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16. Abstract

Barrier separated high-occupancy vehicle lanes, or transitways, have been found to be an effective way to reduce peak period congestion by providing priority treatment for high-occupancy vehicles. The Texas Transportation Institute performed a study to identify the user information needs of this type of facility, and how those needs could best be met.

Driver expectancy requires that motorist information for a transitway be provided in the same manner used on other types of roadways. The results of this study indicate that the unique characteristics of transitways require special treatment in order to meet these motorist information needs. The study proposes guidelines for the use of traffic control devices on transitways, which include distinctive markings for transitway signs, more effective use of lane-use control signals, and specialized regulatory signing. The diamond symbol should be shown with all transitway signing, and signs should be located directly over the facility, whenever possible. The proposed guidelines for the use of traffic control devices on transitways conform to the standards for the use of traffic control devices on freeways, as contained in the Manual of Uniform Traffic Control Devices.

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METRIC (SI*) CONVERSION FACTORS

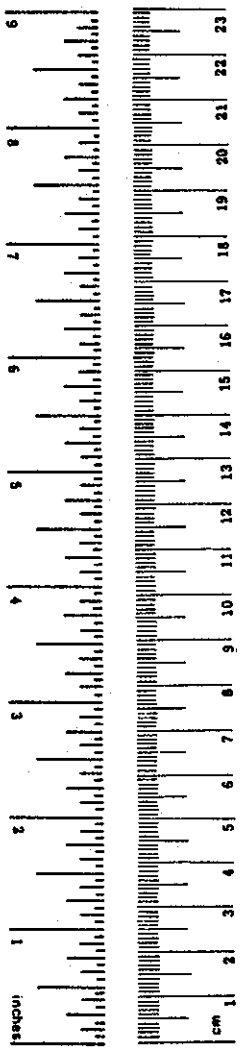
APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	2.54	millimetres	mm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
AREA				
in²	square inches	645.2	millimetres squared	mm²
ft²	square feet	0.0929	metres squared	m²
yd²	square yards	0.836	metres squared	m²
mi²	square miles	2.59	kilometres squared	km²
ac	acres	0.395	hectares	ha
MASS (weight)				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
VOLUME				
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft³	cubic feet	0.0328	metres cubed	m³
yd³	cubic yards	0.0765	metres cubed	m³

NOTE: Volumes greater than 1000 L shall be shown in m³.

TEMPERATURE (exact)

°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
AREA				
mm²	millimetres squared	0.0016	square inches	in²
m²	metres squared	10.764	square feet	ft²
km²	kilometres squared	0.39	square miles	mi²
ha	hectores (10 000 m²)	2.53	acres	ac
MASS (weight)				
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T
VOLUME				
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m³	metres cubed	35.315	cubic feet	ft³
m³	metres cubed	1.308	cubic yards	yd³

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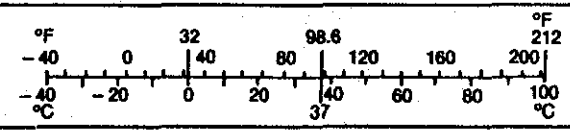

These factors conform to the requirement of FHWA Order 5190.1A.

* SI is the symbol for the International System of Measurements

EVALUATION OF MOTORIST INFORMATION REQUIREMENTS FOR TRANSITWAYS

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Research Report Number 1113-1

Evaluation of Motorist Information Requirements for Transitways
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College Station, Texas 77843

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ABSTRACT

Barrier separated high-occupancy vehicle lanes, or transitways, have been found to be an effective way to reduce peak period congestion by providing priority treatment for high-occupancy vehicles. The Texas Transportation Institute performed a study to identify the user information needs of this type of facility, and how those needs could best be met.

Driver expectancy requires that motorist information for a transitway be provided in the same manner used on other types of roadways. The results of this study indicate that the unique characteristics of transitways require special treatment in order to meet these motorist information needs. The study proposes guidelines for the use of traffic control devices on transitways, which include location of transitway signs, sign content, more effective use of lane-use control signals, and specialized regulatory signing. The diamond symbol should be shown with all transitway signing, and signs should be located directly over the facility, whenever possible. The proposed guidelines for the use of traffic control devices on transitways generally conform to the standards for the use of traffic control devices on freeways, as contained in the Manual of Uniform Traffic Control Devices.

Key Words: High-occupancy vehicle lanes, transitways, HOV signing, MUTCD, signing guidelines

SUMMARY

In recent years, the demand for freeway facilities in many major urban areas has increased faster than the construction of additional freeways, which has been limited due to restricted right-of-way availability and high construction costs. Transportation officials are now faced with the dilemma of how to move increasing numbers of people through major freeway corridors without large expansions of the freeway network.

Officials in Texas have selected the barrier separated transitway as the preferred means for moving large numbers of people through congested urban freeway corridors. The typical barrier separated transitway is located in the freeway median, is separated by concrete barriers from the adjacent freeway traffic, is approximately twenty feet wide, and has reversible traffic flow.

Currently four transitways are operating in Houston, Texas, with additional transitways in the construction and design phase. The successful operation of these transitways is dependent on, among other things, the successful transmission of the required information to the motorists on the facilities. Operational experiences on existing transitways have indicated a lack of sufficient information for the users of the transitways as evidenced by the following:

- The Texas and National Manuals on Uniform Traffic Control Devices (MUTCD) lacks a detailed signing policy for exclusive, freeway median, high-occupancy vehicle (HOV) facilities.

- Standards for the sign design, signal operation and traffic control of each transitway were developed on a project-by-project basis, conforming to the general practices whenever possible. As the transitway system expands, the motorist information systems need to function in a uniform and consistent manner so that drivers will have a clear understanding of transitway operations.

- The history of transitway use in Houston has indicated that transitway motorists range from highly informed drivers to uninformed and unfamiliar drivers. This type of variance in driver familiarity has created a need for improved information systems.

- The location of transitways in the freeway median has created parallel signing systems with the possibility of transmitting information to both freeway and transitway users. The impacts of this situation on operations and positive guidance requirements have not been investigated.

This research study, 2-18-87-113, was performed by the Texas Transportation Institute to evaluate the information requirements for transitways and transitway users. It was sponsored by the Texas State Department of Highways and Public Transportation in cooperation with the Federal Highway Administration.

The study was performed in four steps. These four steps included an engineering analysis of current information needs on Houston transitways, a review of current literature addressing the information needs of HOV motorists, a field evaluation of existing signing on the Katy Freeway Transitway in Houston, and a laboratory study of transitway information concepts.

The engineering analysis examined the relationship between various transitway design elements and information needs for specific transitway designs in Houston. Analysis findings included identifying the information needs of specific aspects of the transitway, such as entrances and exits, and the effects of local conditions on the transmission of information.

The information needs of HOV motorists, as addressed in current literature, were examined to determine what types of information systems have been used on HOV facilities in other areas. The following issues were identified as significant to the development of an information system for transitways:

- The use of traffic control devices should follow the standards established by the MUTCD, which are applicable to HOV facilities.

- Driver information needs are arranged in accordance within a hierarchy, with control needs having priority over guidance needs, which are followed by navigational needs. Satisfying this priority of information needs is basic to the design of any highway information system.

- Consistency in meeting driver expectations is vital to the successful transmission of information to the driver, as the driver expectancy of transitway users is no different than that of users on any other type of facility.

- Agencies in different parts of the country presently use different HOV signs to transmit information to the motorists. However, uniform signing is desirable for all HOV facilities across the country.

- Signing and markings alone are not an adequate teaching device. Driver education is a necessary part of meeting the information needs of transitway motorists.

- Detailed consideration should be given to the design of the traffic control system as an integral part of transitway development.

- The type and detail of information needed on a transitway are dependent on the users of transitways. This requires that the information needs of the least informed user should be met.

- The reversible nature of transitways requires that information applicable only to one operating period not be visible during periods to which it does not apply.

- Signing should be intended for transitway or freeway operations, but not both. Distinctions should be made between parallel signing systems for freeways and transitways so that users of the two facilities will not be confused.

A field evaluation of existing signing was performed on the Katy Freeway Transitway in Houston to determine the effectiveness of the current information system in transmitting the needed information to the motorists. The evaluation was performed by interviewing test subjects as they drove on the transitway. The questions that were asked addressed various transitway characteristics such as advance information signing, access information, ingress signing and markings, braking characteristics, speed readings, and egress signing and markings.

The field study found that most drivers were comfortable driving on the transitway. However, there was confusion among drivers when entering and exiting the facility. In some cases this is attributable to sign location, sign clutter, and sign meaning and application.

A laboratory study of transitway information concepts was performed as the final step in the research study. In the laboratory study, test subjects were exposed to slides and asked to answer questions about their observations. The questions addressed three major areas: transitway concepts, transitway signing, and lane-use controls. Some of the findings of the laboratory study include:

- The words "High-Occupancy Vehicle Lane" and "Authorized Vehicle Lane" were the most common choices for the best name to describe a barrier separated facility.

- The diamond symbol is associated with the traffic restrictions found on a transitway.

- The number of transitway signs should be kept to a minimum to reduce the information demands on the motorists.

- Signs with words are better understood by motorists.

- Transitway motorists prefer signs mounted over the transitway lane.

- Guide signs for HOV lanes should be distinguishable from parallel freeway guide signs. The diamond symbol should be located on the HOV sign.

- High-occupancy vehicle lane guide signs should be placed in advance of and at all exit points. Park-and-ride exits should be identified on the sign as should exit names and other appropriate information such as major traffic generators. Guide signs should also be used to indicate distances to the next and succeeding exit points.

- Drivers on the transitways do not have a clear understanding of lane control signal indications.

The combined results of the four study efforts produced recommendations and proposed guidelines for the transmission of information to transitway motorists. The following recommendations were made:

- Symbols for buses, vans, and carpools should not be used in the sign legend.

- A diamond symbol should appear on all signs which apply to the HOV lane.

- Signs which specifically apply to the users of the HOV lane should be located directly over the lane, whenever possible. All overhead sign installations should normally be illuminated.

- Regulatory signs located in advance of the facility should be mounted on the side of the approach road.

- Transitway guide signs should be distinguishable from freeway guide signs. A diamond symbol should appear in the upper left corner of all transitway guide signs. Transitway guide signs may be white on green or black on white.

- Route marker signs are recommended for each facility.

- The definition of lane-use control indications currently in use in Houston should be modified.

These recommendations are incorporated into a set of guidelines for the application of new signs and traffic control devices for barrier separated HOV lanes.

Six new regulatory signs are proposed for use. They are; a VEHICLES PERMITTED SIGN, VEHICLES PROHIBITED SIGN, TIME OF OPERATION SIGN, PERMIT REQUIRED FOR USE SIGN, DIAMOND SYMBOL ADVISORY PLATE for regulatory signs, and a LANE-USE CONTROL SIGNAL Sign. All regulatory signs should be black on white or white on black. Any regulatory sign which applies to a HOV lane should have a diamond as part of the legend or a diamond symbol advisory plate should be mounted above the sign.

The use of warning signs on HOV lanes is not changed from the recommendations of the Manual of Uniform Traffic Control Devices (MUTCD). The application of the MUTCD principles to HOV lanes requires two new signs, an END HOV LANE sign and a DIAMOND SYMBOL ADVISORY PLATE for warning signs. The diamond symbol advisory plate should be displayed with all warning signs which apply to HOV lanes.

The use of guide signs on transitways is similar to that for freeways with some minor changes. A black diamond symbol should be displayed in the upper left corner of each guide sign. Guide signs should be displayed over the HOV facility. The signs may be mounted on the same sign structure as freeway guide signs. Current practice for transitway guide signs is to use a white letters on a green background with the white on black diamond symbol or black letters on a white background with the diamond symbol. Route markers should be used with a diamond symbol advisory plate to guide motorists to the HOV facility. The advisory plate should be consistent with the colors of the route marker and be placed above the standard route marker. The following functions are among those performed by transitway guide signs:

- Give distance and directions to destinations, streets, or highway routes, including park-and-rides, at exit points.

- Furnish advance notice of the approach to exits and interchanges.
- Direct drivers into appropriate lanes in advance of diverging or merging movements.
- Identify routes and directions on those routes.

The meanings of lane-use control signal indications on transitways should be modified to correspond to driver expectancies and MUTCD standards. Four indications are proposed for use on barrier separated HOV facilities. These four indications and their meanings are described below:

PROPOSED LANE-USE CONTROL SIGNAL INDICATIONS

INDICATION	MEANING
steady downward green arrow	the driver is permitted to drive in the lane
flashing downward yellow arrow	the driver is advised to proceed with caution
steady yellow "X"	the driver should exit the facility at the earliest opportunity
steady red "X"	the driver should not drive in the lane as it is closed

The following actions are recommended to improve motorists' understanding of these indications:

- Erect educational plaques at the entrance to transitways explaining the meaning of the lane control indications.
- Include information on lane-use control signals in the Texas Drivers Handbook.

The implementation of these proposed guidelines will serve to improve driver understanding of transitway operation, resulting in more efficient operation, improved safety, and increased capacity.

IMPLEMENTATION STATEMENT

Relatively little research has been performed which addresses the information requirements of users on barrier separated high-occupancy vehicle lanes located in freeway medians. As the public becomes increasingly exposed to this type of facility, it is necessary that a set of guidelines and/or standards be developed which will meet the information needs of the users of barrier separated high-occupancy vehicle lanes, or transitways.

This study was specifically undertaken to assist the State Department of Highways and Public Transportation in the implementation and operation of transitways. This study, through engineering evaluation and testing of drivers unfamiliar with the transitway, assesses the information needs of the transitway motorist and develops guidelines which can be used to meet those needs.

DISCLAIMER

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INTRODUCTION

Background

Urban mobility has become a key issue in evaluating the quality of life in many large cities. In the past decade, major metropolitan areas in Texas have experienced decreasing mobility as a result of increasing congestion on the urban roadway system. This transportation crisis has led officials to evaluate alternative methods of maximizing the movement of people while minimizing delay to all motorists.

One of the more feasible means of accomplishing this objective has been to provide priority treatment for high-occupancy vehicles (HOV) such as buses, vanpools, and carpools. In Texas, the most cost-effective location for implementing these HOV facilities has been shown to be in the median of existing freeways, along radial commuter routes.

In 1979, the Texas State Department of Highways and Public Transportation (SDHPT) and the Metropolitan Transit Authority of Harris County (METRO) jointly developed a 9.6 mile contraflow lane (CFL) on the I.H. 45 North (North Freeway) in Houston, Texas. This project was an interim measure designed to relieve some of the corridor congestion by providing additional peak direction capacity. This peak-direction capacity was obtained without extensive roadway construction by "borrowing" a lane from the off-peak direction of the freeway and dedicating it to authorized high-occupancy vehicles (buses and vanpools) traveling in the peak direction. During its four years of operations, utilization increased from 2900 daily passengers to more than 16,500 daily passengers. Some portion of this increase is due to the addition of park-and-ride and increased bus service. However, most of the increase is attributable to the construction of the CFL. A picture of the I.H. 45 North CFL is shown in Figure 1.

