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Houston Managed Lanes Case Study: The Evolution of the Houston HOV System

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16. Abstract

A nine-mile contraflow HOV lane on the I-45 North Freeway in Houston, Texas was implemented as a demonstration project in 1979. This demonstration borrowed an off-peak direction traffic lane for use by buses and vanpools in the peak direction. Although in use only during the morning and the afternoon peak periods, the contraflow lane carried some 15,000 persons in buses and vanpools on a daily basis. The success of this facility resulted in the development and operation of the extensive system of HOV lanes, park-and-ride lots, improved transit services, and other elements. The operation of the Houston HOV system has evolved over the years to include a value pricing demonstration program in two corridors. Further, managed lanes are being developed as part of a major improvement program in one freeway corridor.

This report highlights the development, operation, and use of the HOV system in Houston and the evolution toward managed lanes. The institutional arrangements supporting the development and the ongoing operation of the system are presented. As of 2003, some 100 miles of HOV lanes are in operation in six freeway corridors. The lanes are supported by 28 park-and-ride and four park-and-pool lots, transit centers, and express bus services. In 2003, the lanes carried some 121,079 passengers in buses, vanpools, and carpools on a daily basis.

This report also summarizes the issues that may be associated with the development and operation of managed lanes. The Houston case study and the summary of issues should be of benefit to transportation professionals and policy makers interested in developing and operating HOV facilities and managed lanes.

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CHAPTER ONE—INTRODUCTION

Objectives of Study

Traffic congestion continues to be a major issue in metropolitan areas throughout the country. The agencies responsible for the surface transportation system in these regions are using a variety of approaches and techniques to address concerns relating to traffic congestion, mobility, and air quality. The use of high-occupancy vehicle (HOV) facilities and managed lanes represent two related approaches in use or being considered in many urban areas.

HOV facilities are an important element of the transportation system in Houston. HOV lanes and supporting facilities are in operation in six freeway corridors. Building on the success of the HOV facilities, managed lanes are being developed in one freeway corridor and are under consideration in a second corridor.

The Federal Highway Administration (FHWA) sponsored this study examining the development and operation of the HOV system in Houston and the evolution toward managed lanes. This report summarizes the background and the current status of the Houston HOV system and the development of the first managed lanes project. It also highlights some of the issues that may need to be addressed in considering managed lanes. This report is intended for agency staff, consultants, and policymakers interested in pursuing new or enhancing existing HOV facilities and managed lanes.

This study accomplishes a number of objectives. The first objective of the study is to describe the development, operation, and use of the HOV system in the Houston area and the evolution toward managed lanes. The institutional arrangements and the factors influencing the development of the system are also summarized. A good deal of information is available in other documents on the use of the Houston HOV lanes. This report provides an overview of the development and use of the HOV system and the institutional arrangements that have helped foster the evolution of the system. A final study objective is to describe some of the issues typically associated with HOV facilities and managed lanes to assist transportation professionals interested in considering HOV and managed lanes.

Defining HOV and Managed Lanes

HOV facilities represent one approach used in metropolitan areas throughout the country to help improve the people-moving capacity rather than vehicle-moving capacity of congested freeway corridors. The travel time savings and improved trip time reliability offered by HOV facilities provide incentives for individuals to change from driving alone to carpooling, vanpooling, or riding the bus.

The development and operation of HOV facilities have evolved over the past 30 years. The opening of the bus-only lane on the Shirley Highway (I-395) in Northern Virginia/Washington, D.C. in 1969 and the contraflow bus lane on the approach to New York-New Jersey's Lincoln Tunnel in 1970 represent the first freeway HOV applications in the country. Today there are some 130 HOV freeway projects in 23 metropolitan areas in North America, including Houston.

HOV facilities are developed and operated to provide buses, carpools, and vanpools with travel time savings and more predictable travel times to encourage individuals to choose one of these modes over driving alone. The person movement capacity of a roadway increases when more people are carried in fewer vehicles. HOV facilities are usually found in heavily congested corridors where the physical and financial feasibility of expanding the roadway is limited. Supporting services, facilities, and incentives are also used to further encourage individuals to change their commuting habits.

HOV facilities are not intended to force individuals to make changes against their will. Rather, HOV lanes are developed to provide a cost-effective travel alternative that commuters will find attractive enough to change from driving alone to taking the bus, carpooling, or vanpooling. HOV projects typically focused on meeting one or more of the following three common objectives.

- **Increase the Average Number of Persons Per Vehicle**. The travel time savings and travel time reliability offered by HOV facilities offer incentives for individuals to change from driving alone to using a bus, vanpool, or carpool. By moving people, rather than vehicles, HOV projects focus on increasing the average number of people per vehicle on the roadway or travel corridor.

- **Preserve the Person Movement Capacity of the Roadway**. HOV lanes, which may move two to five times as many persons as a general-purpose lane, have the potential to double the capacity of a roadway to move people. Also, the vehicle occupancy requirements can be raised if a lane becomes too congested, helping to ensure that travel time savings and travel time reliability are maintained.

- **Enhance Bus Transit Operations**. Bus travel times, schedule adherence, and vehicle and labor productivity may all improve as a result of an HOV facility, helping attract new bus riders and enhancing transit cost effectiveness. Many transit agencies have expanded or initiated express bus services in conjunction with HOV facilities.

Managed lanes are also used in some metropolitan areas and are being considered in other regions. The Interstate system, which was developed to provide high-speed travel with limited access, represents the most common example of managed lanes. More recently, managed lanes have reemerged in new and different ways in urban areas throughout the country.

There is no one common definition of managed lanes. The term managed lanes is being used in many areas to describe facilities or lanes developed and operated in special ways. Managed lanes may focus on serving special user groups, such as HOVs or trucks; value pricing or tolling options; express lanes; and limited access facilities.

The Texas Department of Transportation (TxDOT) has developed the following definition for managed lanes as part of a research program, and it serves as the official definition of the concept for TxDOT:

> "A managed lane facility is one that increases freeway efficiency by packaging various operational and design actions. Lane management operations may be adjusted at any time to better match regional goals."

The Washington State Department of Transportation (WSDOT) developed the following definition of managed lanes in a 2001 workshop.

> "Managed lanes facilities include any roadway lane that can be managed to prevent congestion from occurring. In managed lanes, one or more of these techniques is used to control the number of vehicles using the lane or roadway:
>
> - Limiting access – providing infrequent on-ramps, as on the I-5 and I-90 express lanes;
> - User eligibility requirements – such as HOV-only, truck-only, permit-only; and
> - Pricing – tolls can be varied by time of day to control traffic volumes.
>
> By considering these as different forms of traffic management, it is possible to plan the best combination of tools to keep a roadway from becoming congested over time, and to optimize traffic to achieve the best person and vehicle throughput."

Although other definitions are being used in different states and areas, all focus on better management of a new or existing facility by targeting a range of possible strategies and user groups. The following facility types and strategies are typically included in general definitions of managed lanes focusing on preserving enhanced travel conditions:

- HOV lanes;
- high-occupancy/toll (HOT) lanes;
- value-priced lanes;
- express lanes;
- separated or bypass lanes;
- truck or commercial vehicle lanes;

- dual roadways, such as physically separated inner and outer roadways in one or both directions where operation can be managed on at least one of the roadways; and
- separate toll lanes constructed within freeways.

Overview of Houston Area

From the late 1940s through the mid 1970s, the Houston metropolitan area grew at a rate well above the national average, increasing in population from less than half a million to over two million. For most of this period, highway and street construction kept a reasonable pace with growth. By the mid 1970s however, traffic congestion was a significant concern. During the same period, the city was considering options to purchase the privately owned bus company, which was reducing service and maintenance levels in the face of financial hardships. The use of what was then a relatively new and untried concept – high-occupancy vehicle (HOV) lanes – was considered to address these concerns, and an initial demonstration project on the I-45 North Freeway was undertaken.

Today, some 4.3 million people live in the 8,800-square mile Houston metropolitan region, which is characterized by low-density development, typical of southwestern cities. In response to ongoing concerns related to traffic congestion on the freeway system, limited available right-of-way, and air quality, the initial nine-mile contraflow demonstration project has evolved over an almost 25-year period into a system that encompasses some 100 miles of HOV lanes, numerous direct access ramps, 28 park-and-ride lots, four park-and-pool lots, an extensive network of express bus service, and a value pricing demonstration project. This system provides preferential treatment to buses, vanpools, and carpools in the major freeway corridors.

The HOV system represents part of a multifaceted approach being taken in the Houston area to manage traffic congestion and to improve mobility. Building on the success of the HOV system, a value pricing demonstration was initiated in two corridors and managed lanes are being developed in one corridor. Other improvements to the surface transportation system include expanding freeways and roadways, building new toll roads, and developing an advanced transportation management system (TranStar). A light rail transit (LRT) line is also under construction and will open in early 2004. Future plans include additional HOV facilities, considering managed lanes in other corridors, expanding the LRT system, examining commuter rail, additional toll roads, and expanding TranStar.

Planning, designing, operating, and enforcing the HOV system elements has been accomplished through the coordinated efforts of the Texas Department of Transportation (TxDOT) and the Metropolitan Transit Authority of Harris County (METRO). Recently, Harris County and the Harris County Toll Road Authority (HCTRA) have joined this partnership to assist with the development and operation of the planned managed lanes. These efforts have been coordinated with the Houston-Galveston Area Council (HGAC), the metropolitan planning organization (MPO) for the area.

