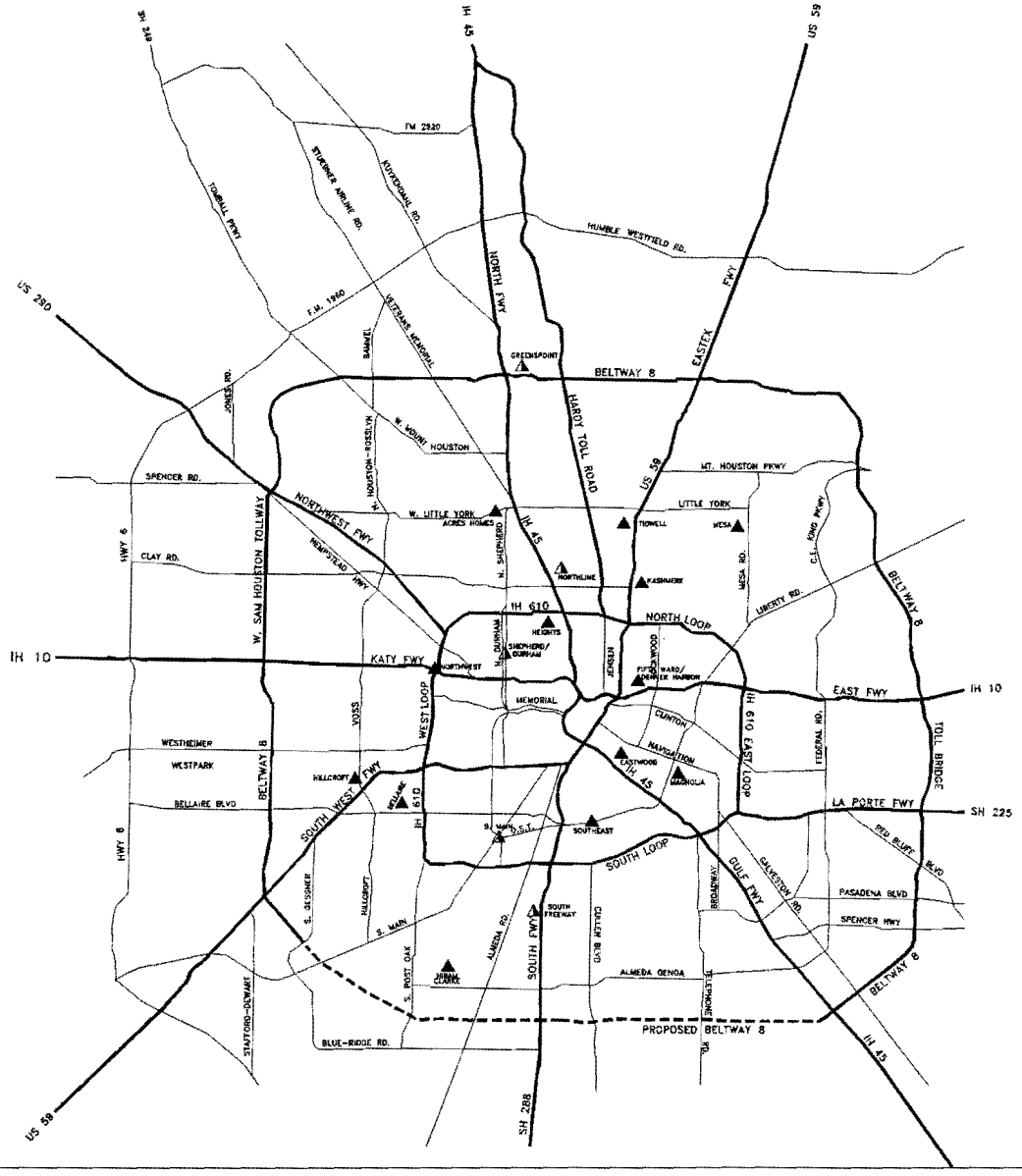
[1] PEAK HOUR varies by facility.
[2] AM PEAK PERIOD is 6:00 a.m.—9:30 a.m.
[3] PM PEAK PERIOD is 3:30 p.m.—7:00 p.m.

Source: Houston High-Occupancy Vehicle Lane Operations Summary, Texas Transportation Institute, March 1995.

FIGURE 9. HISTORICAL HOV LANE USAGE



Source: Houston High Occupancy Vehicle Lane Operations Summary, Texas Transportation Institute, March 1995.



METRO TRANSIT CENTERS

LEGEND

- EXISTING
- PROPOSED

SCALE

1 2 3 4 5 MILES

N

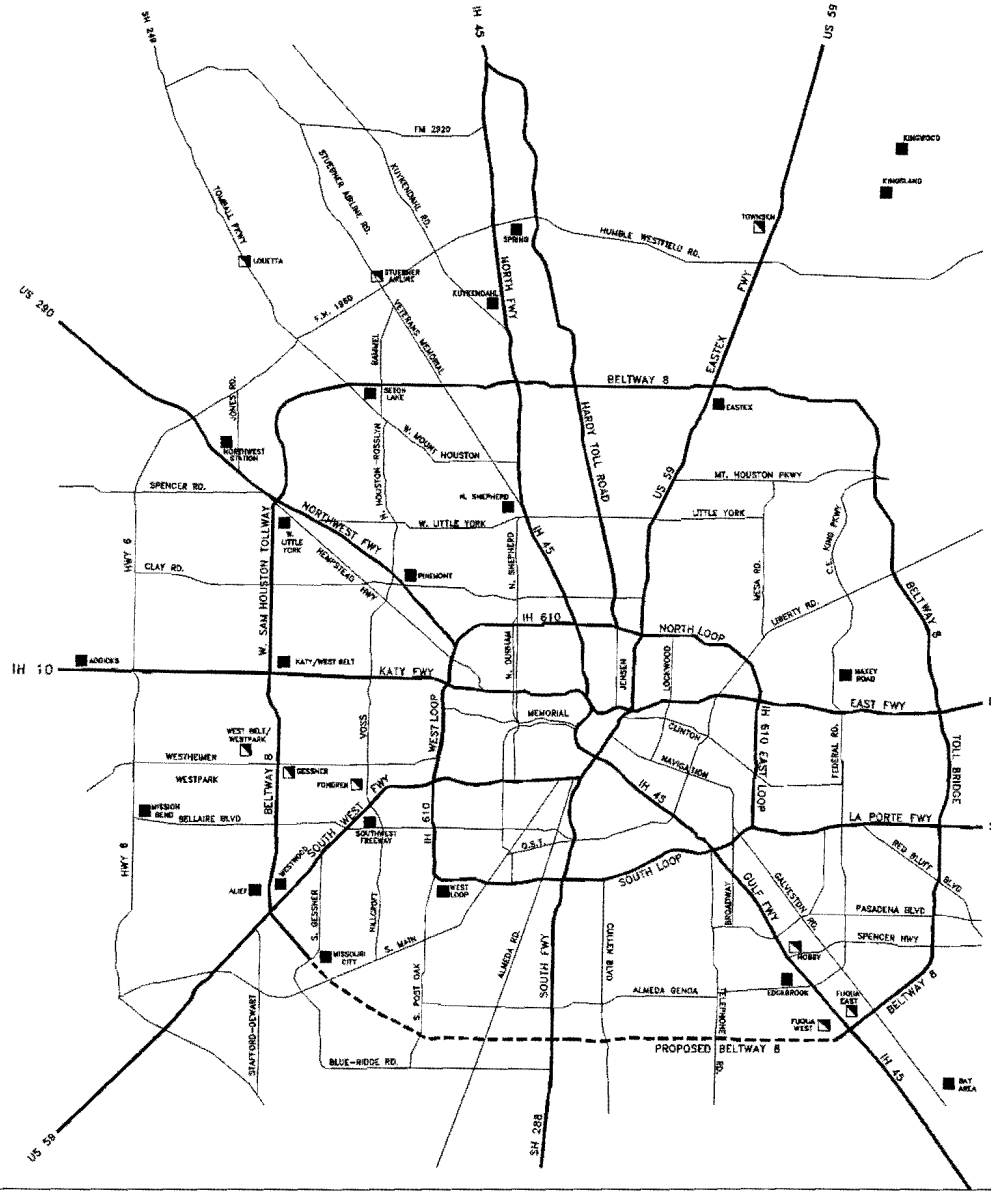
FIGURE 10

METRO operates commuter service from a number of park and ride lots to serve buses, carpools, and vanpools. A number of park and ride lots have direct access to HOV lanes located in freeway medians. Other park and ride lots typically provide bus service with a portion of their routing along HOV lanes. There are currently 22 park and ride lots in operation with nine planned for future development as shown in Figure 11. Existing park and ride facilities have over 24,000 parking spaces, with an average daily usage of over 10,000 vehicles. In addition, TxDOT provides three park and pool lots on the IH-10 Katy Freeway, which have over 1,100 spaces. Table 6 summarizes capacity and average usage of park and ride and park and pool facilities.

ROADWAY DEFICIENCIES

The Houston-Galveston Area Council (H-GAC) conducted an analysis of the existing freeway and arterial system as reported in Issue Paper #3 of Access 2010: 1994 Update, Metropolitan Transportation Plan. H-GAC conducted a detailed analysis of individual freeway and arterial street segments, relating per-lane average daily traffic volumes to generalized daily lane capacity.

Results of the H-GAC analysis are summarized by sectors for Harris County in Table 7, with sectors identified in Figure 12. The inner southeast, inner southwest, and inner northwest sectors (Sectors 4, 5, and 6) have the highest percent deficient freeway lanes. The highest percent deficient thoroughfare lanes are in the inner southwest, inner northwest, southwest, and northwest (Sectors 5, 6, 9, and 10). On a geographic basis, the percent of deficient roadway sections tends to be higher in the western half of the county and outside IH-610.