The success of the contraflow lane HOV project provided the justification for the construction of a barrier separated, priority use facility within the freeway median. This special use lane was limited in

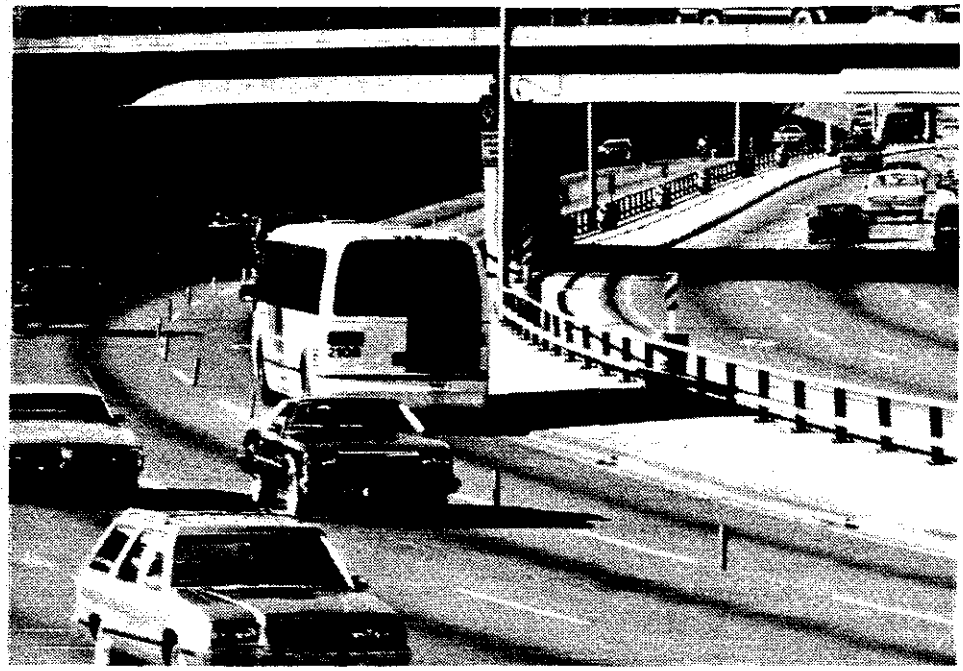


Figure 1. I.H. 45 North (North Freeway) Contraflow Lane, Houston

Figure 2. I.H. 10 West (Katy Freeway) Transitway, Houston

width (19.5 feet), reversible in operation, and referred to as a transitway or "Authorized Vehicle Lane" (AVL). The first transitway of this type in Texas was constructed on I.H. 10 West (Katy Freeway) in Houston, Texas, and became operational in late 1984. A picture of this facility is shown in Figure 2. Also in 1984, the I.H. 45 North Contraflow Lane was converted to a transitway when operations were relocated to the freeway median and protected by concrete barriers.

The transportation agencies responsible for mobility in Houston, Texas are committed to designing, constructing, and operating this type of HOV facility over a significant portion of the freeway network. In 1989, approximately 37 miles of transitway will be operational. Eventually, the system will consist of almost 100 miles of barrier separated transitway in freeway medians. Figure 3 illustrates the proposed Houston transitway system.

The continued success of the transitway infrastructure commitment depends on successfully optimizing the operations of these facilities. The motorist information system is critical to this objective. Early experiences on both the I.H. 45 North (North Freeway) and I.H. 10 West (Katy Freeway) transitways have indicated possible deficiencies in signing, signals, and markings. The need for further study of transitway motorist information requirements was justified by the following findings:

- The Texas and National Manuals on Uniform Traffic Control Devices (MUTCD) (1, 2) lack a detailed signing policy for such exclusive, freeway median, high-occupancy vehicle facilities. Guidelines given for the transmission of information to transitway users are either inapplicable, inconsistent, or nonexistent.

- The planning and design of each new radial transitway was conducted on a project-by-project basis. Standards for sign design, signal operation and traffic control were developed for each facility, conforming to the general practices presented in the MUTCD whenever possible. As the transitway system continues to expand, the motorist information systems

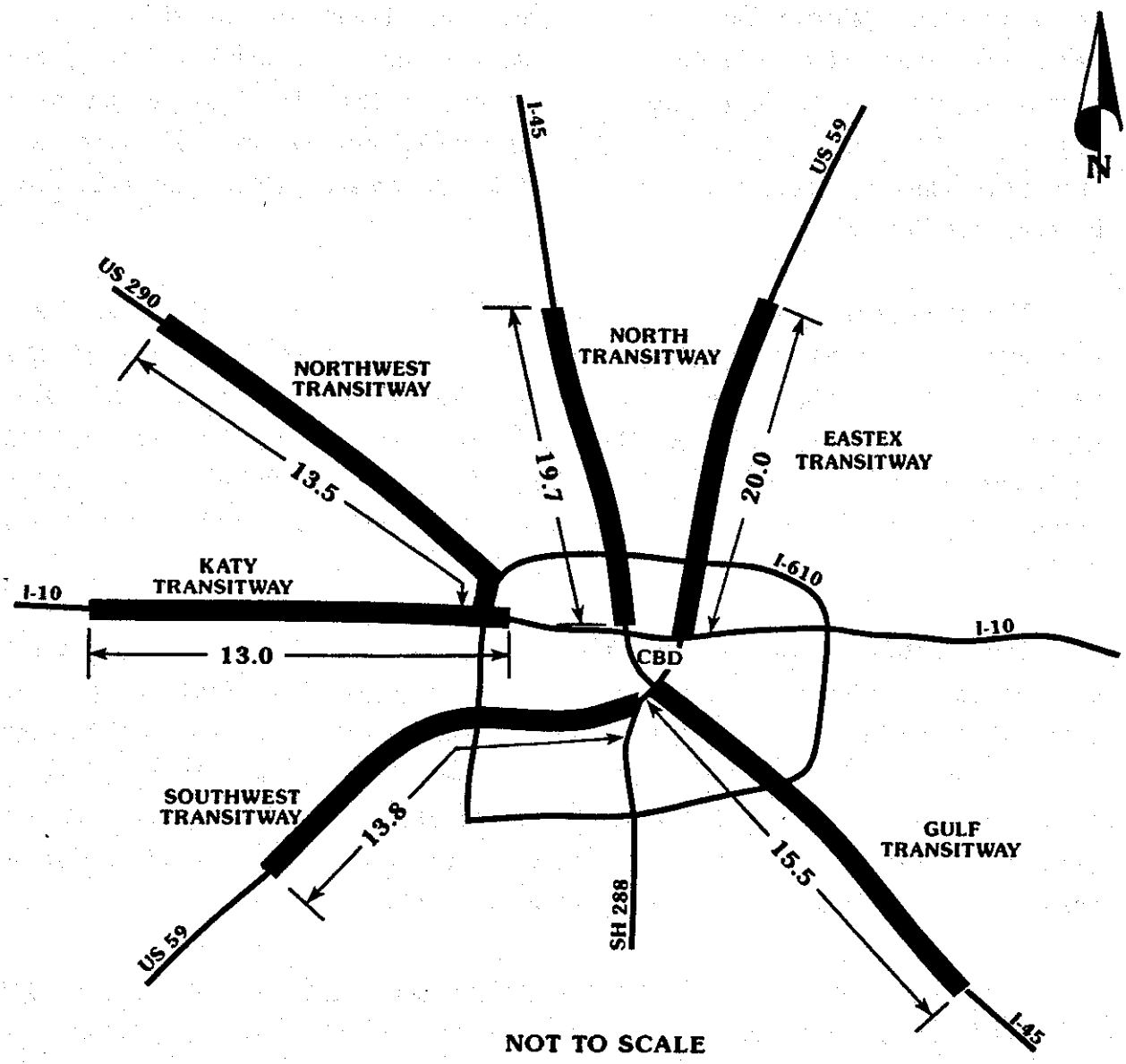


Figure 3. Houston Transitway System

need to function in a uniform and consistent manner so that drivers will have a clear understanding of transitway operation.

- The original transitway design in Houston was based on the restriction that only buses and eight-person authorized (registered) vans would use the facility. In order to improve utilization, the usage restrictions on the I.H. 10 West (Katy Freeway) transitway were lowered to allow three person, authorized carpools on the transitway. Further reductions in occupancy requirements have allowed any carpools with two or more occupants to use the I.H. 10 West (Katy Freeway) transitway. The transition from highly informed drivers to uninformed and unfamiliar drivers on the transitway has created a need for improved information systems.

- The construction of transitways in freeway medians create parallel signing systems with the possibility of transmitting information to both freeway and transitway users. The impacts of this situation on both operations and positive guidance requirements have not been investigated.

Scope and Objectives

This report presents research conducted by the Texas Transportation Institute (TTI) sponsored by the SDHPT under HPR Study Number 2-18-87-113 which began in September of 1986. The goal of the research effort was to conduct a detailed analysis of the requirements for transitway information systems. The research plan included operational studies of existing and proposed signing and markings on transitways by both field and laboratory evaluations. Specific study objectives were as follows:

- Determine the motorist information requirements for all vehicles that may be authorized to use freeway transitways, under all potential operating plans.

- Review the proposed designs of transitways and determine if the motorist information requirements are being accommodated.

CRITICAL TRANSITWAY FEATURES

General

Transitway design in Texas has taken the form of a barrier separated lane located in the freeway median and reserved for the exclusive use of high-occupancy vehicles. The facilities have, at various times in the past, been referred to as High-Occupancy Vehicle (HOV) lanes, Authorized Vehicle Lanes (AVL), busways, and transitways. In Houston, transitway is the term currently preferred by the operating agencies. The typical Houston transitway is a 19.5-foot wide reversible lane located in the median of a radial freeway.

The unique nature of transitways, as compared with freeway mainlanes, is derived from key differences in design elements and operational considerations. The major element of transitway design is access. Transitway access is more limited than freeway access, being provided at 4- to 6-mile intervals. These access points have the greatest impact on motorist information needs. Entrances and exits for the transitway are provided at terminal and intermediate points by slip ramps and direct ramps. The geometric alignment of the transitway also affects the information needs of the users.

The operating plans of a transitway define the manner in which the facility operates. Variables in an operating plan include the number of lanes, one- or two-way traffic flow, geometric segment, and reversible or non-reversible flow. These factors can be combined to provide a variety of operating schemes, each with unique information needs. This study evaluated the information needs of the following operating plans on Houston transitways and transitway connections:

- One lane, one-way reversible mainlanes
- Two lane, one-way reversible mainlanes
- Two lane, two-way nonreversible mainlanes
- One lane, one-way nonreversible connection
- Two lane, two-way nonreversible ramp
- Two lane, two-way reversible ramp

Design Elements

Transitway Access

Transitway access can be classified in a variety of ways, including entry and exit points, terminal and intermediate access, and slip and direct ramps. These classifications can be combined in various ways to provide many different configurations for transitway access. However, there are many similarities between the information needs of the numerous configurations.

Access to the transitways is gained at the entrances and exits. Entrances have specific and detailed information needs. As a transitway is restricted in one form or another, the motorist must be informed of these restrictions in a clear and concise manner. The permitted vehicles, prohibited vehicles, and times of operation need to be given in a clear manner. This information must be available far enough in advance so they can maneuver into the appropriate location to enter the transitway. The motorist must be guided to the entrance with a minimum of confusion and must be able to determine his eligibility without difficulty.

A different type of problem exists with exits. Because of the long distances between exit points on a transitway, a motorist may experience extreme delay if he misses the desired exit due to confusion. To avoid this dilemma, the motorist must receive adequate information about approaching exits in a manner similar to that used on freeways. Each exit should have a name related to a nearby geometric feature (such as a cross street) or a specific destination (such as a park-and-ride lot).

A complicating factor with transitway access is the fact that entrances and exits are often reversed during different operating periods. Due to the reversible nature of many transitways, morning entrances become evening exits. Signing applicable only to one operating period should not be visible to traffic during other operating periods.

The transitway access points may be located at terminal points of the transitway sections or between the terminal points at intermediate access points. Terminal ramps mark the beginning or end of the transitway. At a

terminal entrance, the motorist can decide whether to enter the transitway or continue on his current route. Terminal exits force the transitway motorist off the transitway. In each case, the motorist must be made aware of the existence of the terminal point, and given the appropriate information to enter or exit the transitway.

Intermediate ramps allow the transitway motorist to enter or leave the transitway between the terminal points. The maneuvers required at intermediate ramps are similar to those required of a vehicle entering or leaving a freeway. The vehicle must move from one facility to another, merging with a traffic stream which may be moving at a significantly different speed. Drivers need the appropriate information to locate the correct entry or exit. The appropriate information includes names for and distances to these locations. In addition to the vehicle performing the maneuver, other vehicles need to be prepared for interaction with the maneuvering vehicle.

The access points can be designed as slip ramps or direct ramps. A slip ramp is an at-grade connection between the transitway and the inside freeway lane. It allows a vehicle to enter the transitway by slipping through a gap in the transitway barrier. A direct ramp is a grade-separated ramp that connects the transitway to some other type of facility. The type of facility at the other end of the ramp may be freeway, a frontage road, arterial street, park-and-ride lot, transit center, or other transitway. Direct ramps include flyover ramps and three- and four-way elevated interchanges.

Slip ramp information must compete for the driver's attention with similar information located on the freeway. Freeway vehicles must be guided to the inside lane in sufficient time to allow the entering maneuver to be safely completed. It may also be desirable to provide the off-freeway driver with some guidance information so he can get on the freeway at the proper location to gain access to the transitway. The driver must be able to distinguish these transitway signs from non-transitway signs located in the same vicinity.

A direct ramp connection has information needs similar to that of the freeway slip ramp, but conflicts may be increased by the lack of controlled access on surface streets and the various directions of approach available to the motorist. A motorist must be informed of the ramp location in sufficient time to make the correct maneuver. Also, ramps may have geometric restrictions with specific signing requirements. Direct ramp information may also compete with signs on surface streets, freeway, transit facilities, or other transitways.

Alignment

The geometric design of a highway facility affects the information needs of users. Transitway users can be positively or negatively guided by the geometric design of the facility. The information needs of the motorist can be reduced or increased by the geometric design of the transitway. Care must be used in the design process to develop a transitway that minimizes these information needs by providing adequate sight distance and eliminating unexpected changes in geometric features.

Motorists must be informed of changes in horizontal and vertical design on a transitway in the same manner as conventional roadways, as the expectancies and information needs are no different on a transitway. This is normally done with warning signs. Therefore, requirements for signs and markings related to changes in design features on transitways should be met as described in the MUTCD.

Operational Considerations

There are several operational considerations on Houston transitways which have an effect on the information needs of the users. The primary concern is the reversible nature of the transitways. Because traffic may flow in both directions during a day, it is important that information applicable to one direction of flow not be visible to traffic when it is moving in the opposite direction.