The HOV system has attracted new riders to transit and ridesharing and has influenced commuters to change from driving alone to using an HOV mode. This report highlights the development and the use of the Houston HOV and managed lane system. The institutional arrangements supporting the development and the ongoing operation of the system are summarized. The issues that may be encountered with managed lanes area also highlighted.

Activities Conducted

A number of activities were completed as part of this study. First, available reports, papers, and other documents on the Houston HOV and managed lane facilities were reviewed. The HOV system has been the focus of ongoing monitoring efforts supported by TxDOT and METRO. As a result, a good deal of information is available on the use of the system. Second, additional information was obtained through communication with representatives from agencies and organizations in the Houston area. No further original data collection was conducted due to the limited project scope. Third, information from the Houston case study was synthesized and combined with information on managed lanes in other areas to highlight some of the issues typically associated with HOV and managed lanes.

Organization of this Report

The remainder of the report this divided into three chapters. The evolution and use of the various elements of the HOV and managed lane system in Houston are presented in Chapter Two, along with possible future plans and projects. The institutional arrangements associated with the development and operations of the system are described in Chapter Three. The elements and issues typically considered in planning, designing, implementing, and operating managed lanes are discussed in Chapter Four.

CHAPTER TWO—EVOLUTION AND USE OF THE HOUSTON HOV LANE SYSTEM

Development and Operation of the HOV Lane System

As noted previously, traffic congestion was a significant concern in Houston during the 1970s. The Texas Highway Department (THD) was planning expansions to many freeways and examining possible improvements to others. At the same time, the privately-owned bus company was encountering serious financial difficulties. As a result, service levels were low and buses were in poor conditions.

In the early 1970s, the City of Houston was exploring options for establishing a public transit authority. A long-range transit plan was prepared, which included an extensive rail system and HOV lanes on some freeways. This plan was the basis for a 1973 ballot measure to establish the Houston Area Rapid Transit Authority (HARTA). Although supported by the City Council and community leaders, voters defeated the HARTA proposal. In 1974, the City purchased the privately-owned bus company and established the Office of Public Transportation (OPT).

The OPT began an aggressive program to upgrade the bus system. The Office developed a strong working relationship with the THD Houston District to explore and implement congestion reducing strategies. OPT and THD shared a common interest in addressing increasing levels of traffic congestion by encouraging greater use of buses, vanpools, and carpools. THD was concerned about improving travel conditions on congested freeways and OPT was interested in methods to move buses through traffic more efficiently and to improve services levels and the image of the bus system. Using a federal Service and Methods Demonstration (SMD) grant, the OPT and THD examined the potential of freeway HOV lanes, which were a relatively new concept at the time. A contraflow lane demonstration project on the North (I-45 North) Freeway was recommended to test the HOV concept.

A contraflow HOV lane uses a lane in the off-peak direction of travel for HOV travel in the peak direction. Contraflow lanes are appropriate for corridors with high directional splits, such as 60 percent of traffic in the peak direction and 40 percent in the off-peak direction. The excess capacity in the off-peak direction of travel is used for HOVs moving in the peak direction. The I-45 N corridor had a high directional split and travel in the peak direction was very congested. Thus, the corridor provided the right conditions for the demonstration.

The demonstration project included a nine-mile contraflow HOV lane, park-and-ride lots, freeway ramp metering, and contracted bus service. The demonstration was funded through a variety of sources, including federal highway and transit programs, state highway funds, and local sources. The unique blend of financing provides an indication of the cooperation among agencies and the willingness to take creative approaches. This

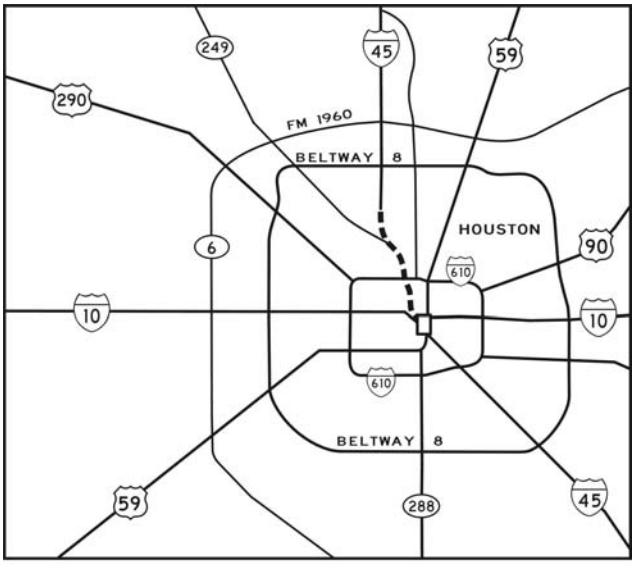
unique mix of financing and interagency cooperation continued as important characteristics of future HOV projects.

The development and operation of the contraflow lane and subsequent HOV facilities was guided by a series of agreements between the two agencies. These institutional arrangements are discussed in Chapter Three. Construction and operation of the contraflow demonstration project also represented a joint effort. The THD, which became the State Department of Highways and Public Transportation (SDHPT), was responsible for construction management, engineering, and inspection, and OPT administered the funds for contractor payments and reimbursement of SDHPT.

During the development of the contraflow lane the city continued to work toward establishing a regional transit agency. In 1978, voters approved the creation of the Metropolitan Transit Authority of Harris County (METRO) and the dedication of one percent of the local sales tax to fund the agency. The 1978 *Regional Transit Plan*, which identified the projects METRO would pursue, included HOV facilities in most freeway corridors, as well as rail transit. The HOV facilities included in this plan have been incorporated and refined in METRO, TxDOT, and Houston-Galveston Area Council (HGAC) plans over the years. With the creation of METRO, OPT was dissolved in 1979.

The contraflow lane began operation in August 1979. Figure 1 shows the location of the contraflow lane. The lane operated from 5:45 a.m. to 8:45 a.m. in the inbound direction toward downtown and from 3:30 p.m. to 7:00 p.m. in the outbound direction. The contraflow lane was created by taking the inside freeway lane in the off-peak direction of travel for use by buses and vanpools traveling in the peak-direction. The lane was separated from opposing traffic by plastic pylons, which were set up and removed by METRO crews each morning and afternoon.

Due to safety concerns, only buses and authorized vanpools were allowed to use the contraflow lane. Figure 2 highlights the operation of the lane. To become eligible to use the lane, vanpool drivers had to register and complete training provided by METRO. During the late 1970s and early 1980s, many large downtown employers subsidized vanpools for their employees in response to the Arab Oil Embargo in 1979. Enforcement of the lane was initially contracted to the Houston Police Department. METRO established its own transit police force in 1982 and assumed enforcement duties of the contraflow lane at that time. METRO also provided wreckers at strategic locations along the lane to deal with any accidents or incidents.



--- HOV Lane

Figure 1. Location of I-45 North Contraflow Lane.

Figure 2. I-45 North Contraflow Lane.

Use of the contraflow lane exceeded projections. Some 8,000 bus riders and vanpoolers used the lane on a daily basis during the first few years of the project. During the morning peak hour, the lane carried nearly as many people as the adjacent two freeway lanes. A 3.3-mile concurrent flow lane upstream from the entrance to the contraflow lane was opened in 1981. Use levels increased to a high of 15,000 riders per day with this improvement.

The success of the demonstration project resulted in a permanent HOV facility on the North Freeway and the consideration of HOV lanes on other freeways. The demonstration proved that commuters would change from driving alone to taking the bus or riding in a vanpool. Survey results indicate that some 35 to 39 percent of bus riders and 30 to 42 percent of vanpoolers previously drove alone.

As a result of the demonstration, a reversible HOV lane was added to plans for upgrading and expanding the North Freeway. The permanent HOV lane was a one-lane barrier separated reversible facility located in the center median of the freeway. A number of factors influenced the use of this design, including limited right-of-way, increased safety due to barrier separation, and the directional split of travel in the corridor. In September of 1984, the first segment of the permanent HOV lane opened and operation of the contraflow lane ceased.

The development of the second HOV lane in Houston took advantage of a planned improvement project. Plans to repair and overlay a 10-mile segment of the Katy Freeway were moving forward in the late 1970s, with a major reconstruction effort anticipated in the future. An HOV lane on the Katy Freeway had been identified in the 1978 *Regional Transit Plan*. To take advantage of the opportunity presented by the repair project, the design of the HOV lane was expedited and the overlay project was delayed slightly. Working jointly, the SDHPT and METRO completed the design and construction process, including obtaining the necessary federal approvals, and the first 4.7-mile segment of the Katy HOV lane was opened in October of 1984. Figure 3 shows the location of the Katy HOV lane and the HOV system in 1985.

The lane initially operated inbound from 5:45 a.m. to 9:30 a.m. and outbound from 3:30 p.m. to 7:00 p.m. Operating hours were extended to 5:45 a.m. to 11:00 a.m. and 2:00 p.m. to 7:00 p.m. in 1986. Following the vehicle eligibility requirements in use on I-45 North, only buses and vanpools were initially allowed to use the Katy HOV lane. Only 66 vanpools and 20 buses, for a total of 86 vehicles, used the lane during the morning peak hour with these requirements. To address this low use, the lane was open to authorized 4+ carpools in 1985. The occupancy requirement was dropped to 3+ carpools later in 1985 and to 2+ carpools in 1986. Table 1 highlights the initial changes in vehicle eligibility and vehicle-occupancy levels and corresponding use levels.