PARK AND RIDE LOTS

LEGEND

- EXISTING
- PROPOSED

SCALE

1 2 3 4 5 MILES

FIGURE 11

Table 6. Park-and-Ride/Park-and-Pool Lot Utilization

		LOT CAPACITY (SPACES)	ANNUAL DAILY AVERAGE PARKED VEHICLES
Katy Freeway (IH-10W)	Kingsland Park-and-Ride	1,306	480
	Addicks Park-and-Ride	1,601	1,262
	West Belt Park-and-Ride	1,175	155
	Fry Road Park-and-Pool*	374	51
	Mason Road Park-and-Pool*	386	29
	Barker-Cypress Park-and-Pool*	409	19
	Corridor Totals	5,251	1,997
North Freeway (IH-45N)	N. Shepherd Park-and-Ride	1,603	313
	Kuykendahl Park-and-Ride	2,244	1,231
	Spring Park-and-Ride	1,263	673
	Seton Lake Park-and-Ride	1,286	500
	Woodlands Park-and-Ride**	990	878
	Corridor Totals	7,386	3,595
Gulf Freeway (IH-45S)	Edgebrook Park-and-Ride	1,009	476
	Bay Area Park-and-Ride	1,155	721
	Monroe Park-and-Ride	913	-
	Corridor Totals	3,077	1,197
Northwest Freeway (U.S. 290)	NW Station Park-and-Ride	1,202	1,290
	Little York Park-and-Ride	1,102	162
	Pinemont Park-and-Ride	938	174
	NW Transit Center Park-and-Ride*	195	74
	Corridor Totals	3,437	1,700
Southwest Freeway (U.S. 59S)	West Loop Park-and-Ride	978	291
	Westwood Park-and-Ride*	800	451
	Alief-Boone Park-and-Ride	1,373	237
	Missouri City Park-and-Ride	779	168
	Mission Bend Park-and-Ride	862	77
	W. Bellfort Park-and-Ride*	1,200	315
	Hillcroft T C Park-and-Ride*	895	215
	Corridor Totals	6,887	1,752
Total Park-and-Ride		24,869	10,141
Total Park-and-Pool		1,169	100
Total All Facilities		26,038	10,240

Source: Houston High-Occupancy Vehicle Lane Operations Summary, Texas Transportation Institute, March 1995.

Note: METRO data unless otherwise noted.
* Source: Texas Transportation Institute
** Source: Brazos Transit Authority

Table 7. Existing Roadway Deficiencies In Harris County

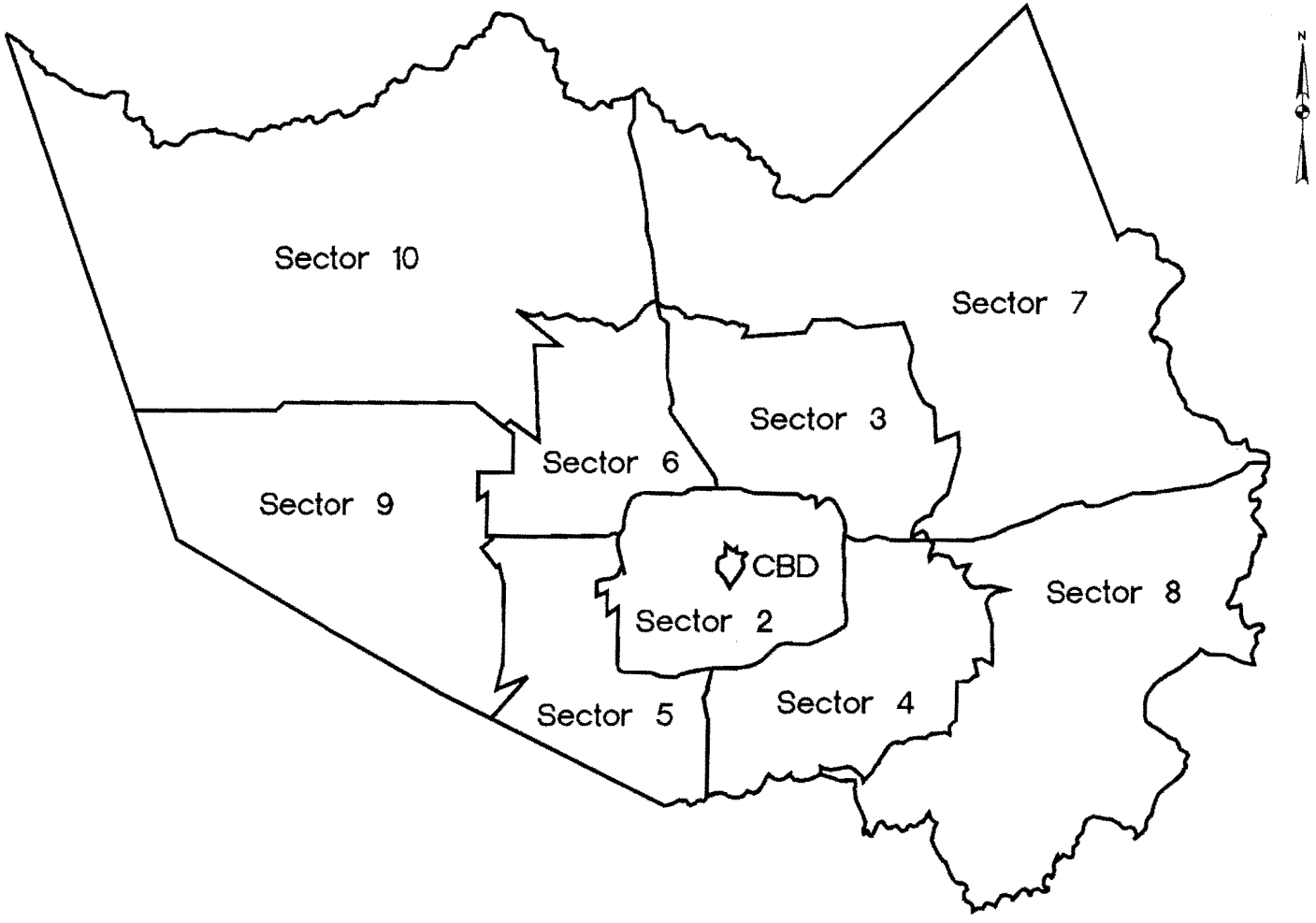
Sector Number	Lane Kilometers (Miles)		Percent Deficient Lane Kilometers (Miles) by Sector					
			FREEWAYS[1]			THOROUGHFARES[2]		
	Freeways	Thoroughfares	Heavy Congestion	Severe Congestion	Total	Heavy Congestion	Severe Congestion	Total
1. Central Business District	74.2 (46.1)	279.8 (173.8)	5	46	51	1	0	1
2. Inside IH-610	801.0 (497.5)	2,110.2 (1,310.7)	7	33	40	5	1	6
3. Inner NE	198.4 (123.2)	1,004.0 (623.6)	0	34	34	4	1	5
4. Inner SE	313.3 (194.6)	1,092.7 (678.7)	25	47	72	4	0	4
5. Inner SW	393.0 (244.1)	1,290.7 (801.7)	11	57	68	21	11	32
6. Inner NW	330.1 (205.0)	1,074.0 (667.1)	14	55	69	9	4	13
7. Northeast	159.6 (99.1)	1,327.6 (824.6)	9	33	42	6	3	9
8. Southeast	374.8 (232.8)	1,495.4 (928.8)	6	12	18	3	2	5
9. Southwest	275.8 (171.3)	1,368.3 (849.9)	20	23	43	10	6	16
10. Northwest	212.4 (131.9)	1,604.4 (996.5)	5	23	28	6	11	17
County Total	3,132.7 (1,945.8)	12,808.4 (7,955.5)	11	36	47	7	4	11

(1) Heavy Freeway Congestion = 17,500 - 20,000 vehicles/lane/day.
Severe Congestion = More than 20,000 vehicles/lane/day.

(2) Heavy Thoroughfare Congestion = 7,000 - 8,500 vehicles/lane/day.
Severe Thoroughfare Congestion = More than 8,500 vehicles/lane/day.

Source: Based on 1990 data from *Access 2010: 1994 Update, Metropolitan Transportation Plan*, Houston-Galveston Area Council, October 1994.

FIGURE 12
PLANNING SECTORS FOR HARRIS COUNTY



Source: Access 2010: 1994 Update, Metropolitan Transportation Plan, Houston Galveston Area Council. October, 1994.

4.0 IDENTIFICATION OF NEEDS AND IMMEDIATE ACTION PROGRAM

FHWA, which is responsible for the USDOT Priority Corridors Program, has developed the framework and provided guidance and direction for ITS project planning. Two important elements of the program are the concept of addressing user service needs and the development of a core infrastructure. These two factors were considered in reviewing existing characteristics/conditions of the corridor, identifying needs, and developing immediate action ITS projects.

NEEDS AND DIRECTION FOR DEPLOYMENT

Considering available and imminent transportation resources in the Houston area and a review of transportation system operational measures and deficiencies, a direction for ITS deployment has evolved. This focus on deployment also reflects the ITS mission and goals. The primary focus for the Houston Priority Corridor, particularly during the initial five years, is in four general areas: institutional arrangements, core infrastructure, transportation management, and traveler information.

Institutional Arrangements

A strength of the Houston Priority Corridor is its institutional framework with four agencies working in close coordination. However, within this framework of varied policies, procedures, and administrative requirements, it is important to develop institutional mechanisms to efficiently deploy and operate Priority Corridor projects. Institutional arrangements are being developed that will enhance interagency cooperation and foster program effectiveness so that deployment of ITS projects can move quickly and efficiently. The Priority Corridor Program anticipates deployment of numerous individual ITS projects and contracts. A consistent project deployment approach must be developed so that agency approaches to project development and contracting can be reviewed and the most effective approaches pursued with the agencies.

Expansion of the institutional structure should be considered in the future. This expansion could include additional area agencies and interested private sector organizations and companies.