The surveillance, communication, and control system used on Houston transitways provides real time information to drivers about conditions on the

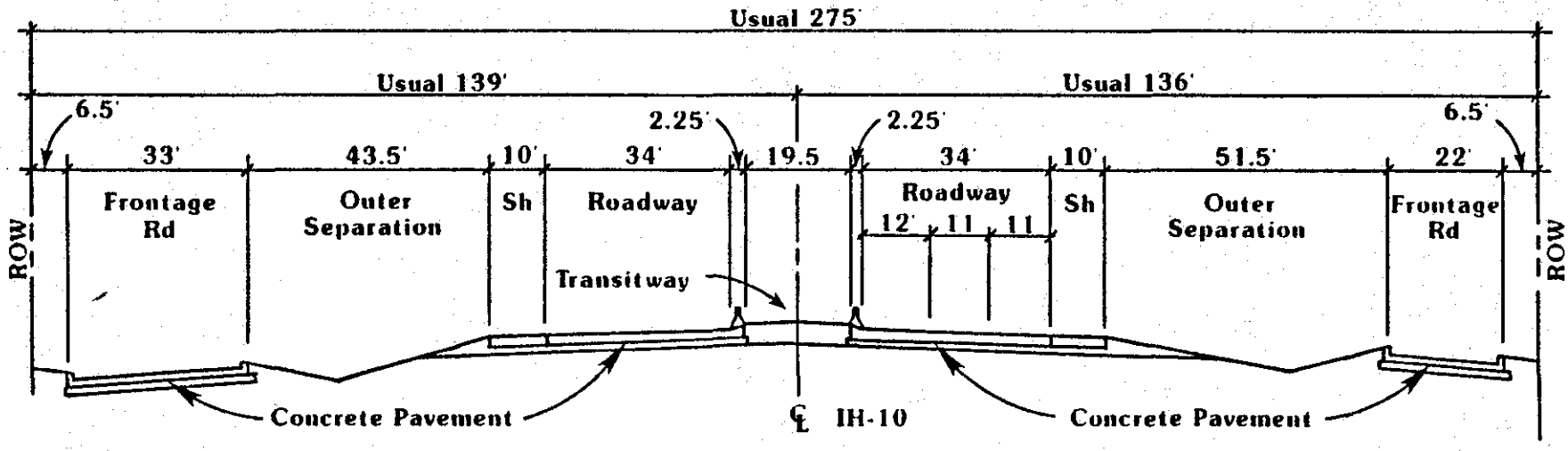
transitway. The facility is monitored by transitway personnel, and motorists are warned of problems by the use of lane control signals located over the transitway lane. These signals convey four messages to motorists: that it is safe to proceed, that they should proceed with caution and/or exit the transitway, that the transitway is closed, or that they are traveling in the wrong direction.

The most unusual transitway operating condition is encountered on elevated interchanges with two reversible lanes. The reversible nature of the two lanes requires that vehicles which occupy the right lane during one operating period occupy the left lane during the other operating period. This is contrary to normal driver expectancy and places additional requirements on the motorist information system of the transitway. Adequate and repeated advance notice of the upcoming change must be provided. Reinforcement of the correct vehicle position should also be provided, once the vehicle is in place. All possible invitations to use the wrong lane must be removed from the driver's field of view. A physical separation of the traffic streams is highly desirable. Due to the reversible nature of this type of ramp, permanent signs and markings are not possible. Therefore, when using this type of operation, vehicles should be physically restricted from entering the incorrect lane.

Transitway Examples

The typical cross section of a Houston transitway is shown in Figure 4. The facility is normally 19.5 feet wide, except at locations where signs or signals are mounted on the adjacent barrier. At these locations the width is 17.5 feet. The travel lane is 12 feet wide. The total width is enough to allow transitway vehicles to pass a disabled vehicle pulled to the side of the transitway.

Design speeds of a transitway are in the 50 to 60 mph range for mainlanes and can be as low as 10 mph for connections. The single unit bus is the design vehicle for geometrics and acceleration and deceleration criteria. The passenger car is the design vehicle for establishing stopping sight distances on transitways.



PROPOSED FREEWAY & TRANSITWAY SECTION

Figure 4. Cross Section of Typical Transitway

A variety of designs have been used for connections on Houston transitways. Connections include three- and four-leg interchanges, flyover ramps, and slip ramps. Figures 5 through 10 illustrate some of these connections. The geometric design of each connection creates unique information needs for motorists negotiating the connection. These information needs include:

Entrances	Advance notice of entrance point
	Guidance to entrance
	Transitway entry requirements
Exits	Advance notice of exit points
	Correct lane for exiting
	Maneuver needed to reach desired exit
	End Transitway warning
	Appropriate exit speed on ramp
	Advance notice of control devices at end of ramp
Other	Advance notice of merge
	Wrong Way signs
	Notice of atypical driving conditions

Southwest Freeway Transitway (U.S. Highway 59)

Westwood Park-and-Ride Proposed Elevated Three-Leg Interchange. This is a proposed intermediate connection on a one-lane, one-way, reversible flow transitway. Figure 5 illustrates the design of this connection. In the vicinity of the elevated "T" interchange, the mainlane segment is one-lane, one-way reversible, with an additional acceleration/deceleration lane. The ramp connecting the park-and-ride and the transitway is a one-lane, one-way reversible ramp with flow onto the transitway in the morning and away from the transitway in the afternoon. The two lanes on the mainlane segment provide acceleration and deceleration lanes for entering and leaving the transitway. Figure 5 also indicates the locations where motorists have specific information needs.

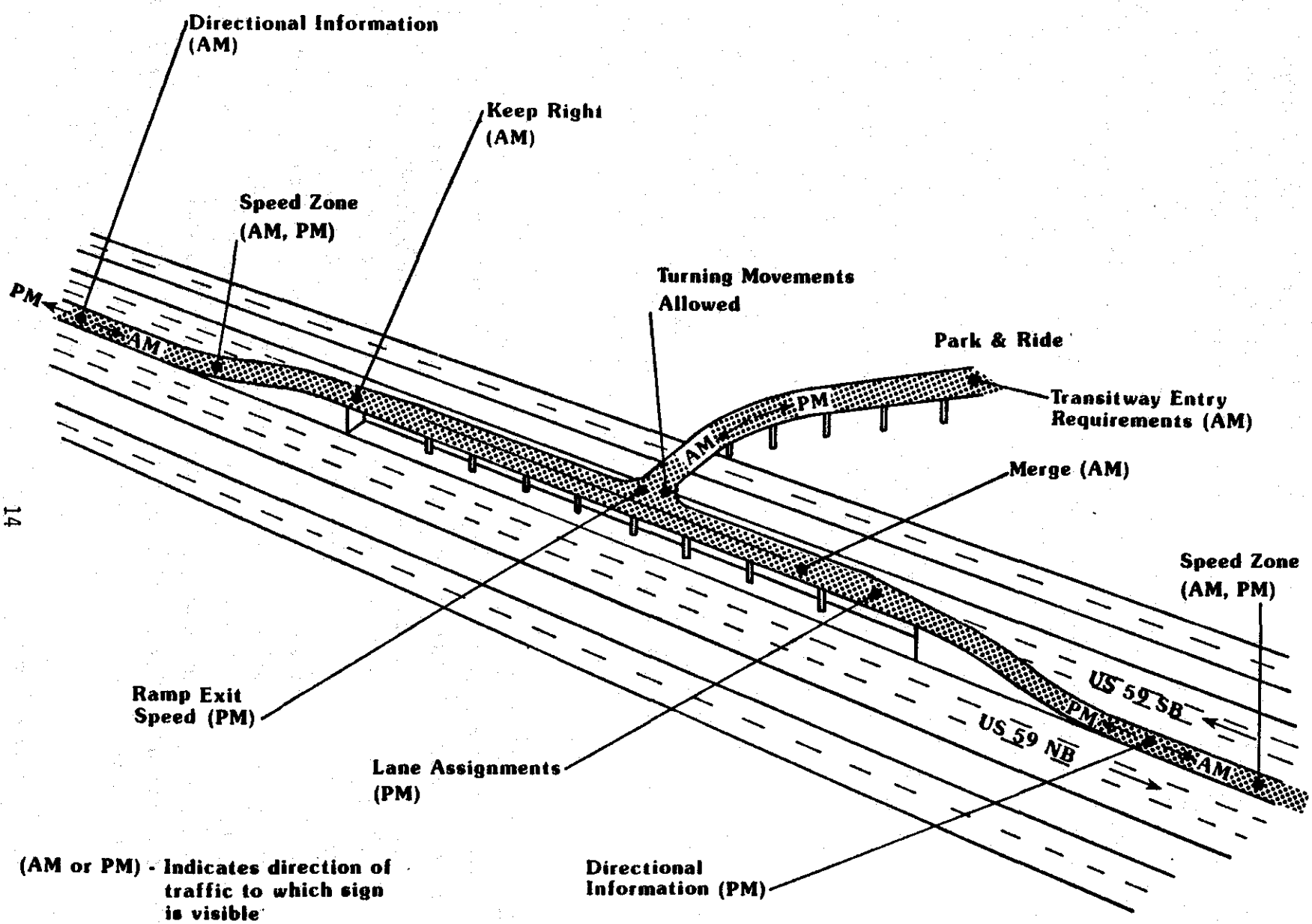


Figure 5. Southwest Freeway Transitway (U.S. Highway 59) Proposed Westwood Park-and-Ride Elevated Three-Leg Interchange

Northwest Freeway Transitway (U.S. 290)

Mangum-Dacoma Elevated Flyover Ramps. This is an intermediate connection located at the transition from a one-lane, one-way, reversible flow mainlane segment to a two-lane, two-way flow mainlane segment. The design of the connecting ramps is shown in Figure 6. There are two ramps connecting the frontage roads and the transitway, each designed for one-lane, one-way nonreversible flow. Traffic enters the transitway from one ramp and leaves the transitway on the other ramp during all periods of operation. The widened portion on the mainlane segment provides acceleration and deceleration lanes for vehicles entering and leaving the transitway. Figure 6 also indicates the locations where motorists have specific information needs.

Northwest Freeway Transitway (U.S. 290)

Flyover Ramps to Northwest Transit Center and Katy Freeway Transitway. There are two connections at this location. Both connections are one-lane, one-way, reversible flow. One ramp is an intermediate connection between two transitways and the other is a terminal connection between the transitway and a transit center. The adjacent transitways are one-lane, one-way reversible flow. A schematic drawing of the interchange design and the locations where motorists have specific information needs is shown in Figure 7.

Gulf Freeway Transitway (I.H. 45)

Hobby Park-and-Ride Proposed Elevated Four-Leg Interchange. This is a proposed intermediate connection on a one-lane, one-way, reversible flow transitway with ramps on both sides of the transitway. Figure 8 illustrates the design of this interchange. On the elevated portion of the interchange, the mainlane segment is three-lane, one-way reversible. The interchange connects the transitway to park-and-ride lots located on each side of the freeway. The connecting ramps are two-lane, two-way reversible with traffic flowing both onto and off of the transitway in the morning and afternoon. Each ramp operates with vehicles traveling on the left side of the roadway instead of the right side during at least one period of daily operation. This operation is contrary to normal driver expectancy and requires extensive information for the motorist. The widened portion on the mainlane segment in the area of the ramps provide acceleration and deceleration lanes for traffic

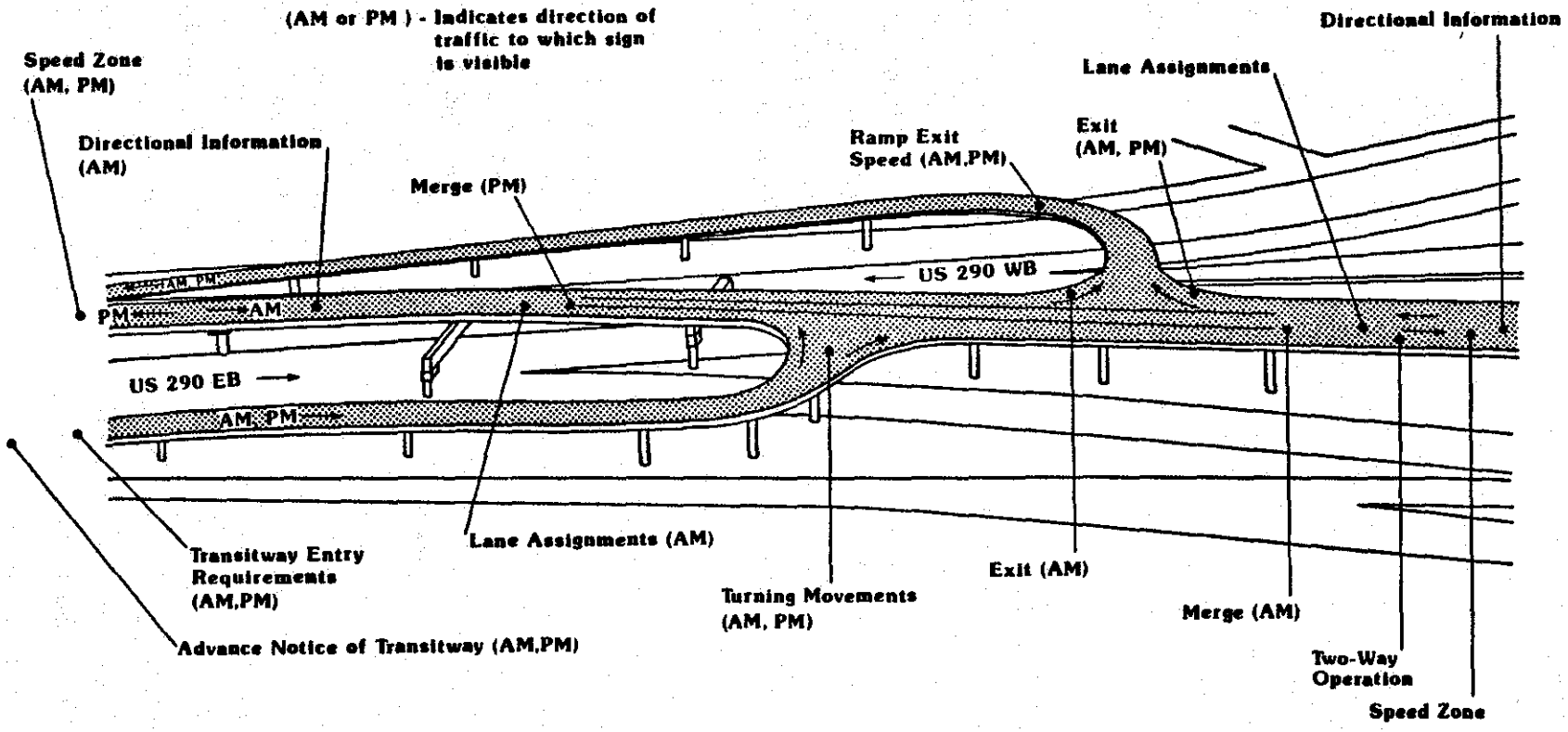


Figure 6. Northwest Freeway Transitway (U.S. Highway 290) Mangum-Dacoma Elevated Flyover Ramps