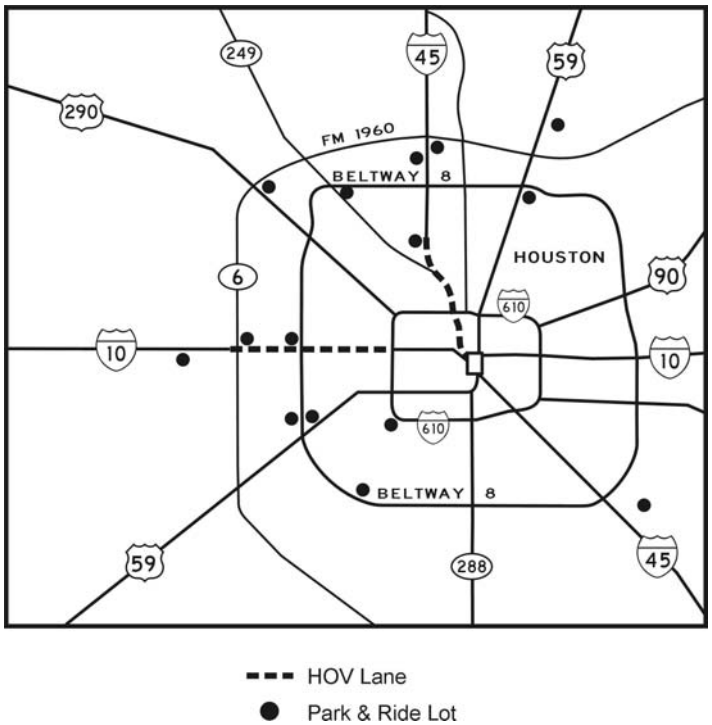


Figure 3. 1985 Houston HOV Lane System.

Table 1. Changes in Vehicle Occupancy Requirements and Corresponding Vehicle Volumes on the Katy HOV Lane

Vehicle Eligibility and Vehicle-Occupancy Requirements	Date (Time after Opening)	AM Peak Hour HOV Lane Vehicle Volumes			
		Carpools	Vanpools	Buses	Total
Buses and Authorized Vanpools	October 1984	–	66	20	86
Buses, Authorized Vanpools and Authorized 4+ Carpools	April 1985 (6 months)	3	68	25	96
Buses, Authorized Vanpools, and Authorized 3+ Carpools	September 1985 (1 year)	53	59	31	143
Buses, Vanpools, and 2+ Carpools	November 1986 (2 years)	1,195	38	32	1,265
	November 1987 (3 years)	1,453	21	37	1,511

Source: "Traveler Response to Transportation System Changes Interim Handbook – Chapter Two – HOV Facilities." Richard H. Pratt, Texas Transportation Institute, et al., Transit Cooperative Research Program, Washington, D.C., 2000.

The HOV system expanded significantly from 1985 to 2003. Figures 4 and 5 illustrate the growth in the HOV system over this 18-year period. METRO and the renamed Texas Department of Transportation (TxDOT) continued to work cooperatively on the development and operation of the HOV system. Funding from METRO, TxDOT, FHWA, and FTA was used for different parts of the system.

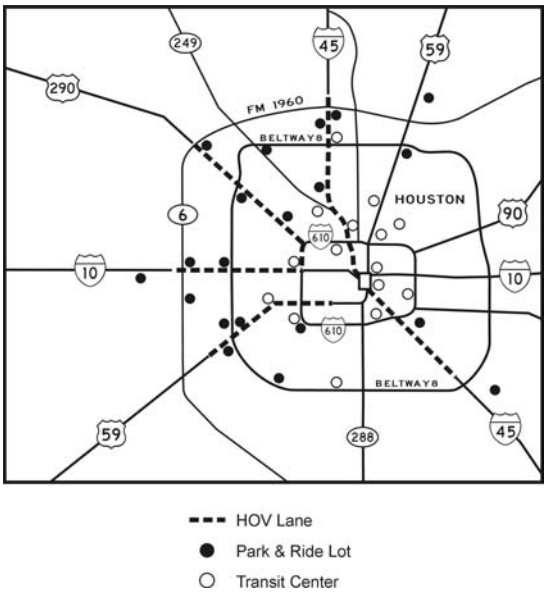


Figure 4. 1995 Houston HOV Lane System.

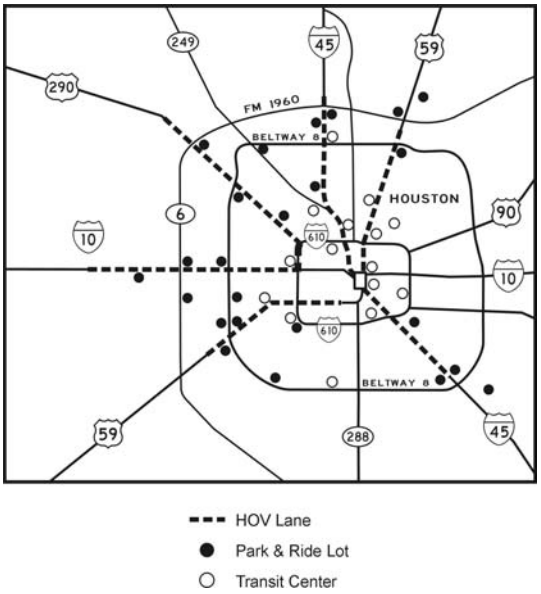


Figure 5. 2003 Houston HOV Lane System.

By 2003, some 100 miles of HOV lanes are in operation in six freeway corridors. The main elements of the HOV system – the HOV lanes, park-and-ride lots, transit centers, direct access ramps, and express bus service – are highlighted next.

- **HOV Lanes**. As Figure 6 illustrates, the HOV lanes are primarily one-lane, reversible, barrier-separated facilities, located in the median of six freeways. A short two-lane, two-direction section exists on the Northwest (US 290) Freeway. A two-way facility, with one lane in each direction of travel, is in operation on the Eastex (US 59) Freeway. A concurrent flow HOV lane is in operation on the Katy Freeway, leading to the reversible lane. As noted previously, the design used for the HOV lanes was influenced by a number of factors. These factors include limited right-of-way in the freeway corridors, providing a safer operating environment through the use of barriers, and the directional splits in the corridors.

  The lanes operate in the inbound direction from 5:00 a.m. to 12:00 p.m. and in the outbound direction from 2:00 p.m. to 9:00 p.m. The lanes are closed from Noon to 2:00 p.m. to reverse operations and are closed to all traffic at other times. A 2+ vehicle-occupancy requirement is used on all the HOV facilities, except the Katy and the Northwest. These two HOV lanes have a 3+ occupancy requirement from 6:45 a.m. to 8:00 a.m. and 5:00 p.m. to 6:00 p.m., due to congestion occurring at the 2+ level. The Quick Ride value-pricing project operates on these two lanes, allowing participating 2+ carpools use of the lane for a $2.00 per trip fee. This project is described later in this chapter.

Figure 6. Katy (I-10 West) HOV Lane.

- **Park-and-Ride Lots**. A total of 28 park-and-ride lots and four park-and-pool lots are located in the six corridors with HOV lanes. The larger park-and-ride lots have direct access to the HOV lanes and transit stations with passenger amenities. There are spaces for between 900 and 2,500 automobiles at 19 of the lots. The number of parking spaces at lots in each corridor range from slightly over 3,000 to almost 7,500. Figure 7 illustrates the Fuqua park-and-ride lot and transit station along the Gulf (I-45 South) Freeway.

Figure 7. Fuqua Park-and-Ride Lot.

- **Transit Centers**. The park-and-ride lots have transit stations with covered passenger waiting areas and other amenities. Transit centers without park-and-ride lots or with only small lots are located at strategic transfer points. Figure 8 illustrates an example of a transit center with direct access to the HOV lanes.

- **Direct Access Ramps**. As Figure 9 illustrates, direct access ramps connect the major park-and-ride lots and transit stations to the HOV lanes. These ramps provide travel time savings for buses using the HOV lanes and enhance the safe operation of both the HOV lanes and the freeways. Use of the direct access ramps is restricted to buses, carpools, and vanpools during operating hours. The ramps are closed during non-operating periods. Carpools and vanpools can access the ramps and the HOV lanes through the lots. The direct access ramps provide significant travel time savings for buses and other HOVs. The 1990 opening of the direct access ramp linking the Northwest Station park-and-ride lot with the Northwest HOV lane

provided travel savings of 14 minutes for vehicles entering and exiting the HOV lane. Prior to the ramp opening, HOVs had to travel local streets, enter the freeway, and merge across the general-purpose lanes to enter the HOV lane. Use levels increased after the ramp opened. As Figure 9 highlights, direct HOV lane access ramps are also provided at selected entry and exit points.

Figure 8. Direct Access Ramp to Kuykendahl Park-and-Ride Lot.