Develop Core Infrastructure

The Houston area has made significant progress in putting an ITS infrastructure in place. This development is "in process," with current freeway projects (CTMS and AVI) expected to be completed by 1996. The Center will be completed in late 1995. On-going development is putting in place the individual pieces of an infrastructure comprised of ITS technologies and techniques. There is a need to accelerate core infrastructure in other areas and to pursue early action projects which are consistent with the concept of an ITS core infrastructure. These areas for emphasis of core infrastructure development are:

- Regional Multimodal Traveler Information Center;
- Traffic Signal Control Systems;
- Transit Management Systems; and
- Incident Management Systems.

Transportation Management

Multimodal transportation system management will be an important element in early action projects. This emphasis on transportation management/operations is consistent with long-standing local priorities, which include the CTMS/control center development. Transportation management will reduce congestion, improve safety, and improve operational efficiency. Efforts in this area will also serve to extend the core infrastructure. Transportation management elements of highest need include:

- Optimizing freeway corridor operations;
- Managing freeway incidents (including Motorist Assistance Program);
- Managing HOV operations;

- Optimizing arterial street operations; and
- Maximizing effectiveness of transit operations.

Traveler Information

The CTMS, AVI, MAP, and Smart Bus systems, operated and coordinated through the Center, will provide the foundation of real time areawide traffic data necessary for deployment of traveler information systems. This combined deployment is consistent with the core infrastructure element calling for a regional multimodal traveler information center, which will be integral with the Center. Features of the traveler information systems should include:

- Real time travel condition monitoring to include real time speed, travel time, and incident information;
- Roadside information systems utilizing changeable message signs and highway advisory radio;
- Fixed site information delivery—real time information delivery to home, office, major generator by computer kiosk or Internet;
- In-vehicle information utilizing evolving wireless and digital device technologies; and
- Transit operations—bus schedules, next bus arrivals, and general transit rider information would be provided for fixed route and for park and ride operations at points of major transit activity in home and at workplace.

OVERVIEW OF THE PROGRAM PLAN

The Houston ITS Priority Corridor Program Plan is being developed in three time frames: Short Range (1996-2000), Intermediate Range (2001-2005), and Long Range (2006-2015), envisioning ITS development through approximately the year 2015. The initial five years are the most important in deployment of ITS projects under the USDOT Priority Corridor Program. The vision of needs and opportunities is clearest in the initial five years.

The framework of the Plan and its direction though the 20-year horizon are as follows:

Short Range (1996-2000)

Emphasis during this time period will be on addressing the areas of indicated need and highest potential for success. Specific deployment projects, including those projects in the Immediate Action Program, will be defined for this five-year program. Focus of the five-year program will be on the following:

- develop core infrastructure/systems - this effort will build on and extend infrastructure development currently underway;
- test concepts, technologies, and user acceptance in deployed projects;
- focus on short time frame projects (14 projects, totalling $9,192,500, have been identified as "early-action" projects); and
- flexibility in deployment projects, permitting modification of projects (or even termination) based on deployment and evaluation results.

Intermediate Range (2001-2005)

The second time period will provide the opportunity to build on the experience of the initial Houston projects and successful ITS deployment projects in other areas. Features of this five-year program include:

- identify additional core infrastructure needed for areawide deployment of proven concepts and technologies;
- pivot from successful Houston ITS projects and experience to expand the deployment areawide or to modify and enhance capabilities; and
- deploy in the Houston Priority Corridor, those ITS projects from other locations (U.S. and abroad) which have been successful or show promise for deployment in the Houston area.

Long Range Plan (2006-2015)

The vision for the second 10 years is an ITS technology which has matured to facilitate wider deployment of transportation management and traveler information systems, but which also benefits from nationwide/industrywide development of commercial vehicle systems, in-vehicle communication, advanced vehicle control, and automated highway systems. With ITS technology (i.e., control, communication, computer, electronics) moving rapidly, a more refined vision of the ITS deployment is difficult.

DEVELOPMENT OF IMMEDIATE ACTION PROGRAM

The immediate action program has been developed over the time period since the designation by FHWA of the Houston ITS Priority Corridor and the need for identification of projects for funding and programming. Some projects are logical continuations of prior development programs, while most others address user service needs through the deployment of new technologies or involve development of core infrastructure.

Project Development Process

The Priority Corridor Technical Committee and TTI staff used a project development process in defining project concepts and selecting recommended projects for the program. The following outline highlights this process.

Selection Process

- Development of needs and project concepts by agencies and Technical Committee;
- Project descriptions developed by Members of Technical Committee and local agencies;
- Assessment of Candidate Projects by Technical Committee—Highest rated-readily implementable projects have higher priority;

- Technical Committee develops recommended program; and
- Steering Committee approves program.

Evaluation Considerations

Evaluation, selection, and prioritization of Priority Corridor Projects are based on a generally qualitative, comparative assessment of candidate projects based on the following considerations:

- Core infrastructure/system development;
- Relationship to other planned projects (building blocks) and on-going projects;
- Impact on traffic congestion/air quality;
- Ease of implementation/project complexity;
- Cost of project;
- Compatibility with National ITS Program Plan;
- Number of persons/vehicles affected;
- Relative potential impact (greater need/higher pay-off);
- High potential for success;
- Distribution of projects among User Services/among agencies;
- FHWA input; and
- Needs of high demand/major activity centers.

Recommended Immediate Action Program

Fourteen projects have been developed for the Immediate Action Program. Table 8 provides a summary of these projects. Total estimated cost of these immediate action projects is $9,192,500. Twelve of the projects involve operational tests or core infrastructure development. Projects 2 and 5 involve development and updating of the program plan and program administration. The Appendix contains descriptions of the fourteen projects comprising the Immediate Action Program. FHWA has approved sufficient funding to provide 80 percent

funding of the Immediate Action Program (from FY 93, FY 94, and FY 95 Priority Corridor Program allocations).

Table 8. Proposed Immediate Action Program, Houston ITS Priority Corridor

Project Number[1]	Title	Estimated Cost	Lead Agency
1	CCTV Surveillance System Lease for Astrodome Area	$ 480,000	TxDOT
2	Development of ITS Priority Corridor Program Plan	400,000	TxDOT
3	Monitoring Traffic and Transit Conditions and Incident Detection with AVI (Phase 4)	1,830,000	TxDOT
4	Changeable Lane Assignment System (CLAS) on Frontage Roads	750,000	TxDOT
5	Public Information/Program Administration	200,000	TxDOT
6	Truck Monitoring and Warning Systems for Freeway to Freeway Connections	220,000	TxDOT
7	Real-Time Information Kiosks	750,000	TxDOT
8	Railroad Grade Crossing Monitoring System	500,000	TxDOT
9	Automatic Vehicle Locator for Incident Management	100,000	TxDOT
10	On-Vehicle Navigation/Information Applications	400,000	TxDOT
11	Monitoring and Information System for Environmental Conditions	500,000	TxDOT
12	Changeable Lane Assignment System (CLAS) at Arterial Intersections	250,000	Harris Co.
13	Integrated Corridor Transportation Management and Traveler Information System	1,862,500	TxDOT/ METRO
14	Washburn Tunnel Traffic Management and Information System	950,000	Harris Co.

[1] This is the Work Order Number in accord with the ITS Partnership Agreement between Federal Highway Administration and TxDOT.

SUMMARY

The Immediate Action Program for the Corridor is outlined in this report. Implementation activities are underway for each of the projects and are in various stages of planning, design, and evaluation.

Planning efforts are continuing for the Corridor Program Plan, with the identification of projects and activities for the Short Range and Intermediate Range programs underway.

APPENDIX

PROJECT DESCRIPTIONS

IMMEDIATE ACTION PROGRAM

PROJECT 1
CLOSED CIRCUIT TELEVISION SURVEILLANCE SYSTEM LEASE FOR THE ASTRODOME AREA

PROJECT OBJECTIVE: For traffic surveillance, most government agencies traditionally install their own communications medium for transmission of video signals from Closed Circuit Television (CCTV) cameras located in the field. The communications and CCTV surveillance subsystems are just two of many transportation management system elements comprising such projects. The installation of such systems require lengthy design periods, tedious approval processes, extensive field testing, and software development. As a result, the minimum construction period for such projects is two years.

The objective of this project is to expeditiously lease a turnkey CCTV system from a private organization utilizing existing communications medium installed by the organization for other purposes. A survey of three potential bidders determined that a minimum lease of five years is required for such an arrangement to be feasible relative to public sector costs and private industry needs. The CCTV system will be operational within six months of awarding the contract and will be monitored initially from the Interim Transportation Management Center (ITMC) and eventually from the Houston TranStar Center.

PROJECT DESCRIPTION: The following are the general requirements as set forth in the specifications for the installation, operation, and maintenance of a closed circuit television system.

1. The vendor shall install and provide service for a CCTV traffic monitoring system according to the specifications.

2. TxDOT will lease the video service from the vendor at a set monthly rate for a period of five years. The monthly rate shall be the vendor's successful lump sum bid divided by 60 months. The monthly payments will begin after the system tests have been successfully completed.

3. The vendor shall install CCTV cameras at the ten locations specified in the specifications. TxDOT will provide exact CCTV field equipment locations and install the camera poles, cabinets, foundations, and electrical power connections to the pole-mounted cabinets.

4. The vendor shall provide and install all CCTV central and field equipment according to the specifications.

5. The vendor shall provide sufficient fibers in the communications plant to transmit the video signals from each of the ten field sites to the ITMC for simultaneous presentation on ten separate video monitors.

6. The vendor shall provide a large screen monitor with associated VCR and switch matrix for switching any signal into the larger monitor or into the VCR.

7. The vendor shall install the necessary fiber optic cable from the Post Oak right-of-way to the ITMC.

8. TxDOT will operate the CCTV system from the ITMC and will pay for the power consumption for the CCTV equipment.

9. The vendor shall maintain all elements of the CCTV system that the vendor installs for the duration of the five-year lease period.