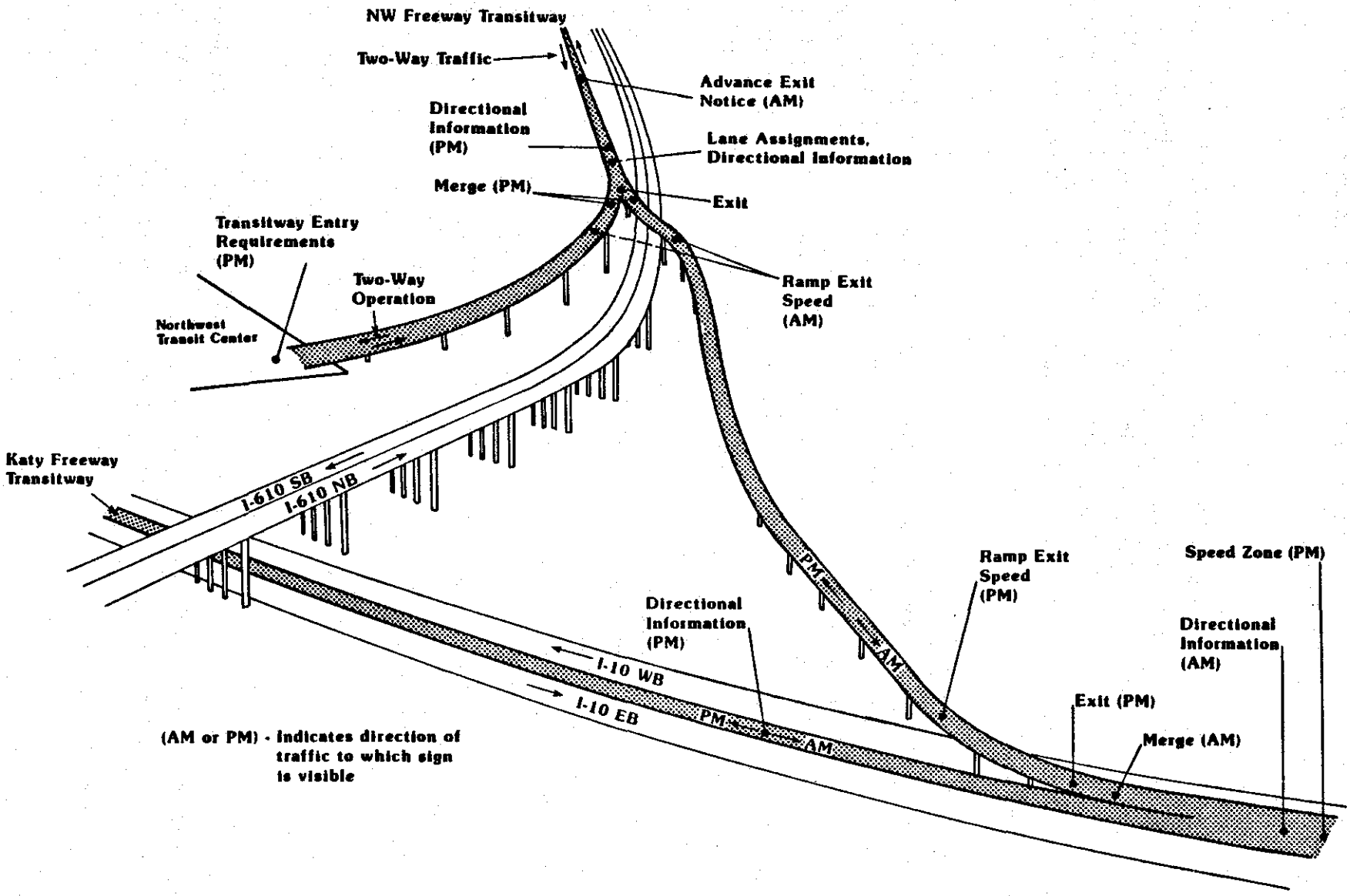


Figure 7. Northwest Freeway Transitway (U.S. Highway 290) Proposed Flyover Ramps to Northwest Transit Center and Katy Freeway Transitway

entering and leaving the transitway. Figure 8 also indicates where motorists have specific information needs.

Katy Freeway Transitway (I.H. 10)

Gessner Road Intermediate Slip Ramps. This connection is an intermediate slip ramp on a one-lane, one-way, reversible flow transitway. The slip ramp is shown in Figure 9. The slip ramp connection allows the transitway traffic to leave or merge into the mainlanes of the freeway traffic stream. Figure 9 also indicates the locations where motorists have specific information needs.

Katy Freeway Transitway (I.H. 10)

Old Katy Road Flyover Terminal Connection. This is a terminal connection at the end of a one-lane, one-way reversible flow transitway. The ramp connecting the arterial street and the transitway is a one-lane, one-way reversible ramp with flow off of the transitway in the morning and onto the transitway in the afternoon. A schematic drawing is provided in Figure 10. Figure 10 also indicates the locations where motorists have specific information needs.

Summary of Critical Transitway Design Features

An evaluation of the information needs of specific Houston transitway designs found that the motorist information needs closely follow those established in the previous portions of the engineering analysis. Other concerns related to information transfer were also determined. The following elements should be considered when determining the best methods to meet the information needs of transitway users:

- High speeds on transitways reduce the length of time a motorist is exposed to a sign.

- Multiple combinations of transitway geometrics and eligibility requirements are possible, depending on the location and operational concerns. As a result, each location has unique information needs.

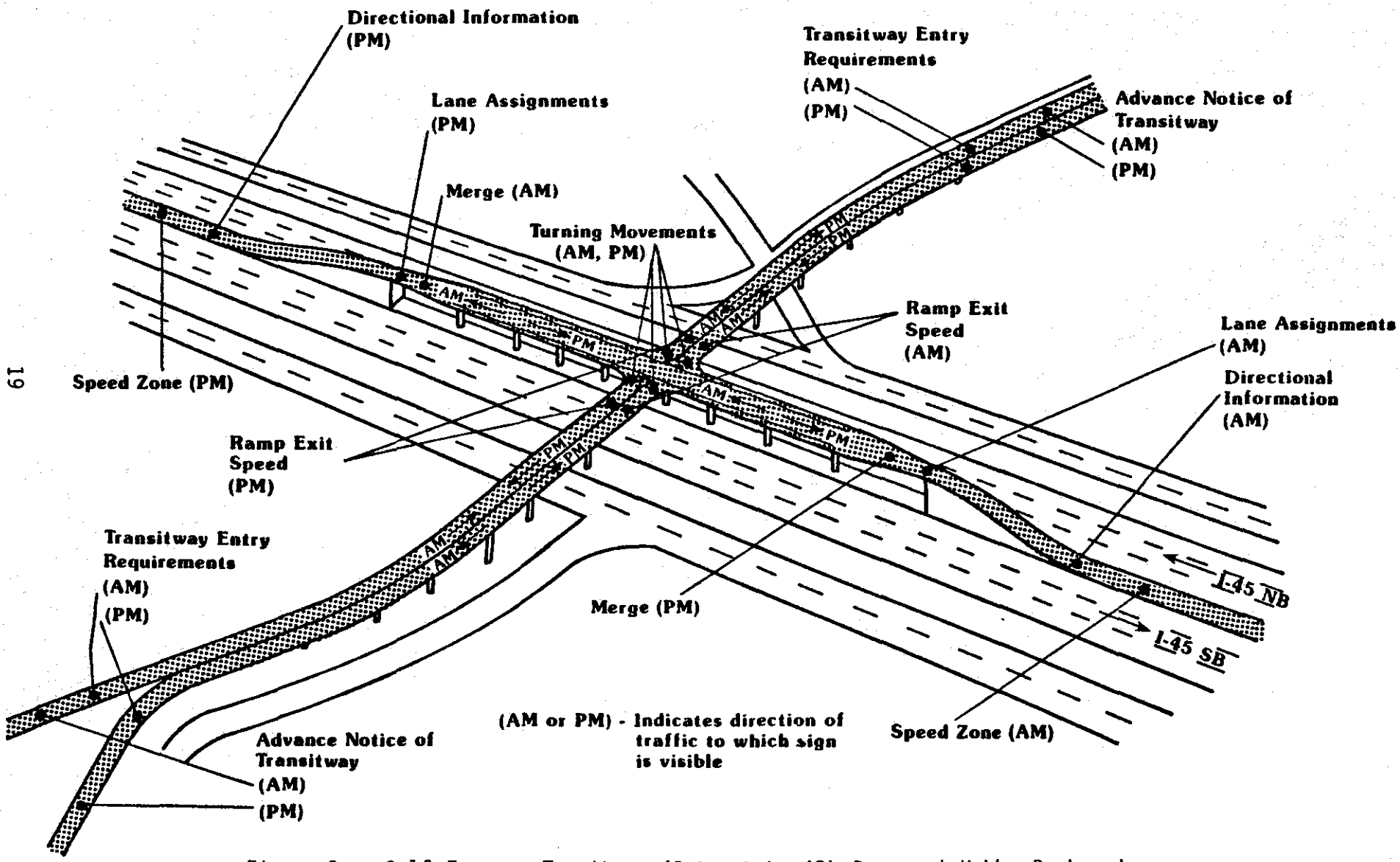


Figure 8. Gulf Freeway Tranitway (Interstate 45) Proposed Hobby Park-and-Ride Elevated Four-Leg Interchange

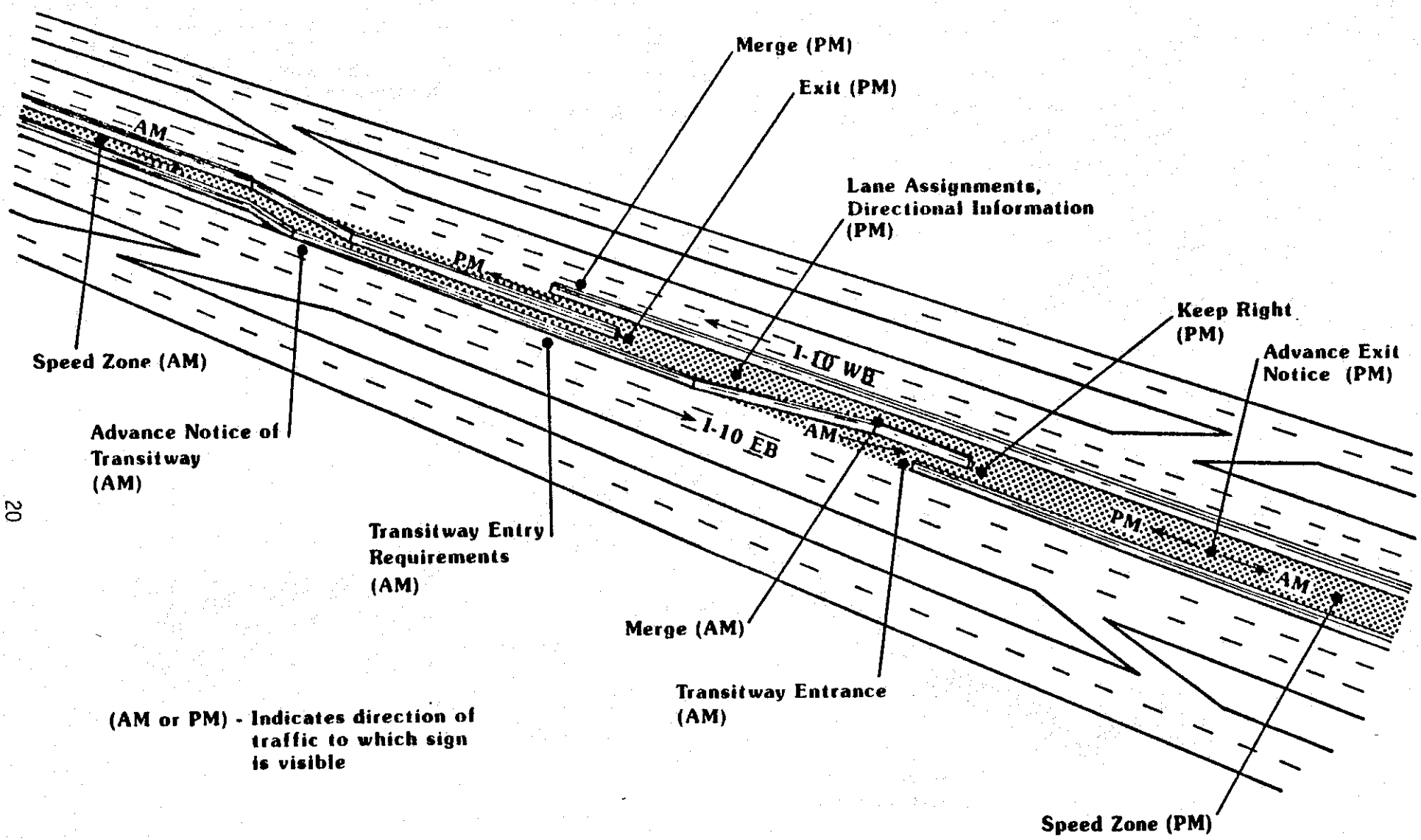


Figure 9. Katy Freeway Transitway (Interstate 10) Gessner Road Intermediate Slip Ramps

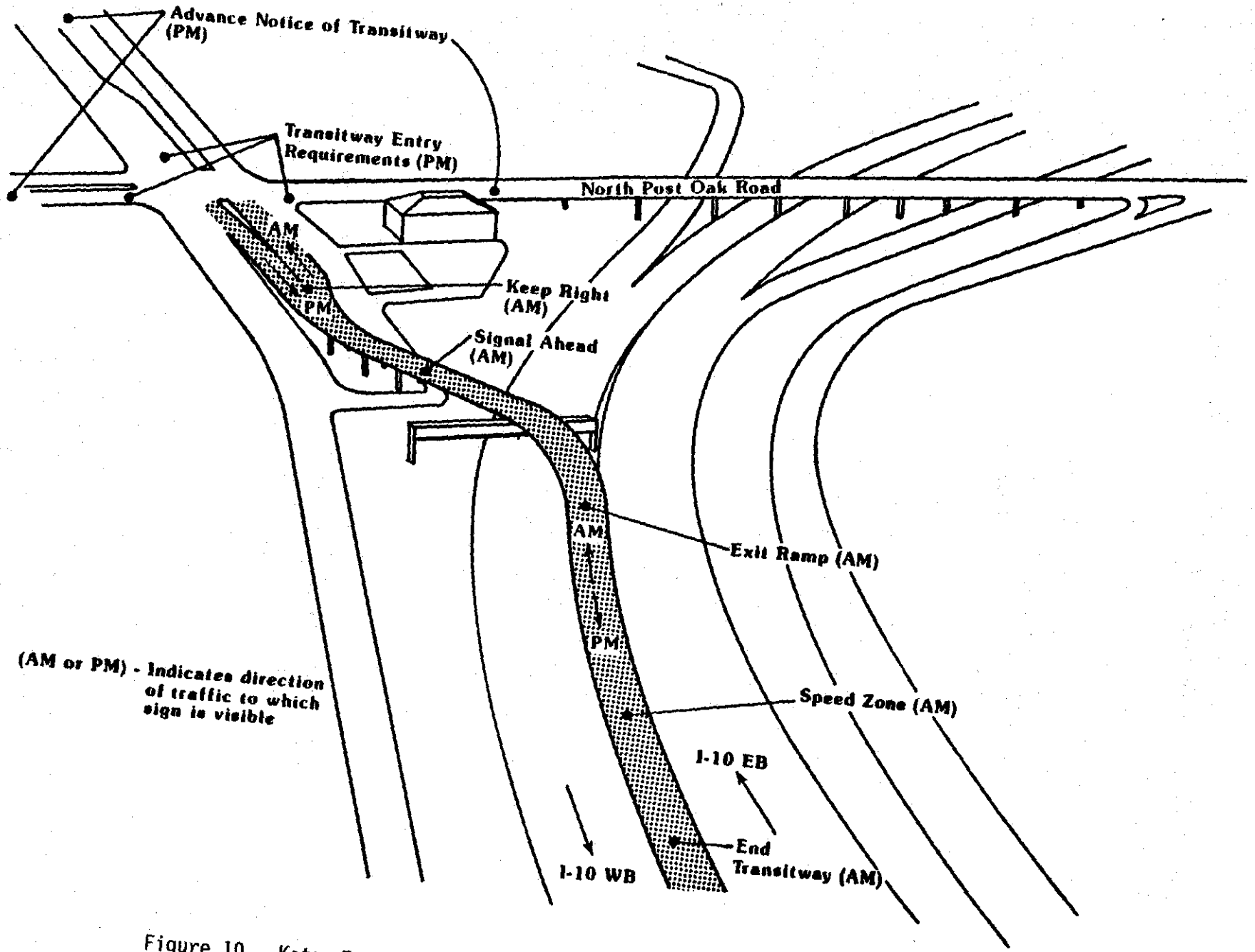


Figure 10. Katy Freeway Transitway (Interstate 10) Old Katy Road Flyover Terminal Connection

- The following information needs apply at different parts of the transitway:
    - Entrances
        - Advance notice of entrance point.
        - Guidance to entrance.
        - Transitway entry requirements.
    - Exits
        - Advance notice of exit points.
        - Correct lane for exiting.
        - Maneuver needed to reach desired exit.
        - End of Transitway warning sign.
        - Appropriate exit speed on ramp.
        - Advance notice of control devices at end of ramp.
    - Other
        - Speed limits.
        - Advance notice of merge.
        - Wrong Way signs.
        - Notice of atypical roadway conditions.
- The reversible nature of transitways requires that information applicable only to one direction of travel be visible only to those vehicles traveling in that direction.
- Lane control signals must be clearly understood by transitway users.