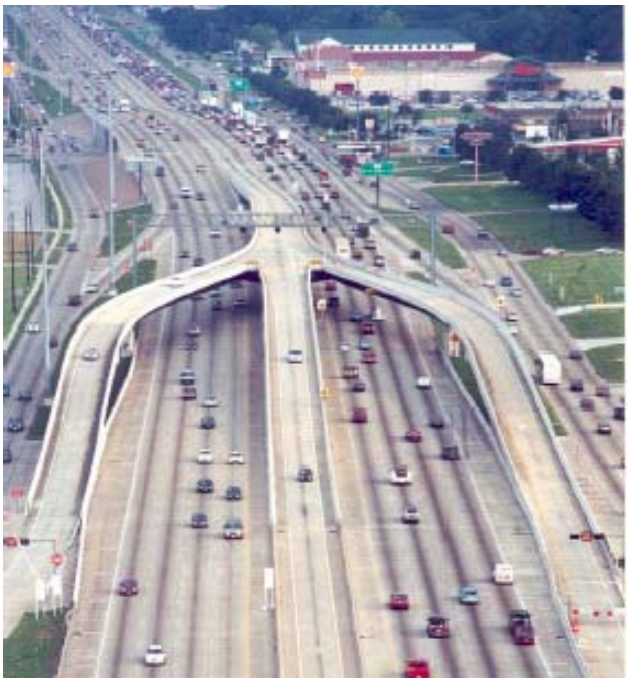


Figure 9. Direct Access Ramp.

- **Express Bus Service**. METRO provides a high level of bus service in each corridor, with frequent trips from the major park-and-ride lots. Over-the-road coaches are operated on many routes, as are articulated buses. Although there is not direct evidence linking increased ridership to use of the coaches, surveys of bus riders indicate support for their use and support for frequent service. The HOV lanes and express bus services are oriented primarily in a radial direction, with downtown Houston as the major destination. The express bus system has evolved over the years, however, providing service to major activity centers such as the Texas Medical Center (TMC), Greenway Plaza, and the Post Oak/Galleria area. More recently, reverse commute services have been added in some corridors, taking advantage of buses in the general-purpose lanes deadheading back to park-and-ride lots.

- **Rideshare Services and Other Supporting Activities**. METRO provides rideshare services in the Houston area. METRO's RideShare program includes a number of elements to help individuals form carpools and vanpools. Rideshare matching services are available by telephone and on-line through METRO's Internet site. The METROVan program helps commuters form vanpools and provides vans for their use. METROVan is co-sponsored by HGAC, allowing METRO to provide vanpools outside the METRO service area. METRO's corporate RideSponsor program focuses on encouraging employees to commute to work by bus, carpools, or vanpools. The program provides computerized ridematching services, vanpools, and employer outreach. Corporate RideSponsors are eligible for discounted bus passes for their employees.

Use of the HOV Lane System

METRO and TxDOT sponsor ongoing monitoring of the Houston HOV system. A multi-year TxDOT research study provided an annual assessment of the system for many years. METRO supports ongoing data collection and evaluation efforts. The monitoring program focuses primarily on HOV and freeway vehicle volumes, bus ridership levels, vehicle occupancy levels, travel times in the HOV lanes and the freeway lanes, and incident data. Periodic surveys of bus riders, carpoolers, and vanpoolers using the HOV lanes, and motorists in the general-purpose lanes have been conducted. Highlights from these and other ongoing efforts are summarized here. More detailed information is available in the reports provided in the references.

- **Use Levels**. Table 2 presents key information on use of the Houston HOV lanes. In 2003, some 212,079 passengers used the HOV lanes on a daily basis. Buses carried 43,225 passengers, vanpools accounted for 2,500 riders, carpools had 74,867 occupants, and 407 motorcycles used the lanes daily. Morning peak-hour utilization levels range from approximately 1,000 vehicles on the Katy HOV lane to 1,551 on the Northwest HOV lanes.

Table 2. 2003 Houston HOV Lane Parameters and Weekday Utilization Data

	Katy (I-10 W)	North (I-45 N)	Gulf (I-45 S)	Northwest (US 290)	Southwest (US 59 S)	Eastex (US 59 N)
Length	13	13.5	12.1	13.5	12.2	14.8
Opening Date	1984	1984	1988	1988	1993	1999
Number HOV/General-Purpose Lanes	1/3	1/4	1/4	1/3	1/5	
HOV Lane Person Volume						
AM Peak-Hour – Total	4,776	5,736	4,818	4,077	5,330	826
Buses	1,710	2,290	1,545	1,260	1,890	195
Carpools/Vanpools	3,001	3,223	3,098	2,794	3,249	626
Motorcycles	25	3	5	23	11	5
Daily – Total	28,585	26,325	18,488	20,566	23,396	5,841
HOV Lane Vehicle Volume						
AM Peak-Hour – Total	1,350	1,405	1,457	1,273	1,548	280
Buses	40	43	29	27	36	4
Carpools/Vanpools	1,283	1,350	1,418	1,223	1,495	271
Motorcycles	18	3	5	23	11	5
Daily – Total	9,778	7,386	5,596	7,332	6,972	1,357
AM Peak-Hour Average Vehicle Occupancy						
HOV Lane – Buses Only	42	53	53	47	52	48
HOV Lane – Carpools/Vanpools Only	2.30	2.30	2.20	2.24	2.19	2.18
Total HOV Lane	3.22	4.08	3.30	3.20	3.44	2.95
General-Purpose Lanes	1.12	1.02	1.07	1.05	1.07	1.05

AM peak hour represents the hour with the highest vehicle volumes.
Source: Houston HOV Lane Operation Summary, March 2003.

Corresponding person volumes in the morning peak hour average between 3,424 on the Gulf HOV lane and 4,836 on the North HOV lane. The HOV lanes account for 40 percent of the morning peak hour total person movement on three of the freeways. The AM peak hour is defined as the hour with the highest vehicle volumes. As a result, the peak hour may vary by HOV lane.

Vehicle-occupancy requirements were adjusted on two HOV lanes due to high levels of use. By 1988, morning peak hour vehicle volumes on the Katy HOV lane were frequently approaching or exceeding 1,500 vehicles. The travel time savings and the trip time reliability provided by the lane and expected by users began to degrade with volumes of 1,500 vehicles in the morning peak hour. HOV lane users, especially bus riders, began to complain over the degradation in service.

A number of alternatives were considered by METRO staff to address the problem of too many vehicles during the morning peak hour. Options considered included requiring authorization for 2+ carpools, metering access, increasing vehicle-occupancy levels, requesting voluntary changes in travel times, and not making any changes. An attempt was made to encourage voluntary changes in travel times through postcards to vanpoolers and carpoolers. This approach did not result in significant changes in peak-hour vehicle volumes.

A policy-level decision was made by both agencies to increase the vehicle-occupancy requirement from 2+ to 3+ during the period from 6:45 to 8:15 a.m. The 2+ requirement was maintained at other times. This change was implemented on very short notice in October 1988.

Table 3 highlights the changes in vehicle volumes immediately after the change to the 3+ requirement in 1988 and the growth in 3+ carpools over the next eight years. The morning peak hour carpool volume dropped from some 1,450 to 510 vehicles immediately after the change, representing a 65 percent reduction. Total AM peak hour vehicle volumes – carpools, vanpools, and buses – dropped from 1,511 to 570, a 62 percent reduction. Person volumes declined by 33 percent during the AM peak hour. Although vehicle and person volumes declined, AM peak hour average vehicle occupancy (AVO) increased from 3.1 prior to the change to 4.5 five months after the change.

Vehicle volumes during the 6:00 a.m. to 9:00 a.m. peak-period declined by some 14 percent. Two person carpools declined by some 41 percent and 3+ carpools increased by 68 percent. Bus ridership grew by eight percent. Based on survey results, it appears that some two person carpools shifted

their travel to earlier time periods and some changed their travel routes to use the newly opened Northwest HOV lane, which had a 2+ requirement.

Table 3. Change to 3+ Occupancy Requirement on the Katy HOV Lane

Vehicle Eligibility and Vehicle-Occupancy Requirements	Date (Time after Opening)	AM Peak Hour HOV Lane Vehicle Volumes			
		Carpools	Vanpools	Buses	Total
Buses, Vanpools and 3+ Carpools[a]	October 1988 (4 years)	510	24	36	570
	March 1989 (4½ years)	660	28	40	728
	December 1989 (5 years)	611	19	37	667
	1996 (12 years)	858	19	33	910

Notes:
[a] The 3+ carpool requirement was implemented for the period of 6:45 a.m. to 8:15 a.m. in October 1988. In May, 1990, the 3+ restricted period was modified to 6:45 a.m. to 8:00 a.m. and in September 1991 the 3+ restricted was implemented from 5:00 p.m. to 6:00 p.m.

Source: "Traveler Response to Transportation System Changes Interim Handbook – Chapter Two – HOV Facilities." Richard H. Pratt, Texas Transportation Institute, et al., Transit Cooperative Research Program, Washington, D.C., 2000.

The time period for the 3+ restriction on the Kay HOV lane has been modified over time. In May 1990, the 3+ period was shortened to 6:45 a.m. to 8:00 a.m. In September 1991, the 3+ restriction was implemented in the afternoon peak hour from 5:00 p.m. to 6:00 p.m. A 3+ restriction was also implemented from 6:45 a.m. to 8:00 a.m. on the Northwest HOV lane in July 1999 in response to congestion levels similar to those experienced on the Katy HOV lane.