10. The vendor shall relocate the CCTV central equipment from the ITMC to the permanent Houston TranStar Center located at 6922 Old Katy Road, Houston, Texas, sometime during the five-year lease period.

PROJECT EVALUATION: TxDOT will contract with the Texas Transportation Institute (TTI) to document and evaluate the procedures used by TxDOT to secure leased fiber optic equipment and services from the private sector. Additionally, TTI will evaluate the operations of the leased fiber optic equipment and services over time.

BUDGET ESTIMATE: The estimated cost of this project is $1,200,000. Only $480,000 is requested from the Priority Corridor Program, including an estimated cost to evaluate the project of $120,000.

Funding (Priority Corridor):
FHWA—$384,000
Local—$96,000

PROJECT 2
DEVELOPMENT OF ITS PRIORITY CORRIDOR PROGRAM PLAN

PROJECT OBJECTIVE: The U.S. Department of Transportation designated the Houston Priority Corridor on April 2, 1993, as one of four Intelligent Transportation System (ITS) "Priority Corridors." This designation will provide the opportunity to plan, develop, and implement evolving ITS technologies and applications in the Houston Corridor. The Houston ITS Priority Corridor includes the transportation corridor surrounding IH-10 and IH-45.

The Priority Corridor program is a key element in the ITS testing and implementation process. The systematic and coordinated activities in the four national priority corridors will provide the basis for future widespread application of ITS technology. The significance of the proposed "Development of ITS Priority Corridor Program Plan" is that it will be the first step in a multi-year effort, and will establish the framework, schedule, and financing of ITS technologies and applications to be deployed in the Houston ITS Priority Corridor.

The objective of this study is to develop the Corridor Program Plan for the Houston ITS Priority Corridor. The study is a multi-year planning effort through 1998. The initial activity and the major effort will be the development of the Plan, which will be completed in the first year. Annual updates of the plan will occur as deployment activities progress, new applications occur, and schedule revisions are made. This annual review and update is considered important in maintaining a viable Corridor Program Plan.

Development of the Corridor Program Plan will result from a cooperative effort of local governmental organizations, the private sector, and Texas Transportation Institute. The Priority Corridor Program Plan is envisioned as a "living document," which will be periodically reassessed and updated based on experience with deployed projects and the evolving state-of-the-art of ITS. This project will be a multi-year planning effort, which will extend through the five-year USDOT Priority Corridor Program.

The scope of work of the initial plan development includes the following tasks:

1. Develop Corridor Framework

2. Review ITS State-of-the-Art and Monitor ITS Activities

3. Document Existing Corridor Characteristics

4. Estimate Future Corridor Characteristics

5. Assess Immediate ITS Deployment Needs

6. Develop Twenty-Year Corridor Vision Plan

7. Develop Five-Year Corridor Plan

8. Develop Financial Plan

9. Define Continuing Program Activities

BUDGET ESTIMATE: The estimated cost of the project is $400,000. First year cost is estimated to be $200,000.

Funding: FHWA—$320,000
Local—$80,000

PROJECT 3
MONITORING TRAFFIC AND TRANSIT CONDITIONS AND FREEWAY INCIDENT DETECTION WITH AUTOMATIC VEHICLE IDENTIFICATION TECHNOLOGY (PHASE 4)

PROJECT OBJECTIVE: This project proposes to provide a traffic monitoring system using Automatic Vehicle Identification (AVI) technology to monitor the following applications: transit vehicle schedules from High Occupancy Vehicle (HOV) lanes' access points from Park and Ride Facilities and from transit terminal facilities for shuttle bus operations; traffic conditions on arterial streets that serve as alternate routes to the freeway system; and freeway incident detection for traffic incidents that block one or more lanes.

The traffic data collected from the ramps and roadways with the expanded AVI coverage will enhance the travel time information used to advise motorists of alternate routes, assist emergency response agencies in incident management procedures, and inform transit agencies and HOV lane users of travel conditions.

PROJECT DESCRIPTION: The Houston Priority Corridor (Corridor) has been instrumented with AVI Systems designed to measure travel times and average speeds on the freeway mainline and HOV lanes. This project will expand the coverage to the transit facilities and arterial streets and will enhance the existing reader stations of freeways, which have average spacings of 4.8 kilometers (3 miles), by adding stations at every 0.8 kilometers (0.5 miles). The implementation designs proposed are:

1. Instrument the entrance and exit ramps to the 11 Park and Ride Facilities in the north and west corridors of Houston.

2. Acquire five mobile AVI reader systems for application at three shuttle bus parking facilities and two special event locations.

3. Deploy an AVI traffic monitoring system on Hempstead Road which is an alternate route for U.S. 290 Northwest Freeway.

4. Enhance the AVI traffic monitoring system on U.S. 290 Northwest Freeway Eastbound travel lanes from the Sam Houston Toll Way to IH-610 North Loop.

The proposed expanded AVI system will use Amtech technology in order to integrate with the existing and planned AVI systems for toll roads, freeways, and HOV lanes in the Houston area. Because Amtech has large AVI systems in Oklahoma, Louisiana, and Texas, a large number of vehicles passing through Houston will also become probes for travel time measurement. However, for the commuter application, TxDOT will be providing additional transponder tags for selected motorists to ensure the coverage in time and facility for the data collection. Transit vehicles and emergency vehicles that normally operate in the Corridor will be issued transponders. The expanded AVI design will use the same communications techniques as used by the other TxDOT AVI systems. In addition, the project will provide for the testing and

demonstration of alternative types of antenna and installation methods. The following tasks are proposed to accomplish the operational test.

1. Develop a detailed deployment plan. With the approval of this project, TxDOT will contract with the Texas Transportation Institute (TTI) to assist in the design, operation, and evaluation of the AVI systems. TTI is currently under contract with TxDOT for similar work tasks for the AVI systems to be installed in 1994-95.

2. Prepare plans and specifications and install the AVI systems. TxDOT will adapt the existing plans and specifications and will either install the AVI system or work with the other agencies involved to have them install the AVI equipment on their facilities. Consideration will be given to modified antennae placements that use side mount platforms. With the increased frequency of installations, existing overhead sign and bridge structures will not be readily available.

3. Prepare the software for the data collection, processing, and dissemination of the AVI information. TTI will modify the current software for probe vehicle data to accommodate increased volume of AVI data. Various incident detection algorithms will be developed, implemented, and tested for response time and accuracy.

4. Operate the AVI system. TTI will operate the AVI systems for one year, providing the information as requested by TxDOT, other agencies, organizations, and other users.

5. Evaluate the AVI system. An evaluation of the AVI applications to transit operations, arterial street operations, and freeway incident detection will be undertaken with the assistance of TTI.

PROJECT EVALUATION: TxDOT will contract with TTI to provide an evaluation of the applications of AVI.

- To determine the effectiveness of the AVI technology: provide bus information and traffic data for managing the transit operations schedules for commuter and special event park and ride systems; provide traffic information on arterial streets for diversion strategies and traffic signal operations; and provide traffic information to various incident detection algorithms.
- Determine the design of reader sites and antennae placements, and the number and frequency of transponder equipped vehicles to provide quality and quantity of data for the various applications.

BUDGET ESTIMATE: Estimated cost to provide AVI implementation and operation for the projects listed above is $1,230,000. The estimated cost to evaluate the operations of the four AVI applications over a two-year period is $600,000, for a total project cost of $1,830,000.

Funding: FHWA—$1,464,000
Local—$366,000

PROJECT 4
CHANGEABLE LANE ASSIGNMENT SYSTEM (CLAS) ON FRONTAGE ROADS

PROJECT OBJECTIVE: The frontage road system is an essential element of design and operation of freeways in Texas. Freeways in the Houston Priority Corridor have continuous one-way frontage roads, essentially over their full length. These frontage roads are typically two or three lanes wide and signalized at interchanging cross streets. Because of high interchanging traffic demands, permitted double turns are often used on one or more approaches to maximize traffic service. Traffic demands are often so different between morning and evening peak periods that different lane use controls are needed on a pretimed basis. In addition, freeway incidents often create unusual (and unpredictable) frontage road traffic demands, as traffic diversion occurs from the mainlanes to the frontage roads. The diverted traffic creates predominantly through traffic demands on the frontage roads. Static permitted double-turn operations can significantly limit the capacity for this increased through traffic demand. Traditional fixed signage does not address the goal of optimizing lane usage and the variable predictable and unpredictable demands which are common in the Houston Priority Corridor. The objective of this project is to design, install, and evaluate 11 changeable lane assignment control systems that can alter the permissive double turns at intersections based on traffic demands.

PROJECT DESCRIPTION: TTI developed a Changeable Lane Assignment System (CLAS) concept which used fiber optic lane use signing. These changeable (dynamic) lane use signs can change to permit double turns when needed, as well as changing to normal lane uses (turns permitted only from outer lanes). TxDOT installed a prototype CLAS system in Houston on the inbound frontage road of IH-10 at Bingle/Voss. This CLAS installation provided reliable, effective control, and it is this lane use control system, with certain improvements, which is proposed for implementation on U.S. 290, as well as replacement of the prototype on IH-10.

The changeable message fiber optic signs are similar to the prototype system installed and operated since 1992 at the Bingle/Voss interchange on IH-10. Specifications for the system will include provisions for a software program for providing the switching function for the signs and a light intensity dimming system. The switching control program will be accessible from a remote IBM compatible computer through a Hayes compatible modem located initially at the Interim Transportation Management Center (ITMC) and eventually from the permanent Transportation Management Center located in the Houston TranStar Center (Center). The proposed locations for the installations are 10 outbound intersections on U.S. 290 Northwest Freeway and one intersection on IH-10 Katy Freeway.

The CLAS system will operate in both pretimed and responsive control modes. Operation in a pretimed mode will use historic (non-incident) traffic turning movement demands. The system will also function in a responsive mode, overriding the pretimed operation when frontage road traffic demand increases significantly (e.g., a freeway incident). Initially, control center personnel will make responsive control decisions. Center personnel will assess the situation and available data to determine which intersections to include in altering pretimed lane use controls.