REVIEW OF CURRENT PRACTICE FOR TRANSITWAY INFORMATION SYSTEMS

Literature Review

High-occupancy vehicle lanes and transitways have been the subject of much research in recent years. Most studies have been aimed at the design, operation, or evaluation of the facilities. Little research has specifically addressed motorist information needs on special use lanes. That which does deal with the subject is typically limited in scope. The following paragraphs describe the resource literature which addresses the motorist information requirements of special use facilities.

National and Texas Manuals on Uniform Traffic Control Devices (1, 2)

The MUTCD provides standards for the use of all traffic control devices. These standards apply on all streets and highways open to public travel, regardless of type or class, or the governmental agency having jurisdiction. The MUTCD states five basic requirements that a traffic control device should meet to be effective. These requirements are: fulfill a need, command attention, convey a clear, simple meaning, command respect of road users, and give adequate time for proper response. All traffic control devices used on transitways must meet these requirements.

The MUTCD also provides three different functional classifications for traffic control signs. The three classifications include **regulatory signs**, which give notice of traffic laws or regulations, **warning signs**, which call attention to conditions on, or adjacent to, a highway or street that are potentially hazardous to traffic operations, and **guide signs**, which show route designations, destinations, directions, distances, services, points of interest, and other general information. Transitway signing should be grouped into one of these three categories and each sign should be in accordance with the principles for that classification.

Development of Informational Requirements and Transmission Techniques for Highway Users (4)

The information requirements of motorists have been documented in a report published by the National Cooperative Highway Research Program and released in 1971. In this study, a team of engineers and psychologists studied the information needs of drivers and the means for satisfying them. Through the technique of task analysis, a body of information needs was identified, the satisfaction of which enables drivers to perform the driving task safely, conveniently, efficiently, and comfortably. Principal factors were defined that organize the needs into functional groups, delineate the interactions between them, and identify the criteria for selecting and transmitting information concerning the needs to be satisfied. The results of this study effort can be directly applied to the information needs of transitway users.

Driver operations can be characterized in terms of a hierarchy. The basic tasks of control (starting, stopping, speed control and steering) are at the top of the hierarchy. Guidance tasks (maneuvering the vehicle on the road in response to roadway elements, traffic, environmental factors, legal requirements, etc.) are in the middle of the hierarchy. Navigation (direction finding, trip planning, and route following tasks) are at the low end of the hierarchy. Driver information needs are arranged in accordance with this hierarchy. A demanding priority exists in satisfying information needs, with control needs having the highest priority, followed by guidance needs, and then navigational needs. Satisfying this priority of information needs is basic to the design of a transitway information system.

Drivers search the transitway and environment for information to satisfy their information needs. For the control tasks, the driver obtains information relative to vehicle operation and keeping his vehicle in motion on the road. Because vehicle control must be maintained throughout, the driver must always have this information at his disposal. For guidance, the driver is involved primarily with maintaining a safe and efficient course in relation to events on the roadway. Because these events do not necessarily occur continuously, the driver needs guidance information about events that will effect his safe and efficient course of travel in sufficient time to

make necessary vehicle control adjustments. For navigation tasks, the driver is following a trip plan from his origin to his destination by obtaining information as to where he is and where he is going. The typical information needs of a transitway motorist are described in Table 1.

TABLE 1

TYPICAL TRANSITWAY INFORMATION NEEDS

ELEMENT	INFORMATION NEED	INFORMATION SOURCE
Control Related	Vehicle handling characteristics	Experience
	Vehicle operating conditions	Observation
	Vehicle acceleration	Experience
	Lateral location on transitway	Observation
	Longitudinal location on transitway	Observation
	Horizontal alignment of transitway	Observation
	Vertical alignment of transitway	Observation
	Cross section (lanes, medians, shoulders)	Observation, Warning signing
	Speed limits	Regulatory signing
	Restrictions on use of transitway	Regulatory signing
Guidance Related	Climatological conditions	Observation
	Surface conditions	Observation
	Changes in horizontal alignments of transitway	Warning signing, Observation
	Changes in vertical alignments of transitway	Warning signing, Observation
	Changes in cross section of transitway	Warning signing, Observation
	Obstacles on and off of transitway	Observation, Warning signing
	Special features of transitway	Warning signing
	Traffic features	Observation
	All regulatory requirements of transitway	Regulatory signing
	Interchange features (geometric and traffic)	Observation, Warning signing
Navigational Related	Direction to destinations	Guide signing
	Distance to destination	Guide signing
	Designation and direction of travel on transitway	Guide signing
	Designation of interchange	Guide signing
	Designation of destination	Guide signing
	Potential destinations from transitway	Guide signing

Reference (4).

The use of this hierarchy of information needs is of prime importance in developing and installing a transitway information system for drivers. For example, in areas where drivers will be busy with speed control or obstacle avoidance, they should not be overly burdened with directional

signing. Such directional information should be planned and installed in areas where there are only "simple" steering and speed control maneuvers. Transitway drivers should not be overloaded by complex or unexpected events during their trip.

Another key factor in the performance of the driving task is expectancy. When a trip is planned, the driver forms expectations of the conditions to be encountered in transit. Expectations regarding transitway conditions, signs, access, etc., are also formed while driving. These expectations operate in such a manner as to provide the driver with a basis for planning his trip, and to provide him with information about what directional information he should expect in transit, when to expect it, and what it should look like. Consistency in meeting driver expectations is vital to the successful transmission of information to the transitway driver.

Signing and Delineation of Special Use Lanes (5)

This three-volume report was released by the Federal Highway Administration in 1981. This study specifically addresses the information needs of the users of high-occupancy vehicle lanes. The research had as its objectives:

- Determination of the information requirements of users and non-users of HOV facilities;
- Development of signing and delineation systems to meet the information requirements; and
- Evaluation of the efficiency of the developed signing and delineation systems.

The report was primarily concerned with special use lanes which are not physically separated from adjacent traffic flow. Therefore, much of its findings do not have direct application to transitways. However, the following findings from the report are useful:

- With only one exception, all the information systems developed and tested in this project performed as well or better than existing systems or no system. This was true across geographic regions. Therefore, the project results suggest it is both desirable and feasible to promote uniform Special Use Lane (SUL) signing across the country.

- The current MUTCD does not list all the different SUL information requirements and associated signing/delineation. The results of this project provide a step in meeting that need.

- The diamond symbol is not sufficiently understood by drivers who have not been exposed to diamond lanes. Signing or marking by itself does not appear to be an adequate teaching device. Greater emphasis needs to be placed on driver education and awareness via other media when diamond lanes are newly introduced. This also applies to SUL's in general. While the information systems tested improved driver awareness considerably, up to 50 percent of the drivers still did not notice the SUL's. The existence, purpose, and rules for an SUL must be publicized over time.

Manual for Planning, Designing, and Operating Transitway Facilities in Texas (6)

This manual was prepared by the Texas Transportation Institute (TTI) for the SDHPT in 1985. It provides information on transitway planning guidelines, design criteria, operational considerations, and transitway support facilities, including transfer centers and park-and-ride lots.

The manual was prepared to promote uniformity of design and operational efficiency for transitway facilities in Texas. Signing and delineation of transitways are addressed as part of the operational considerations. The manual contains the following statements about signing and delineation:

- The proper application of traffic control devices is critical to safe and efficient transitway management and to assure operational integrity on transitway mainlanes and connections.

- Detailed consideration should be given to the design of the traffic control system as an integral part of transitway development.

- All traffic signs need to be in accordance with the MUTCD and full and complete attention should be given to the following five basic considerations: design, placement, operation, maintenance, and uniformity.

The manual also presents several typical transitway signs. These signs are illustrated in Figure 11.

HOV Signing Policies

Metropolitan Transit Authority of Harris County

The Metropolitan Transit Authority of Harris County, Texas, has recently developed a series of proposed signs for use on transitways in the Houston area. These signs are currently under review by the SDHPT and several are shown in Figure 12.

California Department of Transportation

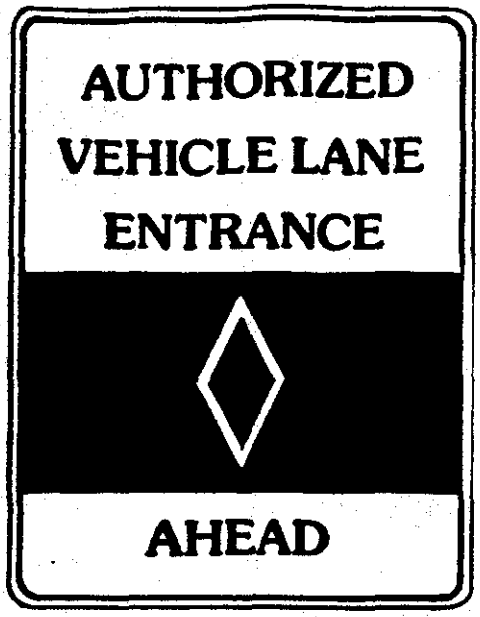
The California Department of Transportation (Caltrans) has developed a series of signs for use on high-occupancy vehicle lanes. The HOV lanes in California are both barrier separated and non barrier separated. An example of some of the HOV signs contained in the state traffic manual are shown in Figure 13.

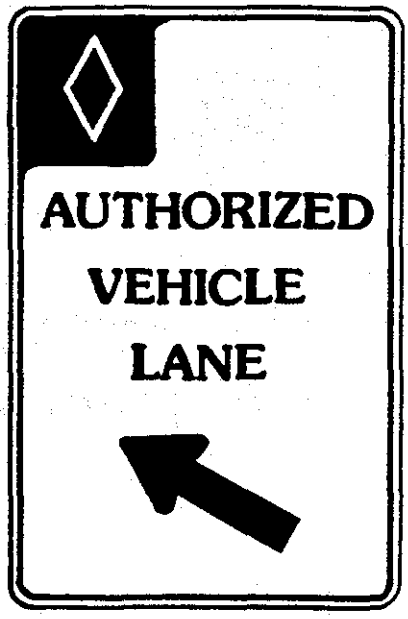
Washington State Department of Transportation

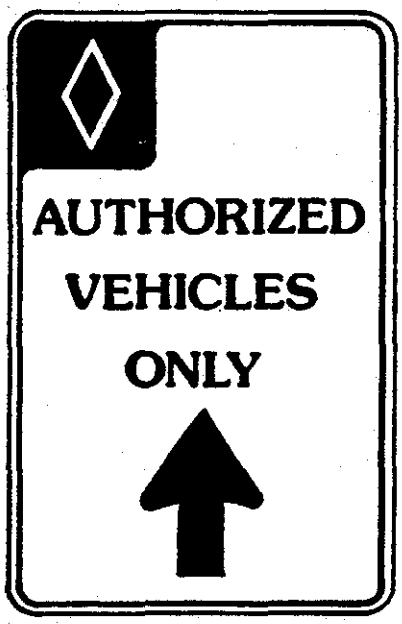
The Washington State Department of Transportation is responsible for the operation of HOV lanes in Seattle, Washington. This facility is not barrier separated, but the Washington DOT has developed some general HOV signing which has application to barrier separated HOV lanes. These signs are shown in Figure 14.