- **Bus Operating Speeds and Schedule Times**. The HOV lanes and direct access ramps have significantly increased METRO bus operating speeds. The peak hour bus operating speeds have almost doubled, from 26 mph to 54 mph, resulting in significant reductions in bus schedule times. Examples of reductions in the morning peak hour schedule time for buses from park-and-ride lots to downtown Houston include from 45 to 24 minutes from the Addicks park-and-ride lot on the Katy HOV lane, from 40 to 25 minutes from the Edgebrook park-and-ride lot on the Gulf HOV lane, and from 50 to 30 minutes from the Northwest Station park-and-ride lot on the Northwest HOV lane.

- **Travel Time Savings**. The HOV lanes provide travel time savings for buses, vanpools, and carpools. Morning peak hour travel time savings range from approximately 2 to 22 minutes on the different HOV lanes. The Northwest Freeway HOV lane generally provides the largest travel time savings of about 22 minutes. The Katy HOV lane averages between 17 and 20 minutes, the North 14 minutes, and the Gulf and Southwest between 4 and 2 minutes. In addition, the HOV lanes provide more reliable trip times to carpoolers, vanpoolers, and bus riders.

- **Park-and-Ride Lots**. Approximately 32,293 spaces are provided at 28 park-and-ride lots associated with the HOV lanes. An additional 1,377 spaces are located at four park-and-pool lots. METRO buses serve the park-and-ride lots, while the park-and-pool lots provide staging areas for carpools and vanpools. In 2003, the overall occupancy levels at the individual facilities ranged from about 10 percent at some park-and-pool lots to 100 percent at well-used park-and-ride lots. Table 4 highlights the growth in the number of park-and-ride lots and use levels from 1980 to 2003. From 1980 to 1990, the number of park-and-ride lots doubled from 10 to 20. The number of available spaces increased from 4,070 spaces to 12,626 spaces. Use of the lots grew from 4,070 parked vehicles to 12,626 vehicles. As of 2003, there are 28 park-and-ride lots, with 32,293 spaces. Approximately 54 percent of the available spaces are used on a daily basis. Table 5 highlights the number of park-and-ride spaces, and the occupancy levels by corridor.

- **Change in Travel Mode**. The travel time savings and the improved trip time reliability have influenced commuters to change from driving alone to taking the bus, carpooling, and vanpooling. Periodic surveys of HOV lane users show that between 36 and 45 percent of current carpoolers formerly drove alone, while 38 to 46 percent of bus riders previously drove alone. Surveys conducted in 1988, 1989, and 1990, indicate that the opening of the HOV lanes was very important in their decision to ride a bus for between 54 and 76 percent of the bus riders using the Houston HOV lanes. Between 22 and 39 percent of the respondents also indicated that they would not be riding the bus if the HOV lane had not been opened.

- **Average Vehicle Occupancy**. The HOV system has resulted in an increase in AVO levels in the corridors with HOV lanes. For example, the morning peak-hour AVO increased on the North Freeway from 1.28 in 1978 before the contraflow HOV lane opened to 1.41 in 1996. The morning peak-hour AVO increased on the Northwest Freeway from 1.14 in 1987 prior to the opening of the HOV lane to 1.36 in 1996. The 1996 morning AVO for the HOV lanes ranged from 2.6 to 3.65, compared to 1.02 to 1.12 for the general-purpose lanes.

Table 4. Houston HOV Lane Park-and-Ride Lot Capacity and Utilization

YEAR	Number of Lots	Number of Spaces	Occupancy	Percent Occupancy
1980	10	6,414	4,070	63%
1990	20	22,882	12,626	55%
2003	28	32,293	17,564	54%

Source: "Traveler Response to Transportation System Changes Interim Handbook – Chapter Two – HOV Facilities." Richard H. Pratt, Texas Transportation Institute, et al., Transit Cooperative Research Program, Washington, D.C., 2000.

Table 5. Houston HOV Lane Park-and-Ride Lot Capacity and Utilization by Corridor

Corridor	Number of Lots	Number of Spaces	Occupancy	Percent Occupancy
Katy Freeway (I-10 W)	3	5,883	3,489	59%
North Freeway (I-45 N)	5	7,313	3,976	54%
Gulf Freeway (I-45 S)	4	3,373	2,120	63%
Northwest Freeway (US 290)	4	4,615	3,093	67%
Southwest Freeway (US 59S)	8	7,311	3,288	45%
Eastex Freeway (US 59 N)	4	3,798	1,598	42%
TOTAL	28	32,293	17,564	54%

Source: Houston HOV Lane Operation Summary, March 2003.

- **Positive Public Perception**. Periodic surveys of HOV lane users and motorists in the general-purpose lanes included questions designed to obtain feedback on the general perception toward the HOV lanes and support for these facilities. Between 40 and 81 percent of motorists in the general-purpose lanes on freeways with HOV facilities and one freeway without an HOV lane have responded positively to these surveys that the HOV facilities are a good transportation improvement.

QuickRide Value Pricing Demonstration

In 1996 and 1997 TxDOT and METRO conducted a congestion or priority pricing feasibility study on the Katy Freeway. The study represented one of the congestion pricing pilot projects funded by FHWA under the Intermodal Surface Transportation Efficiency Act (ISTEA). The name of the pilot project program was changed to priority pricing under the Transportation Equity Act for the 21st Century (TEA-21). The study examined the potential of allowing 2+ carpools to use the HOV lane for a fee during the morning and afternoon peak hours when the 3+ occupancy requirement is in effect.

METRO and TxDOT staff were interested in considering the potential of 2+ HOVs using the lane during the 3+ restricted period for a fee due to the excess capacity available at those times. The pricing demonstration was viewed as a way to increase use of the lane without allowing it to become overly congested as it was in 1988 when the vehicle-occupancy requirement was raised to 3+. The study estimated that approximately 600 additional vehicles could be accommodated in the lane during the peak hour while maintaining free flow operations. Consideration of a potential demonstration reflects the ongoing interest in the part of METRO and TxDOT in maximizing use of the lanes to benefit travelers. Consideration of allowing only 2+ HOVs, rather than single-occupancy vehicles, indicates the commitment of both agencies to maintain the integrity of the HOV lane concept and to provide travel time savings and trip time reliability to HOVs.

A number of key elements were examined during the feasibility study. These included assessing the available capacity and the potential demand at different pricing levels, legal issues, and public reactions. A variety of potential operational strategies were explored, including manual and automated payment techniques. A major question was how many 2+ carpools would use the facility at different pricing levels. This analysis was critical to ensure that the HOV lane did not become congested as a result of a demonstration.

Legal and institutional issues were also examined in the assessment. These concerns included the ability to charge for use of the HOV lane, the ability to enforce fines and penalties associated with not paying the toll, and other policy changes needed to implement the demonstration. The study results indicated that METRO has the authority to charge for use of the lanes under specific conditions, that the fines are enforceable with minor modifications, and that there were no critical policies prohibiting a demonstration.

Like other congestion pricing projects, a critical issue appeared to be public acceptance. As part of the feasibility study, two focus groups were conducted in Houston. One focus group was comprised of commuters who used the Katy Freeway and the other was composed of residents throughout Houston. The focus group participants were somewhat skeptical about the concept. Both groups were also interested in how the revenue from the demonstration would be spent.

Based on a feasibility study, the decision was made to implement a demonstration project to test allowing two-person carpools to use the HOV lane for a $2.00 per trip fee during the 3+ occupancy requirement periods – 6:45 a.m. to 8:00 a.m. and 5:00 p.m. to 6:00 p.m. METRO applied for a federal demonstration grant for the project, but all of the funds had been allocated. As a result, METRO and TxDOT used funding from Houston's allocation under the Priority Corridor Program to implement the demonstration. Approval from both the FHWA and the FTA administrators was requested based on action by the METRO Board and the TxDOT Commission. Approval for the demonstration was received from FHWA and FTA administrators. Approval from both federal agencies was needed since funding from both had been used for the Katy HOV lane and supporting elements.

The demonstration, called *QuickRide*, which uses an electronic toll collection system, was implemented at the end of January 1998. Individuals are required to register for the program and must have an active electronic tag account. By June 1998, 468 *QuickRide* electronic tags had been issued. In 2000, the demonstration was expanded to include the Northwest Freeway HOV lanes, only in the morning peak hour. As of April 2003, there were 1,476 active *QuickRide* accounts.

The daily use of the demonstration has grown slowly over time. In 1998, the demonstration averaged 103 daily users on the Katy HOV lanes. By 1999, some 121 participants were using the program daily. Use levels in 2000, 2001, and 2002 remained relatively constant, averaging between 120 and 128. Use levels are higher in the morning on the Katy, with some 68 percent of the daily participants traveling in the lane in the morning peak hour. Some 22 people used the program in the morning peak hour on the Northwest HOV lane in 2000, with use growing to an average of 56 by 2002.

Each enrolled tag generates an average of one tolled trip every four days, producing an average of 115 to 120 total two-person carpool trips during the 1-1/4 morning hours plus the one evening hour. Only 6.5 percent of enrolled tags produced five or more trips per week (out of a maximum of 10). Approximately 25 percent of the tags had never been used as of June 1998. Many of these may belong to two-tag households. Base on an average time savings of 18 minutes, the estimated minimum value of travel time for participating vehicles, which is the sum for both occupants, is $6.57 per hour.

Although use levels have been modest, the demonstration has been successful at allowing an additional user group to use the HOV lanes during the 3+ restricted period. It appears that many enrollees view having an electronic tag as insurance for the occasional need and opportunity to ensure a quick trip, but cannot use the program on a regular basis.