The following work plan is proposed:

1. TxDOT will develop plans and specifications for the constructed elements of the project. This will include mounting structures, foundations, conduit, physical requirement of signs, and other related elements.

2. TxDOT will develop functional requirements for signal controller and CLAS sign operations. These requirements will be sufficient to define the desired system operations from which the equipment and software supplier can design, construct, and program the system.

3. It is anticipated that the CLAS signs, intersection/sign controllers, and system software development would be accomplished under a sole source procurement with the supplier of existing U.S. 290 controllers, RCTSS controllers, and the CLAS prototype at IH-10 and Bingle/Voss.

4. The vendor shall develop and install 11 dynamic lane assignment systems according to the specifications. The first system will be installed at the IH-10/Bingle Voss intersection to replace the prototype system that is now in operation.

5. The vendor shall provide and install all signs and switching equipment and controller software according to the Specifications, and shall provide the necessary connections to the existing signal control equipment to ensure proper signal phase coordination.

6. The vendor shall provide and install all communications equipment necessary to provide control of the switching function from the Center.

7. The vendor will provide appropriate warranties and system support as provided in the specifications.

PROJECT EVALUATION: TTI will evaluate the dynamic lane assignment applications in terms of:

1. Effectiveness of physical and operational design features.

2. Effectiveness of traffic control strategies employed in both pre-timed and responsive incident management modes.

BUDGET ESTIMATE: Estimated cost to implement, operate, and evaluate the system is $750,000. Estimated cost for installation and one year of operation is $400,000, with system evaluation estimated at $350,000.

Funding: FHWA—$600,000
Local—$150,000

PROJECT 5
PUBLIC INFORMATION/PROGRAM ADMINISTRATION

PROJECT OBJECTIVE: In conjunction with the planning and deployment of ITS Priority Corridor projects, there will be a need for an ongoing program administration and continuing public information program by TxDOT. A Priority Corridor Program Office will be established with a Manager/Project Coordinator.

PROJECT DESCRIPTION: A Project Coordinator's office with sufficient technical and clerical assistance is proposed. The Coordinator will be responsible for supporting the various project deployments, informing the participating agencies and sponsors of the progress of the Priority Corridors Program, and working with the news media to provide information to the general public. The Coordinator will also be responsible for coordinating proposals for the continued efforts in the Priority Corridors Program.

A number of public and private organizations will be involved in the conduct of the deployment projects for the Priority Corridor. Since the tests will involve the public or be of general interest, the news media will also be involved. A public information program will present the operational tests and related research and demonstration projects to the public in a coordinated manner. This will be done through timely releases to the media and preparation of video and written public information materials.

One important public information effort will be the development of information materials for use in public forums, handouts to visitors to the Center, and mailouts to interested public officials and citizens. Initially, this will involve development of a 15 to 20 minute video tape presentation, which will summarize ITS goals, plans, and expected benefits. In addition, a concise printed brochure or handout will provide similar information.

The staff of TxDOT, METRO, City of Houston, and Harris County will use these materials in making presentations to elected bodies, public meetings, and presentations to technical organizations.

This Program Administration activity will continue throughout the deployment phase of the Priority Corridor. Public information materials will be periodically updated in order to maintain technical and temporal currency.

PROJECT EVALUATION: Much of this activity will be ongoing administrative and public information functions. This activity will continue during the course of the Priority Corridor Program. TxDOT will make annual reviews of these activities to assure their continued need.

BUDGET ESTIMATE: Estimated cost of this activity is $200,000 for funding the activity for the first two years.

Funding: FHWA—$160,000
Local—$40,000

PROJECT 6
TRUCK MONITORING/WARNING SYSTEMS FOR FREEWAY TO FREEWAY CONNECTIONS

PROJECT OBJECTIVE: Direct connections in freeway to freeway interchanges are a major source of traffic congestion and safety concerns. Because the design speeds on these connections are usually lower than the design speeds on the mainline roadways and approaches, traffic tends to enter the connection curves at higher than desired speeds. Some ramps should be posted with regulatory speed limits that reflect these desired travel speeds, but the distances along the connection ramp are often too short to permit the proper speed reduction zones. Thus, these ramps are provided with advisory signs that describe safe speeds for the roadway. However, even with the proper signs and additional advisory signs to alert drivers of the critical speed sections, drivers often travel too fast on the ramp. If the vehicle is a large truck with a high center of gravity, the excessive speed can cause the driver to lose control. Additional signs, signals, and/or markings should be provided to assist the driver in selecting the proper speed. Thus, the objective of this project is to implement a system which identifies unsafe speed conditions (which vary by vehicle size and weight) and initiates warning devices to prevent out-of-control accidents by these vehicles.

PROJECT DESCRIPTION: The Houston District of TxDOT has been testing various types of sensors to measure speeds and to classify vehicles by size and weight. The project proposes to apply these technologies on the approaches to and within freeway to freeway connectors that have sections with low design speeds. These monitoring systems will detect large trucks, determine their spot speeds, and determine if they are carrying a cargo. A data processor will determine if the conditions are critical for maintaining control of the vehicle through the connection. If the spot speed is too high for conditions, warning systems will be activated to advise the driver to reduce his speed. The warning systems proposed would be dynamic to increase the target value and the compliance to what would be an advisory speed limit.

Two major interchanges on the IH-610 Loop Freeway in the Priority Corridor Study Area are candidate sites for application of the truck monitoring and warning systems. The difficult factors in the study that require ITS technologies are the requirement to monitor the vehicles on elevated roadways and to communicate the information in a very short time over a short distance. Over-the-road sensors are required. Systems that track the vehicle over short distances could require information that is difficult or impossible to obtain. New techniques for displaying messages on road sides may be enhanced by methods of communicating to the driver within the vehicle.

The following tasks are proposed for the Operational Test.

1. Develop a detailed implementation plan. With the approval of this project, TxDOT will contract with a research organization to assist in the design, operation, and evaluation of the truck monitoring/warning systems using advanced sensor and display technologies on two or more freeway to freeway connection ramps.

2. Prepare plans and specifications and install the AVI systems. TxDOT will prepare plans and specifications and install the truck monitoring/warning systems.

3. Prepare software for data collection, processing, and evaluation of the sensor information. The research agency will develop and implement the control algorithm to activate the warning systems.

4. Operate the truck monitoring/warning system. The research agency will operate the truck monitoring/warning system in conjunction with the TxDOT Traffic Management Center for a period of one year.

5. Evaluate the truck monitoring/warning system. The research agency will conduct an evaluation of the truck monitoring/warning system.

PROJECT EVALUATION: The research agency will conduct the project evaluation with the following objectives.

- Determine the effectiveness of sensor technologies to provide traffic data for truck monitoring.

- Measure the frequency of unsafe speed measurements and system response.

- Determine the effectiveness of displays and other communications techniques for conveying the warning message to the truck driver.

- Determine cost effectiveness of applying the truck monitoring/warning systems to freeway connections.

BUDGET ESTIMATE: The estimated cost to undertake the design, implementation, and two-year operational test is $220,000, including $70,000 for capital cost to implement systems on two connection ramps.

Funding: FHWA—$176,000
Local—$44,000

PROJECT 7
REAL-TIME INFORMATION KIOSKS

PROJECT OBJECTIVE: Currently, real-time traffic information (average speed, travel time) is available through the AVI system in the Houston Interim Transportation and Emergency Management Center. A major intent of this system is to provide real-time information on traffic conditions to commuters, travelers, and commercial operators. For example, this information is being used in the Houston *Smart Commuter* project to provide real-time traffic and transit information to a small group of commuters in the IH-45 North corridor in their home and work place. In addition, METRO will be implementing an automatic vehicle location (AVL) system with their regular route bus system in the near future. This will provide the opportunity for bus passengers and potential riders to obtain real-time information on the status of buses. The potential exists to greatly expand and enhance the availability of real-time traffic and transit information to a wide range of users, allowing them to make more informed travel choices. Further, real-time transit information could be provided in both visual and passenger activated audio formats to enhance the ability of visually impaired or disabled individuals to use the bus.

This project will focus on expanding the availability of real-time traffic and transit information to commuters, travelers, and commercial operators in the Priority Corridor area. Specifically, the project will deploy and test the use of real-time kiosks at activity centers to enhance the travel decision making process of commuters and travelers. Thus, the focus of the demonstration is on providing improved information to transit and roadway system users to help them select the best travel mode, travel route, and time of travel based on current traffic conditions and transit options. The use of these kiosks will be monitored and evaluated as part of the project.

PROJECT DESCRIPTION: This demonstration will focus on deploying ten real-time information kiosks in the Priority Corridor. Development of the systems will build on the experience gained in Houston through the Digiplan Maps, the U.S. 59 reconstruction information displays at Greenway Plaza, and the *Smart Commuter* Operational Test, as well as on the experience in other areas, such as California. This demonstration will include the development and evaluation of real-time information kiosks. AVL data will be used to provide the real-time bus information. If the AVL data is not available upon implementation of the kiosks, or if the AVL data is not available due to system failure, then the kiosks will provide static bus information. Bus information provided will include arrival times and/or departure times. In addition, the bus information system may also include recent route/schedule changes, special event transit services, promotional events, fare information, and other information needed by the transit rider. Thus, individuals will be able to access all the information needed to make their trip. METRO will provide transit information in both visual and audio format at one location, where visually impaired travelers are known to visit, to address the requirements of the American with Disabilities Act (ADA). Real-time traffic information will include the AVI graphic and text information, incident information, and construction/maintenance information.

These kiosks will be located at ten major activity centers, such as transit centers, shopping centers, truck terminals, major office buildings, and other employment centers. Three different kiosk applications will be deployed, tailored to the type of location and type of traveler served.