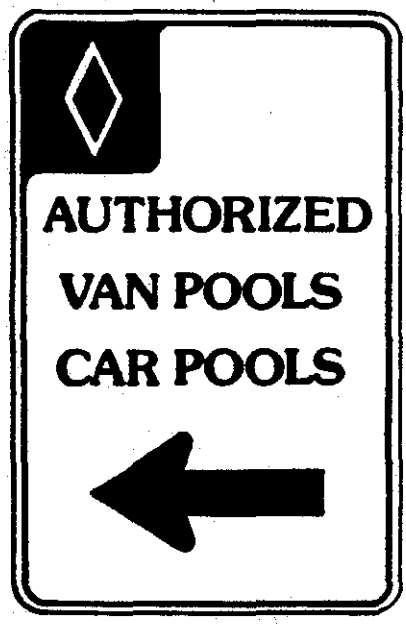
Transitway User's Information Needs

The information needs of transitway motorists closely resemble those of freeway motorists. The transitway has many of the same design and operating



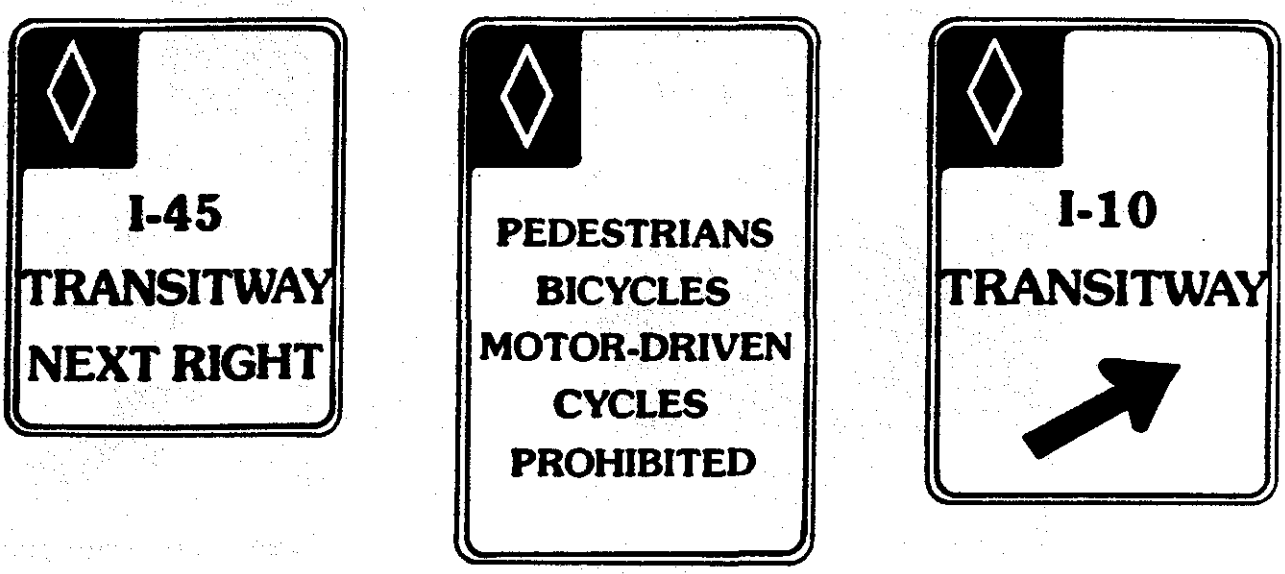


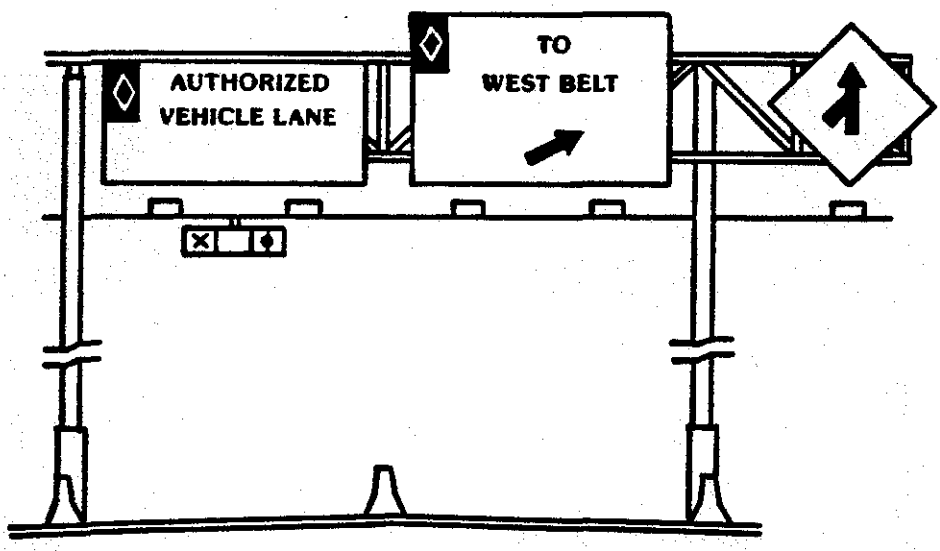




Source (6)

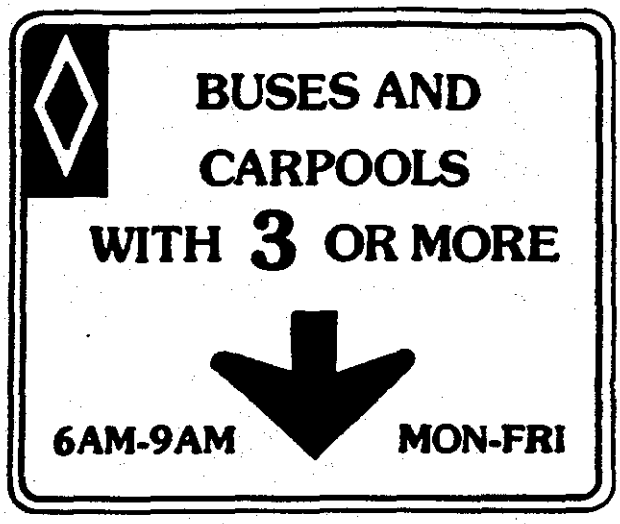
Figure 11. HOV Design Manual Example Signs

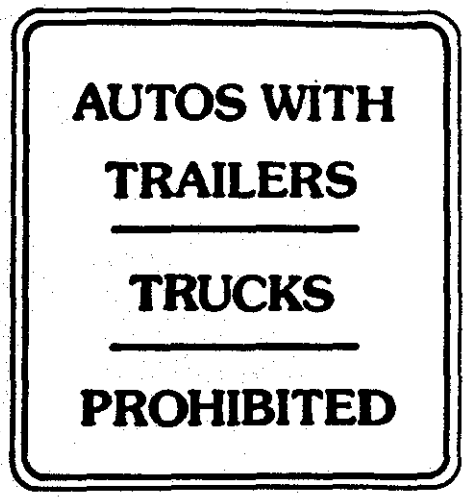


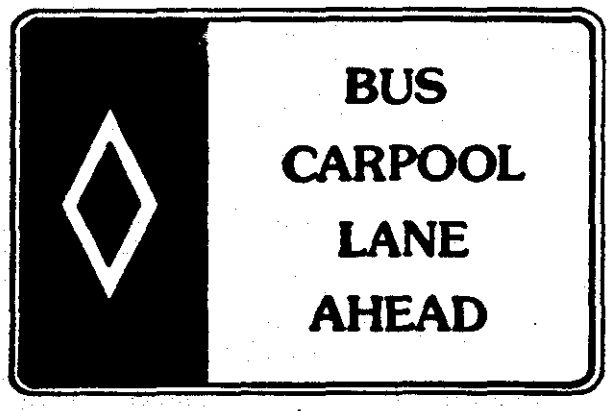


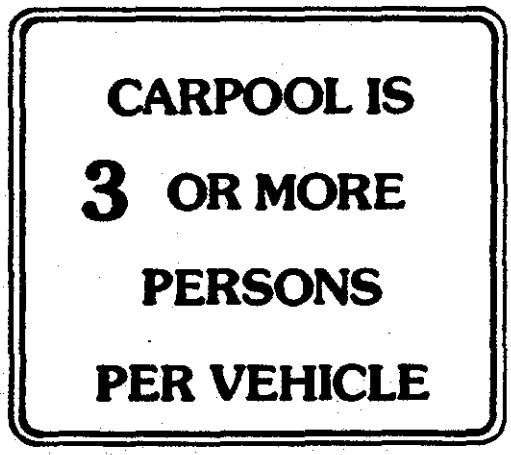
Source - Metropolitan Transit Authority of Harris County, Katy Freeway Transitway plans

Figure 12. Metropolitan Transit Authority of Harris County, Transitway Signing Examples



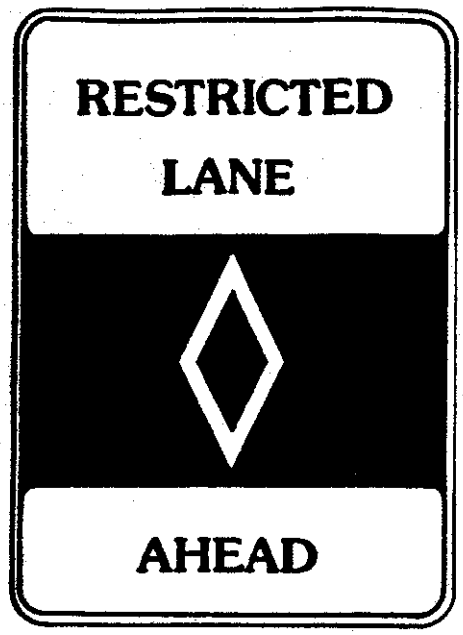


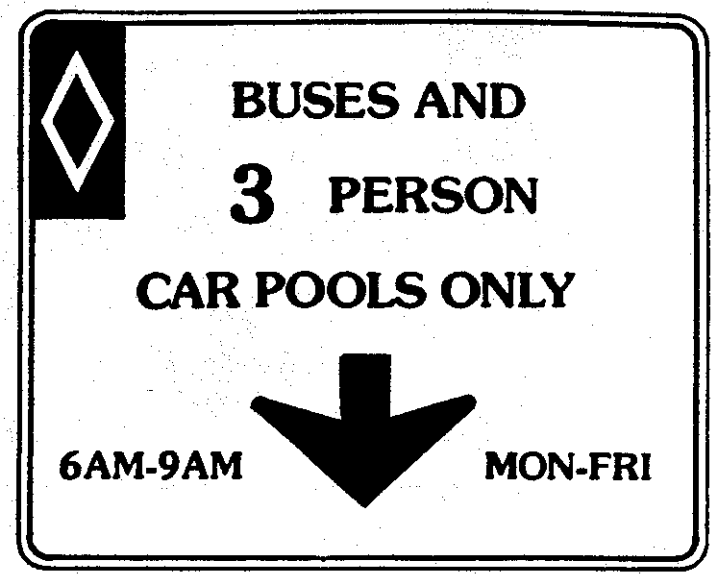


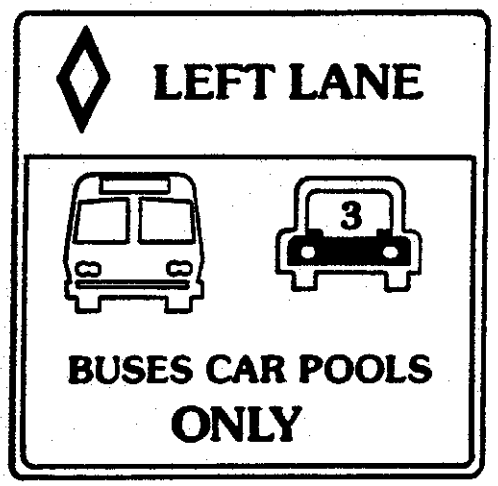


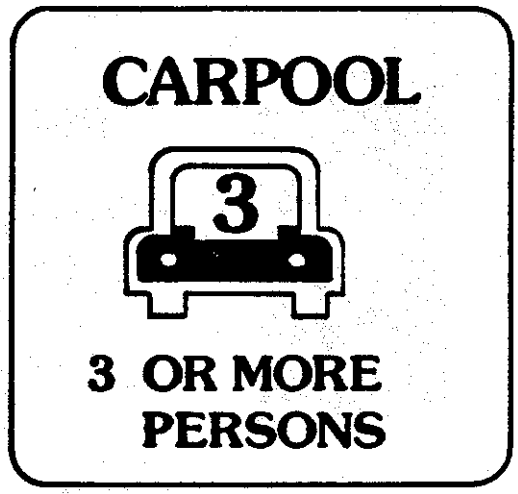
Source (7)

Figure 13. Los Angeles, California Transitway Signing Examples









Source (8)

Figure 14. Seattle, Washington Transitway Signing Examples

features as freeways, including full control of access and high speeds. Transitway design elements which are common to the freeway include limited access, grade separations at cross streets, and ramp connections for entry and exit movements. However, while freeways are intended for the safe and efficient movement of high volumes of vehicles at high speeds, the transitway is intended to provide for the safe and efficient movement of high volumes of people at high speeds. This is accomplished by restricting transitway use to vehicles with high occupancy rates traveling in the peak direction.

The distinction between moving high volumes of vehicles and people is important, as it accounts for the design and operational differences between the freeway and transitway. Features peculiar to barrier separated HOV facilities located in freeway medians may include requirements on vehicle occupancy, restrictions on the types of vehicles permitted to use the facility, greater limitations on access, limited operational periods, and reversible operations. Despite these differences, the motorist information requirements of the two facilities are very similar. The principles used to meet the information needs of freeway users can be utilized when developing strategies for meeting the motorist information needs on transitways. The information needs must be evaluated carefully during the design phase to insure that users of the facility are given the necessary information in a manner consistent with the drivers' expectations.

The expectations of transitway drivers are no different than those of drivers on other facilities. A driver expects to receive information in a timely and easy-to-understand manner, consistent with previous experiences. The minimal amount of information expected by the driver includes notice of unusual or unexpected situations of which the driver has no advance knowledge and also includes reinforcement of current knowledge about the facility.

Transitway drivers require, at the least, information which addresses how they should drive their vehicle (regulatory messages such as speed limits, entrance requirements, etc.), conditions which affect the driving environment (warning messages such as merges, clearances, advisory speeds, etc.) and information on how to reach the desired destination (guide messages

such as advance notice of entrances and exits, entrance and exit signing, etc.)

The type and detail of the information provided to transitway users is dependent on their familiarity with the facility. If the only drivers allowed on this type of facility will be drivers who have received training or orientation to the HOV lane, then only the basic information requirements described above need to be met. However, if any driver meeting the HOV occupancy requirements is allowed on the transitway, then all the information requirements should be met in a manner similar to that used on other non-transitway highways. Consistency is also important. The information provided on various transitways should be presented in a similar manner, even if the usage requirements are different. Therefore, if unfamiliar drivers are to be allowed to use one or more transitways, then all transitways should meet the information requirements of the unfamiliar or uninformed driver in a manner consistent with current guidelines.

Transitway motorists should not be confused by the changing operational features of a HOV facility. Information which applies only to one direction of movement should not be visible to the other direction. Opportunities to misunderstand the operations should be reduced or eliminated by reducing the options available to the driver. Barriers are needed at access locations to prevent their use during the inappropriate operating periods.

It is also desirable to provide HOV users with real time information about the traffic conditions on the facility, in order to maintain a high level of service. This information should be provided in a manner which is compatible with user needs and which provides for optional actions.

Finally, a freeway median transitway produces a parallel signing system between the freeway and the HOV lane. It is important that users of each facility be able to distinguish the information intended for them.

Summary of Current Practice

Current practice was reviewed to determine the information needs of barrier separated HOV facilities located in freeway medians. First, a review was made of existing literature which addressed the subject. An analytical analysis of transitway user information needs was then performed. These two reviews identified key issues which must be addressed when developing an information system for transitways. These key issues include:

- The use of traffic control devices should follow the standards established by the MUTCD.

- The MUTCD does not address all aspects of HOV signing and delineation.

- Driver information needs are arranged in accordance with a hierarchy, with control needs having priority over guidance needs, which are followed by navigational needs. Satisfying this priority of information needs is basic to the design of any highway information system.

- Consistency in meeting driver expectations is vital to the successful transmission of information to the driver and the driver expectancies of transitway users are no different than that of users on any other facility.

- Signing and markings alone are not adequate teaching devices. Driver education is a necessary part of meeting the information needs of transitway motorists.

- Agencies in different parts of the country use different HOV signs to transmit information to the motorists. However, uniform signing is desirable for all HOV facilities across the country.

- Detailed consideration should be given to the design of the traffic control system as an integral part of transitway development.

- The type and detail of information needed on a transitway is dependent on the users of transitways in general. The information needs of the least informed user should be met. If unfamiliar or untrained users are allowed on a transitway, then all other transitways should meet the information needs of the unfamiliar user.

- The reversible nature of transitways requires that information applicable only to one operating period not be visible during periods to which it does not apply.