A survey of travelers on the mixed traffic lanes indicated a low level knowledge of the program. Some 55 percent of the respondents thought it was fair, however, 67 percent viewed it as effective for the HOV lanes, and 85 percent perceived a benefit for the regular lanes. While the low *QuickRide* usage has not resulted in significant changes in person throughput on the freeway, it appears that some 25 percent of the users are forming two-person carpools to participate, compared to only 5 percent of users who appear to be coming from all types of higher-occupancy modes.

Development of Katy Freeway Managed Lanes

Plans for expanding the Katy Freeway began in the late 1990s. The 23-mile corridor carries some 280,000 vehicles a day. The existing cross section in the most congested section from SH 6 to I-610 includes three general-purpose lanes in each direction, the HOV lane, and three lane frontage roads in each direction.

A number of alternatives were examined in the Major Investment Study (MIS), including four special-use lanes in the freeway median. Other options included additional general-purpose lanes and expanding the HOV lanes. The special-use or managed lane option emerged from this study as the preferred alternative. The specific operation of the managed lanes was not defined, but user groups considered included buses, 3+ HOVs, QuickRide HOVs, vanpools, trucks, and long-distance travelers. Other than QuickRide participants, tolling was not considered as an operational strategy. The cross-section for the section between SH 6 an I-610 would include a three-lane frontage road and four main lanes in each direction of travel, and the four managed lanes.

During the environmental impact statement (EIS) process, the Harris County Toll Road Authority (HCTRA) expressed interest in participating in the managed lanes portion of the project. The EIS was modified to include tolling. Additional public involvement activities were conducted, along with a more detailed assessment of potential toll-related issues. Chapter Four, FHWA *Program Guidance on HOV Operations*, provides information on the issues to be examined when major changes in HOV operations are being considered.

There are two multi-agency agreements that have been used to date to advance the toll-managed lanes on the Katy Freeway. A Memorandum of Understanding (MOU) between TxDOT, METRO, and Harris County was signed in 2002. The MOU outlined the general roles of the three groups, specific provisions for transit, and the basic elements of the operating agreement. HCTRA is responsible for enforcement, incident management, and maintenance of the lanes. The MOU identifies a level of service (LOS) C as the target for the managed lanes. It also identifies transit access points, provides an option for future light rail transit (LRT), and allows special signing for METRO. The MOU also identifies the following elements in operating the managed lane:

- METRO may operate 65 buses an hour, 24 hours a day/seven days a week (24/7) toll free;
- METRO may operate METROLift service 24/7 toll free;
- carpools with three or more persons (3+) may travel toll free from 6:00 a.m. to 11:00 a.m. and from 2:00 p.m. to 8:00 p.m.
- METRO support vehicles may travel toll free 24/7;
- single-occupant vehicles, 2+ HOVs, and other vehicles pay the appropriate tolls.

The MOU also outlines the options that will be considered if a LOS C is not maintained. The potential actions include adjusting variable pricing, adjusting the HOV occupancy-level requirements, restricting METRO support vehicles, and expanding the facility to add transit-only lanes. METRO buses and METROLift vehicles are identified as

the top priorities to continue using the lanes, followed by HOVs and non-revenue METRO vehicles are listed as the lowest priority.

The Tri-Party Agreement among TxDOT, FHWA, and Harris County was signed in March 2003. This agreement outlines the roles and responsibilities for funding, design, and reconstruction of the managed lanes. Harris County, through HCTRA, agreed to provide contributions equal to the construction cost, not to exceed $250 million. HCTRA is also responsible for design of the toll-related elements and any additional public involvement needed to consider the toll elements. The toll revenues will be used for debt service, reasonable return on investment, and funding operation and maintenance of the managed lanes. TxDOT's responsibilities include securing federal funding, the remaining right-of-way, and construction. TxDOT also agreed to provide it best efforts to meet the project schedule, including the use of incentives and other techniques.

Managed Lanes are also being considered in the Northwest corridor. A potential alternative in this corridor involves HCTRA purchasing an existing railroad right-of-way and developing a toll road and managed lane facility. Right-of-way would also be reserved for potential future LRT or commuter rail. Development of the toll facility may allow TxDOT to phase improvements to the Northwest Freeway over a longer period of time.

Future Directions

As noted previously, HOV facilities have been a key part of METRO, TxDOT, and HGAC plans since the late 1970s. Plans at the metropolitan level identified the candidate freeway corridors. As more detailed planning activities were undertaken at the corridor level, the location of HOV lanes, access points, park-and-ride lots, and transit centers were identified.

The use of the HOV and managed lane system in Houston continues to evolve through the coordinated efforts of various agencies and groups. Current TxDOT, METRO, HGAC, and HCTRA plans include expanding the HOV system, considering additional managed lanes, extending the initial LRT line, and developing new toll facilities. Plans, projects, and activities anticipated over the next five to 10 years are highlighted below.

- **Expansion of QuickRide**. Activities are underway exploring options to modify and expand the QuickRide demonstration project. Elements being considered include modifying the user fees, changing the fee collection technology, enhancing enforcement capabilities, and expanding marketing and outreach efforts.

- **Expansion of the HOV System**. The *METRO Solutions* 2025 transit plan includes continued development of the HOV system. Components of the plan include a 50 percent increase in bus service, 44 new bus routes, eight new park-and-ride facilities, and nine new transit centers. Many of these elements are part of the 250-mile, two-way HOV service included in the plan.

- **Additional Managed Lane Projects or Joint Toll Projects**. Additional managed lanes or joint projects with the toll authorities are being explored. As noted previously, the Northwest Freeway corridor is being considered for managed lanes to be developed and operated by HCTRA in an existing railroad right-of-way. Reserving an envelope for future LRT or commuter rail is also planned. This approach could result in delaying improvements to the existing Northwest Freeway. It is anticipated that other corridors will also be considered for possible joint projects.

- **Light Rail Transit (LRT) and Commuter Rail**. The initial LRT line is scheduled to open in January 2004. As of August 2003, the METRO Board was finalizing the 2025 transit plan, *METRO Solutions*. The plan provides the basis for a November ballot measure authorizing the agency to issue bonds. The rail element, which includes LRT and commuter rail, of the plan was scaled back based on public and political feedback. The current plan includes 22 miles of rail and a bond issue of $640 million.

- **Continued Toll Road Development**. Both HCTRA and the Fort Bend County Toll Road Authority (FBCTRA) are moving forward with toll road projects. Future facilities may include toll roads and bridges, as well as joint projects with TxDOT and METRO.

CHAPTER THREE—INSTITUTIONAL ARRANGEMENTS

Planning, developing, managing, and operating the HOV and managed lane system can best be described as multi-agency projects requiring multi-agency decisions. TxDOT and METRO have been partners in planning, funding, designing, operating, and enforcing the HOV lane system. Harris County and HCTRA have recently joined the partnership with the consideration of managed lanes. HGAC has also played an important coordination role.

The institutional arrangements among the agencies are evident in both formal agreements and informal working relationships. Memoranda of Agreement and contract documents have been used over the years to identify the specific roles and responsibilities of TxDOT and METRO, and for the financial arrangements on specific projects. Interagency committees have been used to help coordinate projects. Informal working relationships have also played a key role in advancing the HOV and managed lane system.

Formal Agreements

The Houston Office of Transit, the predecessor agency to METRO, was the lead agency in the initial contraflow demonstration project. However, on this and subsequent HOV projects, formal agreements between METRO and TxDOT were used to identify the roles, responsibilities, and financial participation of the two agencies.

METRO and TxDOT initially used a two-stage process for formally adding segments to the HOV lanes. When it was evident that an authorized construction project for an HOV segment was ready to be scheduled, a construction agreement was prepared. The construction agreement spells out each agency's share of design and construction costs, the contract agency, responsibilities for construction management, engineering, inspection, and other matters specific to the construction of that particular segment.

Initially, most of the individual construction agreements included lengthy provisions covering maintenance, operations, and other matters common to all HOV lanes. This approach resulted in lengthy documents with relatively little that applied to the construction project at hand. The maintenance and operational provisions in each construction agreement required the project construction file to be maintained in perpetuity because it contained the basis for post-construction activities. As different individuals prepared the construction agreements, minor changes in the language covering maintenance and operations were made in some of the documents. As a result, it sometimes became necessary to examine the maintenance and operations provisions of all segments when a question arose.

To address these problems, a Master Operation and Maintenance Agreement covering all of the HOV lanes was executed in 1988. The agreement became the only

document needed to address post-construction HOV concerns. Construction agreements ended after project completion, avoiding separate agreements to cover operation and maintenance. When a construction agreement is authorized on an individual segment, it is automatically added to the list of projects covered by the Master Agreement.

Most of the early construction agreement provisions provided that METRO would defray most of the HOV lane cost and that TxDOT would provide experienced personnel to supervise the design, construction, engineering, and inspection. In most cases, the maintenance provisions make METRO responsible for signs, control devices, electrical power, and other items specifically associated with the HOV lanes. TxDOT is responsible for maintaining the HOV lane pavement, barriers, supporting structures, and non-HOV items, and is to perform routine sweeping and litter pickup.