Kiosks with only transit information would be employed at transit centers and park and ride lots, while only traffic information would be provided at CBD parking garages and commercial vehicle terminals (e.g., package delivery company, taxi dispatch). Both traffic and transit information would be provided at such locations as office buildings, shopping centers, or the Texas Medical Center. The experience gained from this demonstration will be used to expand the use of information kiosks in the Houston area and to enhance development of interactive information kiosks in the future.

The following tasks define the scope of the project:

1. Finalize a detailed implementation, evaluation plan, and request for technical proposal (RFTP) for system procurement.
2. Procure real-time visual and audio kiosks.
3. Install kiosks at ten locations throughout the Priority Corridor area.
4. Test the kiosks for a one-year period of time.
5. Conduct an evaluation to determine the utility and effectiveness of kiosks.
6. Prepare a final report on the kiosk demonstration project.

PROJECT EVALUATION: The evaluation of the utility and effectiveness of the real-time information kiosks will be a major element of the demonstration. The project evaluation will focus on the following objectives.

- Determine the technical feasibility of the provision of real-time traffic and transit information through visual and audio kiosk technology.
- Assess the effect of real-time traffic and transit information on changes in commute modes, travel routes, and time of travel of system users.
- Enhance the understanding of information display technology for visually impaired individuals.
- Enhance the understanding of customer preferences related to different types of technologies for receiving real-time traffic and transit information through the testing of the real-time information kiosk.

ESTIMATED BUDGET: The cost to undertake the design, implementation, and one-year operation of the system is estimated to be $500,000. Conduct of the study's needs, development of system requirements, and evaluation are estimated to be $250,000, for a total project cost of $750,000.

Funding: FHWA—$600,000
Local—$150,000

PROJECT 8
RAILROAD GRADE CROSSING MONITORING SYSTEM

PROJECT OBJECTIVE: Railroad grade crossings represent a major source of delay in Houston. There are numerous at-grade crossings that can affect traffic flow and safety on the arterial street system. Often, the trains block the intersections for several minutes during the peak traffic period, resulting in long queues that can block or impede traffic flow on other streets and access driveways to commercial and private property. Information on train movements is not now available to the traffic control systems and the Center. The objective of this project is to examine how information systems and traffic control systems can be used to monitor the movements of trains, adjust traffic patterns, and advise emergency vehicles in the corridor to reduce delays at railroad at-grade crossings.

PROJECT DESCRIPTION: The blocking of major arterials by slow moving trains has the potential of increasing travel times by several minutes for large numbers of vehicles. At some locations and during some time periods, the impact of the blockage can be severe. On major bus routes and on routes frequently used by emergency vehicles, the additional travel times can be critical to their operations. Information concerning the actual roadway closure can be determined in several ways, and several actions can be taken if that information is known.

This project proposes to monitor railroad train movements along three corridors: the Union Pacific rail line that parallels IH-10 Katy Freeway, the Southern Pacific rail lines that parallel the IH-610 West Loop Freeway and the U.S. 290 Freeway/Hempstead Road. The monitoring systems will use AVI readers at eight to ten locations to determine the position and identification of the train and to measure the travel times of trains moving along the lines. Advanced warning/information systems would be developed and implemented on approaches to the intersections. Information and traffic management strategies to be investigated are:

- Installing changeable message signs (CMS) and other information systems on the arterial street approaches to the grade crossings.
- Providing train and grade crossing status information on radio and television traffic reports for critical intersections.
- Notifying agencies responsible for traffic signal operations so the timing of signals near grade crossings may be adjusted to compensate for the roadway closure.
- Coordinating the operation of the frontage road and ramp metering systems with train movements that parallel the freeway.
- Increasing the capacity of the frontage road intersections by dynamically altering the lane assignment of the approaches as the train moves through the corridor.

The following work plan defines the scope of the operational test:

1. Develop a detailed study plan. With the approval of this project, TxDOT will contract with a research agency to develop a detailed study plan and to assist in the design, operation, and evaluation of the railroad grade crossing monitoring system.

2. Prepare plans and specifications for the installation of the grade crossing monitoring system. The research agency will evaluate alternatives for monitoring grade crossings and will prepare plans and specifications for the system selected by TxDOT.

3. Develop a response plan for the grade crossing monitoring system. The research agency and TxDOT will select a study area for the implementation and evaluation of the grade crossing monitoring system. The research agency will develop the requirements for providing the responses to the grade crossing monitoring system, to include signal control adjustments, motorist information systems, and travel lane assignments. The implementation of these requirements will be coordinated with the implementation of the railroad grade crossing monitoring system.

4. Operate the grade crossing monitoring system. The research agency will operate the grade crossing monitoring system for one year, as part of the operation of the Automatic Vehicle Identification Systems.

5. Evaluate the grade crossing monitoring system. The research agency will evaluate the grade crossing monitoring system.

PROJECT EVALUATION: The project evaluation has the following objectives:

- Determine the effectiveness of the system design to detect and monitor train movements and the resultant grade crossing closures.

- Evaluate the effectiveness of informing emergency vehicles, operators of traffic signal systems, and the public of the information relating to the grade crossing closures.

- Evaluate the cost/effectiveness of providing the information on grade crossing closures.

BUDGET ESTIMATE: Funding for this project is based on monitoring the trains on two of the lines operating in the three corridors: the Union Pacific Railroad adjacent to the IH-10 Katy Freeway from Barker-Cypress Road to IH-610; the Southern Pacific Railroad adjacent to the IH-610 West Loop Freeway from U.S. 59 Southwest Freeway to IH-10 Katy Freeway and parallel to U.S. 290/Hempstead Road from FM 1960 to IH-610. The estimated cost to accomplish the design, installation, and evaluation of the operation is $500,000, with estimated capital and operating cost of $300,000 and evaluation cost of $200,000.

Funding: FHWA—$400,000
Local—$100,000

PROJECT 9
AUTOMATIC VEHICLE LOCATOR SYSTEM FOR INCIDENT MANAGEMENT

PROJECT OBJECTIVE: TxDOT and Harris County through the Motorist Assistance Program (MAP), currently operate a fleet of vans to patrol freeways and respond to incidents and disabled vehicles. The application of a fleet management system is essential for coordinated and effective operation. Quick response and effective dispatching of these units can reduce the time for emergency response and the time needed to restore normal traffic operations. The objective of this project is to increase the effectiveness of incident management by implementation of an Automatic Vehicle Locator (AVL) system which identifies vehicles and locations on a real-time basis.

PROJECT DESCRIPTION: The Motorist Assistance Program (MAP) currently operates nine vehicles on Houston area freeways. The MAP fleet is expected to expand to 12 vehicles in 1995. These vehicles patrol and respond to observed and dispatched motorist needs and emergency conditions. The project proposes to implement one of a number of available automatic vehicle locator systems that would provide the management information needed for vehicle dispatch, patrol assignments, and automatic information collection and storage. The project will increase the effectiveness of the program by providing dispatchers in the Transportation Management Center with continuous and accurate vehicle location information. With this information, dispatchers can quickly access availability and location of the nearest MAP vehicle, as well as provide guidance on the best route to use in responding to an incident. The use of the AVL information as a traffic monitoring source will also be tested. In addition, other potential AVL applications for emergency vehicle and transit fleet management may be assessed in defining the full range of potential application of AVL in the Priority Corridor.

The following tasks comprise the operational test.

1. Develop Implementation Plan. With approval of the project, TxDOT will contract with a research agency to assist in the design, operation, and evaluation of the Automatic Vehicle Locator (AVL) system for the Motorist Assistance Program.

2. Prepare Plans and Specifications. The research agency will assist TxDOT in preparing plans and specifications for the AVL system.

3. Prepare Operations Procedures. The research agency will assist TxDOT and Harris County in developing operational procedures for use of the AVL system in fleet management and incident response.

4. Prepare Software for System Evaluation Data. The research agency will develop necessary software to log and evaluate usage of the AVL systems. A one-year test and evaluation will be conducted.

5. Evaluate AVL System Usage. The research agency will conduct and evaluate the usage and effectiveness of the AVL system.

PROJECT EVALUATION: The project evaluation will assess the following system elements:

- Locational accuracy and reliability of the AVL system.
- Improved responsiveness to freeway incidents.
- Reduction in the time incidents impact traffic operations.
- Effectiveness of AVL in monitoring traffic operations.
- Overall acceptance and effectiveness of AVL system.

BUDGET ESTIMATE: The estimated cost to implement the AVL system is $50,000. Estimated cost to evaluate the system is $50,000, for a total project cost of $100,000.

Funding: FHWA—$80,000
Local—$20,000

PROJECT 10
ON-VEHICLE NAVIGATION/INFORMATION APPLICATIONS

PROJECT OBJECTIVE: One of the objectives of the ITS program is to provide current information on travel conditions to travelers at all stages of their trip. Operational tests relating to in-vehicle information systems are being conducted in other major cities, and the intent of this proposed program is to extend these concepts to the Houston Priority Corridor. TxDOT proposes to examine the results of national and international studies on in-vehicle information systems and the resultant products that are available and develop an operational test that will address a particular group of travelers within the Priority Corridor, the travelers that use the Houston Intercontinental Airport (IAH).

PROJECT DESCRIPTION: The project will propose systems for use by all travelers, regardless of the mode of transportation selected to travel to or from the IAH facility. TxDOT will seek the support and participation of public and private industry in the development and operation of this project. Specifically, the public transportation companies, taxicab operators, express delivery services, and the automobile rental companies that serve the airport and the City of Houston Aviation Department will be invited to participate. General Motors has indicated an interest to develop a project in Houston that would extend the on-vehicle concepts of the TravTek Project.

Three major radial freeways and two loop freeways serve the Houston Intercontinental Airport. Travel to any part of the Houston metropolitan area can be facilitated if travel conditions on these roadways are known in advance of the initiation of the trip. Decision points for the alternate routes exist at several points in the corridor—two within the IAH facility. Other information needs by the traveler will also dictate which route to select. Map information on the location of the destination with recommended routes would be useful. The amount and form of information to be provided to the traveler will be determined during project development. At this time, the scope would be limited to simple map information, selection of the best major route to use, and an update of travel conditions on selected freeways and at critical decision locations.