- Signing should address the transitway or freeway, but not both. Distinctions should be made between parallel signing systems for freeways and transitways so that users of the two facilities will not be confused.

ASSESSMENT OF MOTORIST INFORMATION REQUIREMENTS

Overview

Early investigations of this research study indicated the need for continued inquiry into specifics of the information requirements of transitway users. Further evaluation of transitway information issues was necessary to determine motorists' reactions to specific concerns. Issues which needed to be investigated included:

- The most accepted name for this type of facility.
- The comfort level of transitway users.
- Motorists' understanding of existing transitway information systems.
- The effect of non-transitway signing on transitway users.
- Motorists attention to transitway signing.
- The effects of sign location on motorists' understanding.
- The effects of sign legend on motorists' understanding.

Two procedures were used to evaluate potential information systems for transitways. The first evaluation was a field appraisal of the existing motorist information system in place on the I.H. 10 West (Katy Freeway) transitway. In this evaluation, individual test subjects were asked to drive on the Katy Transitway while an observer in the car noted their reactions to various stimuli and asked questions of the driver at pertinent locations. The results of the field evaluation were analyzed to estimate the effectiveness of existing information systems and determine possible improvements.

The second evaluation used a laboratory setting to determine motorists' reactions to specific questions about existing and potential transitway information systems. A thirty-minute visual presentation was made to a number of test subjects in a classroom setting. The responses of the test subjects were then assessed to evaluate the information systems and determine trends among different groups. The results of the field and laboratory evaluations were then combined with the review of current practice to

determine recommendations and guidelines for meeting the information requirements of transitway users.

Field Evaluation of Katy Freeway Transitway Signing

Objectives

The major objectives of the field evaluation of existing transitway information systems included the determination of the following:

- Motorists' reactions to specific signs.
- Driver perception of sign placement.
- Driver understanding of sign meaning.
- Effectiveness of existing signing.
- If the existing signing and lane control signals provided sufficient information.
- Comfort level of transitway users.
- Differences between familiar and unfamiliar drivers in reacting to various transitway conditions.
- Driver expectation or lack of it.
- Weaknesses in the existing signing system.
- Areas requiring further analysis in the laboratory study portion of the research effort.

Study Procedure

The field evaluation was conducted in May of 1987 by interviewing drivers as they drove on the I.H. 10 West (Katy Freeway) transitway in Houston. Prior to conducting the field evaluation, each subject was shown a map of the freeway corridor depicting the Katy Transitway entry and exit points. No additional directional information was provided, so that the existing signing could be tested. The subject was then driven, out of sight of the transitway, to a point near the entrance. After the subject assumed the driver position, the interviewer instructed the subject to enter the transitway. The interviewer then asked the driver questions at various locations. Each driver was tested twice, in the outbound direction on the first trip and in the inbound direction on a second trip.

Study Elements

The field study was given to a total of 31 test subjects who were available for testing. Table 2 contains demographic information related to the test subjects. All 31 of the outbound trips began at the Post Oak entrance to the transitway. Twenty of these subjects exited the transitway at the Gessner intermediate slip ramp and the other eleven continued on and exited at the West Belt terminal slip ramp. On the inbound trips, twenty began at the West Belt slip ramp entrance and eleven began at the Gessner slip ramp entrance. All 31 of the inbound test subjects exited at the Post Oak terminal flyover ramp.

TABLE 2
FIELD EVALUATION DEMOGRAPHIC INFORMATION

AGE	MALE	FEMALE	TOTAL
25 or younger	10	2	12
25 - 45	14	2	16
45 or older	2	1	3
TOTAL	26	5	31

EDUCATION	MALE	FEMALE	TOTAL
High School or less	1	0	1
College or more	25	5	30
TOTAL	26	5	31

PREVIOUS EXPERIENCE ON TRANSITWAY		TOTAL	
None		30	
Once		0	
2 or more times		1	
TOTAL		31	

The desire for an evaluation by unbiased drivers led to the selection of motorists that had not used the transitway prior to the test. There were three prerequisites to being selected to participate in the field study. The qualifications included:

- Limited exposure to the Katy Freeway corridor;
- Generally unfamiliar with the Katy Freeway Transitway; and
- State of Texas employee (for liability reasons).

The interviewer asked questions at the following locations:

- Prior to beginning the study.
- Approach to entrance or intermediate access point.
- Entrance or intermediate access point.
- Through segments.
- Exit.

The questions addressed a variety of aspects of transitway information and operational features. The question areas included general information about the test subject, advance information signing, access information, ingress signing and markings, braking characteristics, speed readings, through segment characteristics, and egress signing and markings. Four different questionnaires were used for the evaluation reflecting the four possible travel paths. The questionnaires were similar except for variations resulting from the different conditions at the entrances and exits. A typical example of a questionnaire is shown in Appendix A.

Results of Signing Evaluation

The Katy Freeway Transitway signing evaluation resulted in a number of findings which indicate how drivers react to transitway stimuli and where there were needs to improve how information is provided to the transitway user.

The majority of the drivers were comfortable driving on the transitway despite the fact that only one of the test subjects had ever driven on it. Subjects reported that transitway geometrics were satisfactory, resulting in a pleasing driving experience. Drivers were able to drive at 55 mph for most of the test period. Speed readings indicated that drivers slow down when warranted by geometric conditions. Speed limit signs and pavement markings (35 mph) were seen but largely ignored in the vicinity of the intermediate slip ramp.

Some of the subjects were confused when trying to enter the transitway. This demonstrated a need for improved information and channelization

indicating the path to the transitway. The number of signs and the changing geometrics also created confusion by diverting the driver's attention.

The field study also indicated weaknesses in the existing signing on or near the transitway. Few drivers (approximately 40 percent) saw the first advance information sign. A large percentage (approximately 70 percent) noticed the second advance information sign. An even smaller number of drivers was able to comprehend the entire message on the information signs. Sign placement and visual clutter are probably the reasons for the low observation rate.

Test subject reactions to emergency situations was generally opposite of the desired maneuver. Most (80 percent) of the drivers would stop in the right shoulder in case of a breakdown. However, entry signing indicates drivers should pull over to the left shoulder. This sign was not observed by the majority of drivers due to its location at the entrance point. Drivers were preoccupied with the task of getting onto the facility and were not able to devote attention to the sign. In addition, the proper emergency response is contrary to normal driver expectancy.

Freeway mainlane signing had a large effect on the test subjects. Approximately 38 percent of the drivers were affected by the freeway guide signs. In some cases, they assisted the driver in locating the proper access points, while in other cases, they confused the motorist because they were placed in the same cone of vision as the transitway exit signing.

Drivers also reported confusion over the meanings of the lane control signal indications.

Field Evaluation Conclusions

The field evaluation's major finding was that the existing transitway signing did not meet the needs of the current transitway users. This can be attributed to the fact that the existing signing was intended for use by users which had completed a transitway training course. The introduction of untrained drivers on the transitway significantly increased the information

needs of the transitway users while also decreasing the effectiveness of the existing signing.

A number of recommendations were developed as a result of the findings of the Katy Freeway Transitway signing evaluation. These recommendations are listed below. Some are specific to the Katy Freeway Transitway, while others would apply to transitway operations in general. Several of the recommendations require further evaluation before implementation.

- The first advance information sign should be located approximately 1/2 mile in advance of the entrance to improve its observance rate.

- Pavement lane markings should be placed at transitway approaches to indicate proper lanes for traffic entering the transitway.

- Transitway signs and mixed mode signs should be distinguishable from each other. This can be done by placing the diamond symbol on the transitway signs.

- The use of symbols to indicate permitted and prohibited vehicles should be evaluated to determine their effectiveness in relaying important motorist information.

- Fewer words per sign should be used to increase the comprehensibility of transitway signs.

- Signs should be located away from areas with changes in geometric design. Drivers tend to ignore signing while negotiating these changes.

- The abbreviation "HOV" should be defined at the entrances to the transitway if it is to be used in signing.

- Transitway signs should be mounted over the lane whenever possible.

- Signing for emergency operation should be located after the entrance where the driver has the opportunity to read and comprehend the sign.

- Guide signs should be used for exit signing. These signs should include directional arrows.

- Route markers should be placed at transitway exits onto the arterial street system. These route markers should direct the driver to adjacent freeways.

- Transitway signing should be designed to meet the needs of the untrained driver, even if the facility is originally planned to only allow trained drivers on it.

Laboratory Study of Information Requirements

Objectives

The final step in the evaluation process of the research study was a laboratory evaluation of potential alternatives to meeting the motorist information needs of transitway users. The laboratory setting was used to determine motorists' reactions to specific alternatives which could not otherwise be evaluated due to the difficulty and expense of field testing.

The laboratory evaluation addressed three key areas: transitway concepts, transitway signing, and lane-use control signals. The major objectives of the evaluation included the determination of the following:

- Motorists' understanding of transitway concepts.
- The most accepted name for the transitway.
- The types and location of signing which have the most positive effect on transitway motorists.
- The most appropriate sign legend to convey certain messages.
- The best location for transitway signing.
- Any differences in interpreting transitway information which might exist between different socio-demographic groups.

Study Procedure

The laboratory evaluation was given in November of 1987 at the offices of TTI in College Station and Houston to groups of approximately six people

at a time. The evaluation used a thirty-minute slide presentation with a prerecorded narrative. Participants were shown slides and asked to answer questions about the pictures. The slides depicted actual operating conditions on the Houston transitways, conceptual drawings of possible transitway features, and various types of signs. Each participant was provided an answer form on which to record their answers. The questions required a combination of multiple choice and short answers. Throughout the exercise, the facility was referred to as a commuter lane in order to avoid bias by the use of another, more common term.

Study Elements

The sample of test participants consisted of 123 subjects, assembled from a variety of sources available to the research team. The test sample represented a range of socio-demographic categories including familiarity, age, sex, education, and region. A total of 19 different demographic groups was identified as subsets of the total population resulting in a total of 20 analysis groups. The demographics of the participants in the laboratory study are shown in Table 3. Sample size was selected to provide a minimum precision of $\pm$ ten percent for the entire sample. Although there is no data available about the demographics of transitway users, the test sample is assumed to be a representative sample of transitway users. Answers to the questions were analyzed by examining results in each of the groupings.

Thirteen questions were asked during the slide presentation. The questions addressed specific issues such as the most accepted name for the transitway, where signs should be located, what signs should say, how signs should convey the desired message, the meaning of the diamond symbol, the meaning of various lane control signal indications, and transitway entrance and exit signing. The narrative, including the questions used in the evaluation, can be found in Appendix B-1. The answer form used by the test participants is also included in Appendix B-2. Selected graphics from the presentation are shown in Appendix B-3.

Results of Laboratory Study

The answers to the questions were summarized into the twenty demographic categories listed in Table 3. The results were examined to determine any

significant trends with the various categories. The only major distinctions found were between the various familiar and unfamiliar groups. The results of individual questions are summarized in Appendix C, Laboratory Evaluation Answers.

TABLE 3
LABORATORY DEMOGRAPHICS

Basic Categories	
Familiarity	123 participants
Familiar	72 participants
Unfamiliar	51 participants
Location	123 participants
College Station	65 participants
Houston	58 participants
Sex	123 participants
Male	75 participants
Female	48 participants
Age	123 participants
Young (16-30 years old)	61 participants
Mid Age (31-45 years old)	43 participants
Older (46-70 years old)	19 participants
Other Categories	
Familiar	
Male Familiar	56 participants
Female Familiar	16 participants
Young Familiar	38 participants
Mid Age Familiar	27 participants
Older Familiar	7 participants
Unfamiliar	
Male Unfamiliar	19 participants
Female Unfamiliar	32 participants
Young Unfamiliar	23 participants
Mid Age Unfamiliar	16 participants
Older	12 participants

Transitway Concepts

Two of the laboratory questions dealt with transitway concepts. The first question of the evaluation attempted to determine which term motorists

use as a name for the facility. The other question tested their understanding of the diamond symbol.

Two terms were the most commonly accepted names for the facility. "Authorized Vehicle Lane" and "High-Occupancy Vehicle Lane" appeared as the first or second choice in at least 15 of the 20 categories. "Authorized Vehicle Lane" seemed to have a very slight preference over "High-Occupancy Vehicle Lane," with 28 percent of all test subjects choosing it and 27 percent choosing "High-Occupancy Vehicle Lane." These two terms were each chosen by approximately one-fourth of the respondents in each category.

Both of these names have been used in the past on Houston transitways. Therefore, it is not surprising that they were the popular choices. "High-Occupancy Vehicle Lane" has also been used in other parts of the country.

No mention of an authorization process was made to the test subjects before they were asked to name the facility. Therefore, it is not clear if they interpreted the term "authorized" to mean authorized by a process or authorized by the sign. In the past, the term has been used on the Houston transitways when an authorization procedure was in place. Without a procedure for authorization, this term may create confusion among the users.

The use of "High-Occupancy Vehicle Lane" as the description depends on the definition of the term. In today's society of one driver in one car, any vehicle with two or more passengers is above the average occupancy. Is above average to be considered high-occupancy? The laboratory did not explicitly address these issues.

Other terms which were provided as choices, but were not readily accepted include "Transitway," "Express Lane," "AVL," "HOV Lane," "Restricted Vehicle Lane," and "Busway."

When the test subjects were asked about the meaning of the diamond symbol, three answers appeared the most often. The most common replies were "High-Occupancy Vehicle Lane" (chosen by 33 percent of all test subjects), "Restricted Vehicles Only" (25 percent), and "Two Directional Traffic" (17

percent). Other responses included "You are in the Commuter Lane" (6 percent), "Don't Know" (7 percent), and "Other" (11 percent).

The MUTCD states that the diamond symbol is intended to convey that there is a restriction on the class of vehicles which are permitted to use the lane. In this context, both the "High-Occupancy Vehicle Lane" answer and the "Restricted Vehicles Only" answer are correct. The question demonstrates that the public has generally accepted the diamond symbol and identifies it with special use lanes. The responses also indicate the association of the term "High-Occupancy Vehicle Lane" with this type of facility.

From the results of these two questions, some conclusions can be drawn about public perception of transitways. Regarding the name of the facility, the term "Transitway" is not readily identified with the facility. "High Occupancy Vehicle Lane" and "Authorized Vehicle Lane" were the most common terms. "High-Occupancy Vehicle Lane" also appeared in answers to a number of questions throughout the evaluation. The term "Authorized Vehicle Lane" is ambiguous as to the existence of an actual authorization process, and may lead to confusion on the part of motorists. The use of "High-Occupancy Vehicle Lane" as the description is dependent on how high-occupancy is defined.

The diamond symbol is associated with special use lanes by the public and should be used in both signs and pavement markings to help motorists in distinguishing between high-occupancy vehicle lanes and mixed mode lanes.

Transitway Signing

Ten of the laboratory questions dealt with signing for a barrier separated HOV lane. Specific questions addressed issues such as what the sign should say, whether sign symbols are understood, where the sign should be located, and sign comprehensibility.