Under the Master Agreement's operational provisions, METRO is responsible for operating the HOV lanes in accordance with a jointly-prepared Operational Plan, which covers all aspects of operations, enforcement, eligibility, and safety. The Master Agreement required a Management Team, comprised of METRO and TxDOT staff. The Management Team was responsible for preparation of rules and regulations, operating manuals, and amendments to operations plans. The Management Team met monthly and monitored all aspects of the HOV lanes. Researchers from TTI provided support to the Management Team.

The Houston Traffic Management Team (HTMT) was formed in 1981 as an ad hoc group of key individuals from agencies interested in operations. Participating organizations included THD, METRO, the city and county transportation departments, law enforcement agencies, the fire department's emergency service section, and TTI. The HTMT met on a monthly basis for many years to help coordinate projects and discuss other issues.

TxDOT and METRO have used similar approaches on other projects. For example, TranStar, the Greater Houston transportation emergency management center, was designed and constructed through the cooperative efforts of METRO and TxDOT. Both agencies, along with the City of Houston and Harris County, signed a Memorandum of Agreement creating TranStar. The agreement identified the roles, responsibilities, and financial contributions of the agencies.

TranStar monitors and coordinates all aspects of the traffic management system in the Houston area. TranStar houses METRO, TxDOT, city, and county transportation and enforcement personnel, along with other groups. A Leadership Committee and an Executive Committee, comprised of the top staff and the agency directors, respectively, meet on a regular basis to oversee the operation and management of TranStar.

The two multi-agency agreements on the Katy Freeway managed lanes project represent additional examples of the formal arrangements used to advance projects. As

described in the previous chapter, these agreements outline the policies for operating the managed lanes, and identify the roles and responsibilities for funding, design, construction, and operation of the lanes.

The various HOV and managed lane projects have also been incorporated in to the appropriate MPO and state plans. The projects have been included in HGAC's long-range plans and transportation improvement programs (TIPs). The projects have also been included in the state transportation improvement programs (STIPs).

Informal Arrangements

In many ways, the informal arrangement among staff at TxDOT, METRO, and other agencies have been as important in advancing the HOV and managed lane system in Houston as the formal arrangements. While not always in agreement on every aspect of the system, staff at all levels have developed strong working relationships, trust, and mutual respect. These relationships have played key roles in the development and the operation of the HOV and managed lane system.

During the decades of the 1950s, 1960s, and 1970s, the public and private sectors in Houston shared a positive and aggressive attitude toward projects, including the National Aeronautic and Space Administration (NASA) Manned Spacecraft Center and the Astrodome. Staff at the various agencies involved with the I-45 North Contraflow demonstration project shared this positive attitude. Key staff members at OPT and THD developed strong working relationships during the demonstration project. Staff from HGAC, FHWA, and area associations were also important participants in these working groups.

In addition to the formal committees described in the previous section, informal working groups of agency staff helped coordinate the design, development, and operations of different projects. Further, staff from both agencies participated in the various HGAC committees and planning activities. Researchers from TTI also participated In these informal groups, providing technical assistance as needed.

Many of these informal activities continue today. The top staff from the TxDOT Houston District and METRO meet on a monthly basis to discuss projects and topics of mutual interest. Staff from both agencies are located in TranStar, providing opportunities for daily interaction. TxDOT and METRO staff continue to actively participate in HGAC committees and other local groups.

Factors Influencing the HOV and Managed Lane System

A number of factors appear to have helped influence the development, the ongoing operation, and the evolution of the HOV and managed lane system in Houston. These factors include the conditions of the bus systems and freeways in the 1970s and early

1980s, the lack of a regional consensus for rail, and the ongoing entrepreneurial spirit of agencies and individuals.

As noted previously, the privately-owned bus system was in very poor condition when it was purchased by the city. Thus, the major initial task facing the city and later METRO was to rebuild the transit system. This effort focused on new vehicles, new fixed facilities, and new services. Working with TxDOT on the HOV system represented the opportunity to quickly implement an improved transit system for the area. The HOV system also projected a positive image for transit and METRO in those early years.

At the same time, a consensus did not emerge over the role that LRT or heavy rail should play in the Houston area. In 1973, voters defeated the initial HARTA referendum, which included development of a significant heavy rail system. A subsequent bond referendum, which also included a major rail element, was defeated in 1983. A 1988 plan, which included rail, an expanded HOV system, local bus service, and a general mobility program to fund roadway improvements, was approved. The rail component never moved forward, however. The current LRT line has been funded through local sources. As described in the next chapter, the future of rail in the area is still being debated.

The entrepreneurial spirit of the 1950s and 1960s is still alive and well in Houston. This spirit is evidenced by a willingness to explore and develop value pricing programs, managed lanes, TranStar, and other efforts. The culture at the various agencies supports these efforts and risk taking, within the scope of public accountability. Staff at the various agencies continue to explore innovative approaches to address the traffic congestion, mobility concerns, and air quality issues facing the region.

CHAPTER FOUR—DEVELOPING AND OPERATING MANAGED LANES

This report summarizes the development, operation, and use of the HOV system in Houston and the development of managed lanes in one corridor. The institutional arrangements and the factors influencing the development of the system were also described. This chapter summarizes some of the issues that may need to be examined when managed lanes are being considered in an area, as well as those typically associated with operating projects. It also highlights current and future FHWA activities related to advancing the state-of-the-practice associated with the use of managed lanes.

Issues to be Considered

A number of issues may need to be examined when HOV and managed lanes are being considered in an area or when changes to an existing facility are being contemplated. While many of these issues are similar to those associated with HOV facilities or other transportation improvements, some are unique to the special characteristics of managed lanes. This section summarizes some of the issues that may arise with managed lanes, as well as those associated with ongoing management and operation.

- **Defining Project Goals and Objectives**. Similar to any transportation project, a key step early in the planning process is to identify the issues or problems to be addressed and to define the goals and objectives of a facility. For example, the issues and project goals in a corridor with very high truck volumes will typically be much different from those in a corridor serving commuter travel. A clear definition of the problems, goals, and objectives will help ensure that the ultimate project provides the needed benefits.

- **Identifying User Groups.** A key step in examining managed lanes is to define the user groups to be served. HOV facility user groups are typically classified as carpools at different vehicle-occupancy levels, vanpools, and buses. Other user groups, such as motorcycles and low emitting vehicles (LEVs), may also be considered. Managed lanes frequently include consideration of other user groups or operational strategies, including trucks, pricing, and limited or special access. Different pricing strategies may also be considered, including flat fees, value pricing, and free passage for HOVs. The appropriate user groups and operating strategies should be matched to the issues in the corridor and the goals and objectives of a project.

- **Design Elements**. Special design elements may need to be considered with HOV and managed lanes. The specific design elements should be matched to the anticipated managed lane user groups and operating scenarios. For example, the design issues associated with a truck-only

facility will be different than those associated with lanes serving HOVs and priced vehicles. Examples of design elements that may need to be addressed with HOV and managed lane include access treatments and location, signing and advance notification of occupancy or pricing requirements, toll collection facilities, and toll or occupancy enforcement requirements.

- **Pricing and Equity**. As noted previously, pricing may be considered as one element of a managed lanes project. A number of different approaches may be considered with a priced facility. First, a toll may be assessed to all vehicles using a facility. Second, tolls may vary by time-of-day, either based on a set pre-established schedule or based on variable levels depending on congestion. Third, HOVs may pay a lower toll or travel free. The appropriate pricing strategy will be based on the goals and objectives of a project.

  The use of pricing strategies may raise equity issues. Equity relates to concerns that lower income groups or other individuals may be excluded from use of the lanes due to an inability to pay the tolls. Experience to date with value pricing projects in the country indicate that all income groups use the facilities and that equity does not seem to be a major concern.

  Another issue that may need to be addressed with pricing strategies is the use of the toll revenues. If bonding is used to pay for constructing a facility, toll revenues typically go to pay off the bonds. If bonding is not used, the revenues may go to pay for the cost of operating and enforcing a facility, providing transit services, or making other improvements in the corridor. It appears that public acceptance of pricing strategies may be higher if the revenues are used for transportation-related efforts in the corridor or region.

- **Legislation**. New legislation or changes in existing laws may be needed to implement and operate managed lanes. Elements that may need to be addressed include the legal authority to charge fees or tolls, to enforce occupancy levels or variable fee structures, to restructure the use of a facility to specific groups or vehicles, and to use automated enforcement techniques. The policies and procedures of FHWA, FTA, and other federal agencies should also be checked.

- **Policy Maker Support**. The Houston case study and other HOV projects around the country highlight the importance of support from policy makers. Critical elements to obtaining support from key individuals and groups include outreach efforts to explain the need for a project and the anticipated benefits, periodic updates on the status of a project, and ongoing information on the use and benefits of the completed facility.

- **Public Involvement**. Federal and state legislation and regulations govern the public involvement process on transportation projects, including consideration of HOV and managed lanes. Given the potential unique features of managed lane projects, especially if pricing strategies are included, extra efforts may be necessary in the public involvement process. Similar to the policy maker outreach activities described above, efforts should be made to communicate the problems and issues in a corridor, to solicit input on the alternatives being considered, to provide information on the goals and objectives of the selected approach, and to maintain ongoing communication on the benefits of a project.

- **Transit Service**. Bus service is an important element of most HOV projects. Many transit systems have started new routes or expanded existing services in conjunction with HOV lanes. Bus services may also be an important element of a managed lanes project. As noted in the Houston case study, special considerations may be needed to ensure that buses are provided with travel time savings and trip time reliability. In addition, buses may be exempt from fees or tolls. Considering the operation requirements of buses in a corridor and ensuring that access is provided at strategic locations is also important.