It is the intent of this project to provide support for the planning and coordination of a major demonstration project that may develop in the Houston area. Preliminary discussions concerning the deployment of a "TravTek" type project indicate that the schedule would require two to three years. This time frame allows the Automatic Vehicle Identification (AVI) Traffic Monitoring Systems to be in place, the Computerized Transportation Management Systems (CTMS) traffic management systems to be operational, and the Houston Transportation Management Center (TMC) to come on line. Implementation of the On-Vehicle Information System for IAH in one to two years is feasible since the traffic monitoring systems in the north sector of Houston will be operational.

The following work plan is proposed to accomplish the objectives of the project.

1. Develop a detailed study plan. With the approval of this project, TxDOT will contract with an organization (Contractor) to prepare a proposal and a study plan.

2. Develop a project team. The Contractor will contact potential participants and assist in developing agreements with various public and private agencies that will participate in the conduct of the project.

3. Acquire communications systems for vehicles. The Contractor will work with the private agencies to acquire the devices to be placed in the vehicles for communications with the Center.

4. Prepare the software and the data collection, processing, and transmission of traveler information. The Contractor will work with the public and private agencies to develop the means for transmitting the necessary information to the vehicles to enable drivers to make the proper decision on route selection.

5. Operate the information system. The Contractor will operate the information system in conjunction with the Center.

6. Conduct evaluation of system. The Contractor will conduct an evaluation of the traveler information system.

PROJECT EVALUATION: The Contractor will undertake an analysis of the information systems to assess:

- Traveler usage of the system;
- Effectiveness of the system in providing useful information;
- Travel time savings by travelers; and
- Reliability of system operation.

BUDGET ESTIMATE: Total cost of the project will be difficult to determine until project scope is refined and private sector participation is determined, particularly that of General Motors. TxDOT estimates that the cost by public agencies in the development, operation, and evaluation of the project will be $400,000. Significant funding and in-kind services are anticipated from the private sector.

Funding: FHWA—$320,000
Local—$80,000
Private Sector—undefined

PROJECT 11
MONITORING AND INFORMATION SYSTEM FOR ENVIRONMENTAL CONDITIONS

PROJECT OBJECTIVE: The Houston Area is subject to unpredictable and severe weather conditions that can result in extensive roadway flooding during periods of intense rainfall. Several freeways, frontage roads, and major arterials are historically closed due to the flooding conditions during severe storms.

Although the Harris County Flood Control District (HCFCD) stream monitoring system provides information on potential flooding conditions, it lacks sufficient coverage to provide detailed reports on roadway flooding on the urban freeway and arterial system. In addition, there is no information available on specific atmospheric conditions such as ice, fog, smoke, haze steam, and high wind conditions that severely impact public safety on the freeway system. The technology is currently available to provide real-time monitoring of these conditions, linked to the Center. In addition to monitoring roadway and waterway conditions, the availability of real-time weather radar and National Weather Service weather alerts would provide for advanced warning of severe conditions that may impact roadways. Because unpredictable and variable weather conditions occur at all times of the year, the implementation of such a system could be a useful component of an Advanced Travelers Information System (ATIS). The objective of this project is to investigate the potential to integrate weather and roadway flooding information into the ATIS.

PROJECT DESCRIPTION: This project will integrate the electronic data stream from an existing network of stream-level and rainfall gages with a proposed system of devices which monitor roadway environmental conditions and the operational status of TxDOT's stormwater pumping facilities.

Monitoring of environmental conditions is proposed for the Priority Corridor by utilizing the HCFCD monitoring system, existing sources of weather advisory information, and by providing monitoring stations at selected critical roadway locations within the Priority Corridor. Critical TxDOT pump station locations will monitor pump status and/or surface water depths. The Harris County Flood Control District monitoring system will be utilized as an important source of area flooding information. Using these sources of real-time information on the status of general weather conditions and location-specific data, ATIS services will assist motorists in both pre-trip planning, as well as en-route response to advisory information.

This project will be conducted in three separate but related stages. The first stage involves assessing the requirements and benefits of such a weather monitoring system for the Houston metropolitan area. The second stage would involve an assessment of equipment that is now available for weather and roadway condition monitoring and the type of information that each provides. The final study element is the integration of the information into the central information system and the evaluation of the equipment. This would involve installation of a prototype monitoring system, connection to the Center (either via telephone modem, radio, or hardwired connections), and the development of computer software to monitor and react to roadway flooding conditions.

TxDOT proposes the following work plan to accomplish the operations test.

1. Develop a detailed study plan. With the approval of this project, TxDOT will retain a contractor to develop a detailed work plan for this effort and to assist in assessing system requirements, design, operation, and evaluation of the weather systems.

2. Review available weather and roadway monitoring equipment. The contractor will assess the function and probable applicability of available hardware and software systems.

3. Prepare plans and specifications for weather monitoring systems to be installed. The contractor will develop plans and specifications for the prototype weather monitoring systems, and TxDOT will acquire and install the approved systems.

4. Prepare the software for data collection, processing, and dissemination of weather information. The contractor will prepare the software for the central computer system at the Center for receiving, processing, displaying, and disseminating the weather information.

5. Operate the weather monitoring system. The contractor will assist TxDOT in operating the weather monitoring system for one year, providing the information as requested by TxDOT to other agencies and organizations.

6. Evaluate the weather monitoring system. An evaluation of the weather monitoring system will be conducted and a study report published.

PROJECT EVALUATION: An evaluation of the weather monitoring system will include the following elements:

- Measure the frequency and type of weather related information provided.
- Assess reliability of the monitoring equipment.
- Assess effectiveness of the information received in defining travel-related conditions.
- Determine the usefulness of weather information to the public and other users of the ATIS.

BUDGET ESTIMATE: Estimated total cost for the project is $500,000. Estimated cost for development, implementation, and operation (for two years) of the system will be $350,000, with evaluation cost estimated at $150,000.

Funding: FHWA—$400,000
Local—$100,000

PROJECT 12
CHANGEABLE LANE ASSIGNMENT SYSTEM (CLAS) AT SELECTED INTERSECTIONS

PROJECT OBJECTIVE: In the system of urban highway transportation facilities, the arterial street network has long been recognized as the backbone for the regional transportation infrastructure. Urban arterials primarily serve through traffic and provide access to abutting development as a secondary function. Operation of an arterial's signalized intersections directly affects the capacity of an arterial street and the level of traffic service offered to its users. In urban areas, the general characteristics of arterial flow are over-saturation during the recurrent and non-recurrent congestion periods. In addition, limited right-of-way and financial resources prevent further roadway capacity improvements. Development of an advanced traffic control technology will allow the signalized arterial street intersections to dynamically respond to the changing demand of interchanging traffic existing at these locations. In addition, freeway incidents often create unpredictable arterial flow patterns, and the proposed strategy would also facilitate responsive traffic diversion within the impacted corridor area.

A priority corridor project has been proposed to deploy CLAS at arterial/arterial street intersections in Harris County. It is also the objective of this project to expand the deployment strategy to include traffic responsive operation of the traffic signal control system and the CLAS.

PROJECT DESCRIPTION: Harris County will select two or three intersections to test CLAS deployment in operational treatments not included in the earlier CLAS deployment along freeway frontage roads. There are four potential CLAS applications which may be tested in this project:

- Arterial/Arterial intersections;
- Interior approaches of arterial streets with wide median separations;
- Capability of dynamic traffic diversion on arterial network as an incident traffic management alternative; and
- Explore the possibility of developing traffic responsive algorithm and guidelines for real-time integrated CLAS and signal control system.

Selection of two or three locations and the potential CLAS applications at these locations will be made in the initial task of the project. The selection will also consider deployment experience gained from the proposed U.S. 290 system. Selection of arterial intersections will be based upon traffic demand characteristics, which could benefit from different lane use/turn permissive operation during different periods of the day.

Another possible CLAS application to be considered is for approaches on the interior leg of super arterial street intersections with wide median separations. Dynamic operations may be achieved through the use of a phase-by-phase CLAS application for the interior cross street approach along the super thoroughfare/parkway type of facility. This operational strategy would

flexibly accommodate the varying degree of left-turning demands during different signal phases within the same signal cycle.

An additional application is to enhance CLAS by developing a real-time integrated traffic responsive algorithm. Based upon the best match of historical data and the real-time traffic information detected in the field, an integrated mathematical algorithm and thresholds can be established to automatically deploy the best traffic signal control strategy (i.e., different phase sequences and other timing parameters) and the lane-use assignment options. This deployment approach would also be applied in responding to incidents. It would be beneficial to evaluate such an approach in conjunction with the freeway incident detection algorithm for its reliability and responsiveness.

The proposed work plan for the project follows.

1. Develop study plans and select sites. The study plan will identify the CLAS application(s), select intersections, and develop functional and operational requirements.

2. Procure CLAS systems. Plans, specifications, and estimates will be prepared, and the CLAS implemented at the selected locations. Develop standard specifications and communication protocol for the sign assembly of CLAS project.

3. Develop/implement control plans. Control plans will be developed for operation of the CLAS application(s). Time-of-day or integrated traffic responsive control strategy will be developed as applicable to the sites and applications selected.

4. Evaluate the System. The system applications will be evaluated in terms of operational impacts/improvements at the CLAS sites.

PROJECT EVALUATION: The CLAS applications will be evaluated to assess:

- Adequacy of physical and operational design of CLAS.

- Effectiveness of control plans as reflected by operational strategies.

BUDGET ESTIMATE: Estimated cost for implementation and evaluation of two or three CLAS installations is $250,000. Deployment cost, including O&M costs for one year, are $150,000, with evaluation study cost estimated to be $100,000.

Funding: FHWA—$200,000
Local (Harris County)—$50,000

PROJECT 13
INTEGRATED CORRIDOR TRANSPORTATION MANAGEMENT AND TRAVELER INFORMATION SYSTEM

PROJECT OBJECTIVE: The Houston Priority Corridor project has proposed a number of individual deployment projects in the Integrated Corridor project area. TxDOT proposes to build upon these projects with additional system deployment to provide an "integrated" approach to multimodal transportation operations, incident management, and traveler information in a single geographic corridor.

The concept and objective of the integrated corridor is to focus appropriate ITS technologies into coordinated management systems for future deployment as part of the Priority Corridor program.

PROJECT DESCRIPTION: The project proposes to deploy, operate, and evaluate various traffic and transit monitoring, transportation management, and traveler information systems on: U.S. 290 Northwest Freeway mainlanes, HOV lanes, and frontage roads; the parallel Hempstead Road; and other arterial streets in the Northwest corridor from FM 1960 to IH-610 West Loop.

The Northwest Corridor is an excellent test area for the Priority Corridor Program. The freeway has high levels of congestion for distances of 8 to 11 kilometers (5 to 7 miles). Hempstead Road provides a parallel multi-lane arterial alternative to U.S. 290 for corridor traffic optimization and incident management. In addition, the corridor is bounded on the east by the Smart Commuter Transit Study and on the west by the Smart Commuter Carpool Study. Computerized Transportation Management Systems (CTMS) are being installed on the IH-10 Katy Freeway and U.S. 290 Northwest Freeway. All freeways, plus the Sam Houston Tollway and the IH-610 Loop Freeway, are to be equipped with AVI monitoring systems.

The following previously proposed Priority Corridor projects are located in the integrated corridor and will become a part of the infrastructure for the Integrated Corridor project:

- Changeable Lane Assignment System (CLAS) on frontage roads;
- Monitoring traffic and transit conditions and freeway incident detection with Automatic Vehicle Identification technology (Phase 4); and
- Railroad grade crossing monitoring system.

The operational concept of the Integrated Corridor Project is to focus within one geographic corridor, a number of ITS concepts and technologies, most of which are complementary and synergistic. The core infrastructure developed in the Integrated Corridor will provide the ability to monitor traffic conditions, operate traffic control systems, and communicate current operational conditions to travelers.

The proposed integrated corridor approach will apply ITS technologies and applications which can be assessed individually and on a system basis. These technologies include:

- Automatic Vehicle Identification (AVI) technology to measure travel times over sections of roadway along the freeway and arterial streets and to advise travelers of travel times on alternate routes, to detect and analyze train movements parallel to the arterial street, and to monitor the arrival and departure of transit vehicles at park and ride stations.

- CCTV systems on freeways and arterial streets to monitor travel conditions, verify incidents, and confirm security requests from transit facilities.

- Bus locator systems for priority operation of traffic signals, which will utilize the AVI system or other on-vehicle AVL systems.

- Variable message signs and other dynamic signals to include fiber optic matrix signs for messages, turning movements (CLAS—formerly known as Dynamic Lane Assignment), and advanced warnings of railroad grade crossing blockages.

- Highway Advisory Radio with messages automatically selected by information developed from the AVI and other traffic monitoring systems.

- Traveler information system providing travel times for alternate routes.

- Other in-vehicle communication technologies, such as commercial radio, cellular telephone, and personal communication devices.

The following tasks are proposed to accomplish the integrated Corridor Transportation Management and Traveler Information System.

1. Develop detailed corridor deployment plan. On-going and planned system development in the corridor will be reviewed and coordinated with additional deployment requirements. A detailed deployment plan and schedule will be developed. Implementation will follow a "building block" approach, with different elements of the Integrated Corridor being deployed on a staged basis.

2. Prepare functional requirements for needed deployment. Requirements will be developed for needed system elements to expand surveillance, control, and traveler's information systems into the entire integrated corridor. Expected system expansion includes AVI, CCTV, vehicle detection, HAR, and CMS.

3. Develop surveillance, control, and traveler's information plans. Development of the functional integration of existing and additional systems will be a key task for optimizing transportation operations. Plans developed will include traffic and traveler information handling of a broad range of contingent conditions. The plans will form the basis for software development and system control.

4. Procure system hardware and software. Plans and specifications will be developed, and the hardware will be acquired and installed. Software to guide the surveillance, control, and traveler information systems will be completed.

5. Evaluate the integrated corridor control and information systems. An evaluation plan will be developed and evaluations of the system elements and impacts on corridor operations undertaken.

PROJECT EVALUATION: TxDOT will contract with a research agency to conduct an evaluation of the project. The evaluation will assess monitoring, traffic control, and traveler information systems related to operation of the integrated corridor, including:

- Effectiveness of detection and AVI systems to define corridor operating conditions.
- Responsiveness of arterial control systems to freeway incidents.
- Operational effectiveness of systems over a range of incident and non-incident conditions, as measured by vehicle/person throughout, average speeds, and other measures of effectiveness.

BUDGET ESTIMATE: The estimated cost to develop, implement, operate, and evaluate the three-year operational test is $1,862,000, including $1,062,500 for capital costs, $300,000 for system development, and $500,000 for operations and evaluation.

Funding: FHWA—$1,490,000
METRO—$372,500

PROJECT 14
WASHBURN TUNNEL TRAFFIC MANAGEMENT AND INFORMATION SYSTEM

PROJECT OBJECTIVE: The Washburn Tunnel was constructed under the Houston Ship Channel in 1950 to connect the cities of Pasadena and Galena Park. The area adjacent to the Houston Ship Channel is one of the most intensely developed industrial areas in the United States, dominated by large oil refineries, chemical plants, and related industries.

The Washburn Tunnel provides access to area industries as well as important linkage between major employers and the residential areas on both sides of the Ship Channel. The tunnel can withstand hurricane conditions and has never been flooded during its existence. It is, therefore, one of the hurricane evacuation routes for the coastal area.

Weekday traffic volumes through the tunnel are approximately 30,000 vehicles per day with directional (one lane) peak hour volumes of 1,400 vehicles per hour. These peak period traffic volumes approach capacity for the 6.7 meters (22-foot) wide roadway with six percent grades. The tunnel is approximately 1,220 meters (4,000 feet) long and has a maximum grade of six percent. An estimated 20 percent of the tunnel traffic is trucks, with those carrying hazardous materials prohibited. Trucks are stopped and inspected at manned stations near the tunnel entrances. The alternatives to use of the tunnel are the IH-610 Ship Channel Bridge (6.4 kilometers [4 miles] west) and the Jesse Jones Toll Bridge (6.4 kilometers [4 miles] east). Rerouting from the tunnel to one of these bridges can cause significant increases in travel time, particularly if there is no warning.

A CCTV system is used for tunnel surveillance and incident detection. Closures of the tunnel are required to handle most traffic incidents and weekly (at night) tunnel cleaning, since the tunnel has only two lanes. Closing the tunnel requires manual closing of hinged gates at each end of the tunnel. If tunnel closures are to be in effect for extended periods, local radio traffic services are notified, and telephone calls are placed to major nearby industries to advise of the situation.

The objective of this project is to implement automatic incident detection and closure systems for the tunnel and develop traveler information services to advise travelers of conditions at the tunnel.

PROJECT DESCRIPTION: The proposed integrated, areawide traffic management and traveler information systems extend over a large area in order to minimize the user impacts of tunnel closures. Two arterials (Federal Road and Clinton Drive) serve the tunnel on the north side and three on the south side (W. Richey, Shaver, and Red-Bluff Road). These arterials connect to IH-10 on the north, SH 225 on the south and IH-610 to the west. Traveler information systems will extend to traveler route decision points on IH-10, SH 225, and IH-610.

The project will include four implementation components: an incident detection system, automatic tunnel closure, areawide traveler information, and an AVI-based CVO permitting process. It is anticipated that visual imaging technology will be used for incident detection at

three detection locations in the tunnel, such as the Mobilizer Advanced Tracking System. Automatic gates would replace manually operated gates at the tunnel entrances.

Design of the traveler information and CVO permitting systems will depend on analysis of origin-destination patterns of tunnel traffic. Use of two information delivery technologies is anticipated: Changeable Message Signs (CMS) and Highway Advisory Radio (HAR). These systems will be coordinated with CTMS systems on IH-10, SH 225, and IH-610. Since alternative routes are located 6.4 kilometers (4 miles) east and west of the tunnel, the traveler information systems would extend to these route decision points. In addition to considering use of HAR on tunnel approaches, its deployment inside the tunnel to provide information to vehicles will be investigated.

A large number of trucks which use the tunnel are "local" and make repetitive trips. Permitting of these local trucks and equipping with AVI transponder tags and readers at tunnel entrances could eliminate many of the truck inspections made at the tunnel entrances. Permitted trucks would be subject to spot inspections of permit compliance, and permit renewals would be necessary at periodic intervals.

The following tasks are proposed for the operational test.

1. Develop Implementation Plan. Study of traffic and origin-destination characteristics will guide the definition of functional and physical requirements.
2. Develop Plans and Specifications and Deployment. Plans and specifications will be developed for system components, systems acquired and installed.
3. Preparation of Operations Procedures. TxDOT and Harris County will prepare operational procedures and contingent plans for operation of the incident detection, closure, traveler information, and CVO permitting systems.
4. Prepare Software for System Operation and Evaluation. Software will be developed for both system surveillance control and data acquisition for system evaluation.
5. Evaluate System Effectiveness. Components of the tunnel traffic management and information systems will be evaluated to assess their effectiveness.

PROJECT EVALUATION: Conduct of the project evaluation will include the following:

- Adequacy and reliability of the physical components of the system.
- Effectiveness of operations plans and system operations concepts.
- Effectiveness of information systems.
- Impacts on traffic operations (e.g., travel time, diversion, travel).
- Impacts on traffic safety.

BUDGET ESTIMATE: Estimated cost to develop and implement the proposed systems is $750,000, with the evaluation study estimated to be $200,000 for a total cost of $950,000.

Funding: FHWA—$760,000
Local—$190,000