- **Institutional Relationships**. As illustrated in the Houston case study, the formal and informal relationships among agencies are important in developing and operating HOV and managed lanes. Consideration should be given early in the planning process to the roles and responsibilities of the various agencies in planning, designing, funding, constructing, operating, managing, enforcing, and monitoring HOV and managed lanes. Formal Memorandums of Agreement or other documents are typically used to identify the responsibilities of the different agencies involved in HOV and managed lanes. Multi-agency teams are also frequently used to help ensure the involvement and the cooperation of all appropriate agencies during all phases of project development and ongoing operation. As noted with the Houston case study, the involvement of a tolling entity makes these relationships more complex. The Houston case study also points out the importance of the informal working relationship among agency staff in advancing projects.

- **Enforcement**. Managed lanes may require special enforcement practices and equipment. The exact type of enforcement needed will depend on the nature of the managed lanes. Key elements that will influence enforcement include the eligible use groups and the inclusion of pricing. Enforcing vehicle-occupancy levels represents the major concern with HOV lanes. If a managed lane project includes an HOV component, enforcing vehicle-

occupancy requirements will be important. Currently, enforcement personnel must visually monitor monitoring occupancy levels as there is no commercially available technology for monitoring the number of individuals in a vehicle. Advances in technology may provide this capability over the next few years, however.

Enforcement is also critical when pricing is a component of a managed lane project. The appropriate fee of toll may be paid through the use of electronic toll collection (ETC) or manually at toll booths. Toll authorities have extensive experience in enforcing both payment methods. Electronic surveillance of ETC systems is commonplace on most toll facilities.

The need for enforcement should be considered early in the planning process to match the appropriate type of enforcement to the user groups and operational strategies being considered. It is important to ensure that legislation is in place to provide agencies with the necessary enforcement authority, that enforcement elements are incorporated into the design of a facility, and that operational strategies for enforcement are in place when a project opens.

- **Performance Monitoring**. Monitoring conditions on HOV and managed lanes is a key element of successful proactive management and operational efforts. A variety of advanced technologies may be used to monitor the freeway, HOV, and managed lane system. Advanced Transportation Management Systems (ATMS) provide real-time monitoring, incident detection, and rapid response capabilities. In addition, many areas conduct ongoing monitoring and performance evaluations of HOV and managed lane facilities. These efforts combine to enhance the day-to-day operation of these facilities and to provide the information needed for ongoing operational changes.

  Ongoing performance monitoring programs help identify the benefits accrued from a project, determine if the goals and objectives are being met, and identify operating problems or issues that may need to be addressed. Evaluations provide an opportunity to ascertain the degree to which the desired results are, in fact, occurring. Performance monitoring programs provide an official database for a project. This information can help ensure that all groups are utilizing the same data, assisting to clarify any possible disagreements over the impact of a project.

  The information collected as part of an ongoing performance monitoring program has value for operating decisions relating to the HOV and managed lane facility. Information on usage, violation rates, and accidents are critical for ensuring the efficient and safe operation of a facility. Monitoring these

and other aspects of a project as part of a performance process will help identify problems that may need to be addressed. For example, changes in operating hours, vehicle-occupancy requirements, pricing levels, bus services, and access points may be necessary. Longitudinal data on the use of a facility serves a critical operations function. This information can also be used to evaluate the marketing and public information programs associated with a facility, as well as helping to identify if additional marketing is needed.

The results of performance monitoring programs are also beneficial in future planning efforts. The information generated can be used to calibrate planning and simulation models for future use. Calibrating models with the results of local evaluations will ensure that they accurately reflect actual experience, provide a valuable check on the modeling process, and improve the future capabilities of the models. In addition, the results from a monitoring program, along with the experience gained from a project, can enhance the decision-making process on future projects.

- **Incident Management.** Managing accidents and incidents on HOV lanes and managed lanes is a key part of management and operation. Elements of an incident management program include detecting a problem, responding appropriately, clearing the incident and returning the facility to normal operations, and communicating necessary information to motorists to help manage the situation. These four elements – detecting, responding, clearing, and communicating – form the basis of an incident management program.

  An accident or incident must be reported for a response to be initiated. Detection refers to the ability to identify that an incident has occurred, and to obtain accurate information on the location, nature, and scope of the problem. The sooner an incident can be identified, and the proper responses initiated, the faster the problem can be cleared and the facility returned to normal. A wide variety of methods and technologies can be used to help detect an incident on HOV and managed lane facilities. Approaches include visual detection by enforcement and operation personnel, calls from motorists using cellular telephones, roadside telephone call boxes, commercial radio and television traffic reports, loop detectors, closed-circuit television cameras (CCTV), advanced transportation management systems and centers, and other intelligent transportation systems (ITS) and advanced technologies.

  Once an accident or incident has been identified, the proper response can be initiated. A variety of approaches can be used, depending on the nature, severity, and scope of the problem. The general types of response vehicles

and personnel include Highway Helper or Courtesy Patrols, dedicated agency tow trucks, commercial towing services, police, EMS, fire, and specialized response teams.

The clearing process involves removing the disabled vehicle or clearing the incident scene and returning the HOV or managed lane facility to normal operations. Tow trucks will be needed to remove disabled vehicles, while a Highway Helper Patrol may be able to assist with a vehicle that has run out of gas. Traffic control and site management are also important elements of this process. The roles and responsibilities of personnel from the various agencies should be established to allow for the safe, efficient, and coordinated management of an accident or an incident site.

The final element of incident management focuses on communicating information on the status of the HOV, managed lane, and freeway facilities to other agencies and the motoring public. A variety of techniques and technologies can be used to provide current or real-time information to HOV lane users, motorists in the general-purpose lanes, and other agencies. Possible approaches include commercial radio and television stations, highway advisory radio (HAR), variable message signs, and other technologies. This step is important to provide commuters and travelers with information on major problems and significant delays on a facility, as well as alternative routes that they may wish to take.

- **Ongoing Consideration of Enhancements.** A key part of the management and operations philosophy is continually looking for opportunities to enhance the performance of HOV, managed lane, and freeway facilities. Information from performance monitoring programs can be used to help identify possible areas for improvements or changes. Examples of possible enhancements include new or expanded bus services, innovative rideshare programs, pricing strategies, public outreach activities, motorists service patrols, ramp metering and HOV bypass lanes, and special treatments for HOVs at major destinations. The use of new technologies, techniques, and strategies should also be considered on an ongoing basis. These approaches may include advanced transportation management systems, variable message signs, advanced traveler information systems, and other techniques.

Federal Interest in HOV Operational Changes

FHWA has periodically issued guidance on HOV facilities. The most recent *Program Guidance on HOV Operations* was issued on March 28, 2001 (36). The Program Guidance identifies the circumstances under which federal action is required to initiate changes in the operation of an HOV facility, and the federal review process and requirements to be used

in these situations. The Program Guidance is available on the FHWA Internet site at http://www.fhwa.dot.gov/legsregs/directives/policy/index.htm.

Federal action is required when significant changes are proposed to existing HOV facilities constructed with federal funds. Significant changes include major alterations in operating hours and converting an HOV lane to general-purpose use. Minor modifications in operating hours and changing from different multi-person occupancy levels (from 3+ to 2+, for example) do not require federal approval. Coordination and consultation with FHWA is appropriate even when an operational change is only being considered or discussed, however, as a basis to determine what may be needed for actual changes to occur.

The Program Guidance identifies the information to be included as part of a federal review. Examples of needed information include original studies and plans for the HOV facility, project agreements, commitments made in the environmental process, operational assessments, analysis of future conditions, examination of alternative operating scenarios, and possible impacts on air quality levels and plans. The Program Guidance further outlines the federal review requirements related to air quality conformity, the state implementation plan, the congestion management system, the National Environmental Policy Act (NEPA) process, and other issues.

The Program Guidance and other available documents support the need to examine HOV systems on a regional, not just individual project, basis. Elements in this approach include a multi-year regional HOV system strategic plan, which is integrated into the metropolitan area long-range plan, and a multi-agency program to manage implementation of the system plan and to support day-to-day operation of HOV facilities and supporting services. This approach allows for the long-term regional commitment for infrastructure improvements, the careful phasing of operating segments, and coordinating the development and operation of supporting services, facilities, and policies.

Current and Future Activities

FHWA and other groups have begun a variety of activities related to managed lanes. Additional activities are planned to help share information related to managed lanes and to help advance the state-of-the-practice. This section highlights a few examples of FHWA-sponsored activities.

- **Managed Lanes: A Cross-Cutting Study**. FHWA is sponsoring the development of a report examining the types of managed lanes and potential issues associated with different approaches in more detail. The report, which will be available in late 2003, provides a definition of managed lanes, highlights examples of managed lane projects throughout the country, and describes some of the elements associated with planning and operating managed lanes.

- **Managed Lanes Primer**. FHWA is sponsoring the development of a Managed Lanes Primer. This document, which will be available in early 2004, highlights key aspects of managed lanes, potential benefits, possible issues, and best practice case studies.

- **Managed Lanes Initiative**. FHWA is developing a managed lanes initiative that will identify policy, program, and research elements to help advance managed lanes. A November 2003 workshop involving selected transportation professionals from throughout the country will help in the development of the initiative.

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