Two of the questions evaluated current signing. The answers indicated that there is confusion and lack of individual sign recall at some locations. Many signs are not noticed or are not fully comprehended, possibly because of the large amount of information contained in the signs, or the location of

the signs. In addition, drivers seemed to ignore signs which did not pertain to them. Signs should be sufficiently large and located in the appropriate locations for motorists to read them easily and quickly.

Some signs are absolutely necessary on a HOV lane approach to meet the information needs of motorists and also meet MUTCD requirements. However, too much information overloads the motorist, who then ignores the messages. Sign messages should be short and easy to comprehend. Signs should not be spaced in rapid succession.

Clearer signing is necessary to indicate the destination of the exit points and distance to the exit. Significant destinations (especially park-and-ride lots) should be indicated by name on the exit guide signing.

Two questions addressed the content of the sign legend. The questions indicate that motorists prefer specific sign messages as opposed to sign messages which are ambiguous. The more specific sign is the most desirable. Motorists prefer information that is easily understood and leaves no doubt as to the meaning. The use of a black legend on a yellow background is reinforced by the test subjects for warning conditions.

Two questions addressed the use of vehicular symbols in the sign. In both questions, words seem to be the preferred choice of the test subjects, possibly because of the uncertainty of the meaning of the vehicular symbols. Words had the clearest meaning and left no doubt as to which vehicles were permitted or prohibited. The symbols used in the test have not gained a high level of acceptance.

Four questions addressed the best location for various signs. The overhead sign mount was the clear choice as the most desirable location for transitway signing. Overhead signing has greater visibility because it is located directly over the lane and because overhead signs are larger. An overhead sign reduces the possibility of the sign being confused with other freeway signs.

The ground mounted sign, located adjacent to the lane, is smaller and could be missed by a motorist who has their attention fixed on the lane itself, or confuses the sign with freeway signing. However, there may be situations when a ground mounting is the only possible location. The speed limit sign is one sign that may be located adjacent to the lane on a ground mount. In this situation, special efforts need to be taken to insure that transitway motorists understand that a particular sign applies to that facility. The diamond symbol is one method which can be used to identify HOV signs in this situation. Supplementary pavement markings are desirable, but should not be used without a sign.

Driver acceptance of transitway guide signs located on the same support as freeway guide signs was also indicated in the questions. This gives the motorist additional opportunity to gather information about his location from the surrounding environment. However, special precautions should be taken to eliminate confusion between freeway and HOV signs. The diamond symbol should be used to identify all HOV signs.

Lane-Use Control Signals

One question asked the test subjects to indicate the meaning of three lane-use control signal indications currently used in Houston. The subjects were asked to identify the meaning of a flashing yellow arrow, a steady red "X", and a flashing red "X".

Flashing Yellow Arrow

In all 20 of the categories, "Caution" was the first choice for the meaning of a "Flashing Yellow Arrow." Of all the participants in the study, 65 percent selected "Caution" as the meaning. "Slow Down" was the second choice (29 percent), followed by "Lane Closing" (17 percent), and "Congestion" (12 percent).

The correct meaning for the flashing yellow arrow, as currently used on transitways in Houston, is that an incident is located ahead. This answer was not correctly identified by any of the test participants. However, the answers "Caution" and "Slow Down," which were the two most common answers, can be considered essentially correct. Apparently, drivers equate the

flashing yellow arrow with the flashing ball at intersections, indicating they may proceed with caution. It is clear that drivers do not have a clear understanding of the proper meaning of this indication.

Steady Red "X"

The answer "Wrong Direction" was the first choice in 15 of the 20 categories. Of all the participants in the study, 48 percent selected "Wrong Direction" as the preferred meaning. "Lane Closed" was chosen by 37 percent of the participants, followed by "Stop" (24 percent), and "Congestion" (7 percent).

The meaning of the steady (or solid) red "X", as currently used on Houston transitways, is that the lane is closed to traffic. This indication would be displayed to both directions of the facility during periods when no vehicular movement is permitted. The correct answer was typically the second choice in the evaluation, although the first choice, "Wrong Direction," would result in the proper response from the driver. Once again, drivers do not clearly understand what this indication means.

Flashing Red "X"

The first choice in 15 of the categories was "Stop." A total of 29 percent of all the test subjects choose this as the correct meaning for the indication. "Wrong Direction" was chosen as the preferred meaning by 24 percent of the participants. "Lane Closed" (17 percent) and "Congestion" (11 percent) were also chosen by some of the participants. A variety of other meanings were chosen by 20 percent of the participants.

The meaning of the flashing red "X", as currently used on Houston's transitways, is that vehicles facing the indication are traveling in the wrong direction. The correct answer was the first choice in only 5 of the 20 categories. The other 15 categories selected "Stop" as the meaning of the indication. While this interpretation would result in the appropriate response, it is clear that drivers are not correctly interpreting this indication.

Lane-Use Control Signal Summary

The results of the lane-use control signal question indicate that few people know the proper meaning of the lane control signals used on the transitways in Houston. When the transitway became operative, only authorized users were permitted to use it and they were required to go through a training process in which the meaning of the signals was explained. When the Katy Freeway Transitway was opened to non-authorized, or untrained users, those drivers were not given the information on what the signals meant.

It appears that most people equate the lane control signal to an intersection signal. Most people chose "Caution" as the meaning of the flashing yellow arrow. That is the correct meaning of a flashing yellow ball at an intersection. With the flashing red "X", most people chose Stop, which is the meaning of a flashing red ball at an intersection. The association of these lane control signal indications with intersection signal indication will continue until efforts are made to educate the motorists.

It is also important to note that many people chose the steady red "X" to mean the wrong direction, which is actually the meaning of the flashing red "X" as currently used on Houston transitways. The percentage of the total test subjects which made this choice was 48 percent.

The MUTCD has defined various indications for lane control signals. The definitions in the MUTCD are meant to apply to lanes that are not barrier separated. However, indications used on barrier separated HOV lanes should be similar to those in the MUTCD. Conflicts in meaning result in confusion among motorists. Table 4 shows the meanings of various indications defined for Houston Transitways, in the MUTCD, and by the laboratory study.

Laboratory Evaluation Conclusions

Transitway Concepts

- The words "High-Occupancy Vehicle Lane" and "Authorized Vehicle Lane" were the most common choices for describing the barrier separated facility. The abbreviations "HOV" and "AVL" should not be used alone

without previous exposure to its meaning at entry points, but the abbreviation may be used within the facility.

TABLE 4
LANE CONTROL SIGNAL INDICATIONS

INDICATION	TRANSITWAY DEFINITION	MUTCD DEFINITION	LABORATORY STUDY
Flashing Yellow Arrow	Accident Ahead	Not defined	Caution
Flashing Yellow "X"	Not Used	2 Way Left Turn Lane	Not Tested
Steady Yellow "X"	Not Used	Vacate the Lane	Not Tested
Solid Red "X"	Lane Closed	Shall not drive in Lane	Wrong Direction
Flashing Red "X"	Wrong Direction	Not Defined	Stop

- The diamond symbol should be shown on all signs and pavements markings which are for the exclusive use of high-occupancy vehicle lane traffic. The symbol should appear in the same location on all signs.

Transitway Signing

- Some signs are absolutely necessary at a high-occupancy vehicle lane approach to meet the information needs of motorists and also meet MUTCD requirements. However, too much information overloads the motorist, who then ignores the messages. The number and complexity of signs should be kept to a minimum.

- Signs should indicate with words which vehicles are permitted or prohibited on the facility. The use of vehicular symbols is confusing to the motorist.

- The vehicles permitted sign should state "**BUSES, VANS, 2 OR MORE PERSON VEHICLES ONLY**" when stating restrictions.

- Signs which apply specifically to HOV lanes should be mounted overhead using a median support whenever possible. HOV guide signs may be mounted on the same sign frame as the freeway guide signs.

- The black on yellow sign should be used to inform drivers that the transitway is ending. The diamond symbol should also be included with the sign to increase its association with the facility.

- Signs should be the primary means of telling the driver what the speed limit is. In addition, pavement markings may be used in the same vicinity of the signs, if desired.

- Guide signs for transitways should be distinguishable from parallel freeway guide signs. The diamond symbol should be located on all transitway signs.

- Transitway guide signs should be placed in advance of and at all exit points. Park-and-ride exits should be indicated on the sign as should exit points and other major traffic destinations. Guide signs should also be placed in advance of all exits indicating distances to the next and succeeding exit points.

Lane-Use Control Signals

- Lane-use control signals currently used in Houston are not well understood by transitway motorists.

- New definitions for signal indications may be needed to improve motorists' comprehension of the signal meanings.

- The public needs to be educated about the meaning of the signals. Signs should be placed near the entrances to the transitway to inform drivers of the meaning of the lane control signals. Also, a media campaign should be undertaken to assist the information exchange.

- Lane control signal indications should also be added to the Texas Drivers Handbook. Currently, the handbook does not address the use of

lane control signals; therefore, drivers cannot be expected to understand the meaning of the signals.

SUMMARY OF FINDINGS

Current Practice

Current practice for meeting information requirements of transitways was examined to determine the major issues and key concepts that need to be considered in developing an information system. Current practice was reviewed in three areas: information needs of transitway users, literature addressing information systems for transitways, and an evaluation of the information needs at specific locations on the Houston transitway system.

As assessment of the information needs of transitways determined that driver expectancy on this type of facility is no different than that on a mixed mode facility. Unfamiliar drivers are the controlling design element if they are to be allowed to use the transitway. If this is the case, then a transitway should provide the same information as a freeway. Additional information, such as vehicle restrictions and times of operation, is also required. The transitway user should be able to distinguish information which is meant for him from information intended for the parallel freeway system.

If only familiar or trained drivers are to be permitted on the facility, then the information needs can be reduced, but not eliminated. Driver expectation must still be met. Adequate information must be provided at entry and exit points and wherever a driver needs to be informed of special circumstances.

A literature review of current practice revealed little research specifically addressing the information requirements of high-occupancy vehicle facilities. Research which did address HOV facilities was examined, along with that which addresses the general information requirements of mixed mode facilities.

Traffic control systems for transitways should conform to established principles currently in use. All devices should be in accordance with the MUTCD and meet the basic requirements of a control device. As the proper

application of traffic control devices is critical to the safe and efficient operation of a transitway, detailed consideration should be given to the information needs of the users during the planning stages.

Driver information needs are arranged in a hierarchy of which control has top priority, followed by guidance, and then navigation needs. This primacy of information needs must be satisfied if information is to be transmitted successfully. Driver expectancy must be consistently satisfied for the driver to effectively interpret the information.

Some critical design elements of the Houston transitway system were examined to determine the crucial information needs of the users. Six different locations were evaluated, and the findings closely followed that of the general information needs for transitways. Additional elements related to information needs were also determined.

The high speeds on transitways reduce the length of time that motorists are exposed to information, requiring the use of short, easy to comprehend messages. The information requirements of a given location are dependent on the geometric and operational elements. Information systems must be individually designed for a particular location, but fit within an overall scheme.

The reversible design of transitways creates the opportunity for the incorrect information to be communicated to the users. All information which specifically concerns only one direction of movement should not be visible during other periods of operation.

If real time information is to be provided to transitway drivers, then it must be delivered in a manner which is clearly understood.

Critical Transitway Features

A review of various transitway design features was performed to determine the effect of these features on the transmission of information to

the transitway users. The review was performed in three areas; design elements, operational considerations, and specific transitway examples.

The information needs of the various design elements can be classified by terminal and intermediate access, entry and exit points, slip and direct ramps, and alignment. Each of these classifications has information needs which distinguish it from the others. In general, the information needs of the various groups include:

- advance notice of the beginning and ending of the facility
- advance notice of entry and exit points
- interrelationship with nearby traffic at access points
- changes in horizontal and vertical alignment

The operational considerations also affect the information needs of the users. The most significant of these considerations is the reversible nature of transitways. The transmission of real time information to the users is also important. The possible combinations of various operating conditions is too large to address the information needs of each one separately. General principles must be used to determine the best method to meet these needs.

The information needs of different combinations of design elements and operational considerations were evaluated by examining six locations on Houston transitways.

Field Evaluation

A field evaluation was performed to determine motorists' reactions to existing signing and control methods on a Houston transitway. Participants were observed and questioned as they drove on the facility.

Drivers were generally comfortable in driving on the facility. However, the findings indicate that many motorists were confused upon attempting to enter the facility due to the large number of signs, the poor location of the signs, sign clutter, lack of clear channelization, and changing geometrics. Sign location and comprehensibility need to be improved. This can be done by

locating the signs over the lane, locating the signs away from areas of geometric changes, reducing the number of words on the signs, and locating the diamond symbol on the signs.

Freeway mainlane signing both helped and hindered the drivers. Some used the mainlane signing to assist in locating the exits from the transitway, while others confused freeway signing with transitway signing. Drivers were also unsure of the meanings of the lane-use control signals.

Recommendations for improving transitway signing include investigating the use of vehicular symbols to improve the comprehensibility of signs, locating signs over the lane, providing guidance to assist the driver in entering and exiting the facility, and distinguishing transitway signs from freeway signs.

Laboratory Study

The laboratory evaluation attempted to determine motorists' preference for specific alternatives to meeting transitway information requirements. This was done by testing a number of participants' reactions to a series of slides. Alternatives were examined in three different areas: transitway concepts, transitway signing, and lane-use control signals.

The test participants readily identified two terms with this type of facility: "High-Occupancy Vehicle Lane" and "Authorized Vehicle Lane." The diamond symbol is well associated with this type of facility and should be visible on any control devices which apply to the transitway.

Signing on transitways should be easily distinguishable by the motorist. This can be done by locating the sign over the transitway, showing the diamond symbol on the sign, and distinguishing the sign from parallel signing on the freeway. Signs should be easy to understand and convey simple messages. Entrance and exit locations should be clearly labeled as such with appropriate names.

Lane-use control signals are poorly understood by transitway users. Most of the test participants associated the meaning of the signals with similar indications found on traffic signals at intersections. The lane-use control indications used on the transitway should be used in a manner consistent with driver expectancy and signs should be erected on the transitway to inform the driver of the meaning of the signals.

Conclusions

The review of current practice and evaluations of drivers' reactions for barrier separated high-occupancy vehicle lanes indicated a number of precepts that should be followed when providing the information needed by the facility's users. The key concern is related to the type of driver that will use the transitway. Experience in Houston has shown that this driver can be an unfamiliar driver without previous training or exposure to driving on this type of roadway. The unfamiliar driver requires a greater amount of information than the informed driver.

Driver expectation for both familiar and unfamiliar drivers on this type of facility is no different than on any other; therefore, information requirements should be met in a manner consistent with other types of roadways and with other high-occupancy vehicle lanes. With experience indicating that some barrier separated high-occupancy vehicle lanes may be used by unfamiliar drivers, all facilities of this type should meet the information needs of the unfamiliar driver by using similar methods of providing the information required by drivers.

The signing and traffic control used on high-occupancy vehicle facilities should follow the same general guidelines used for signing on other roadways. Because of the unique nature of barrier separated high-occupancy vehicle lanes, special attention must be given to certain matters such as sign placement, parallel signing systems, sign legibility, and comprehension of control devices.

Signing on high-occupancy vehicle facilities should be readily visible, easy to read and comprehend, and should be located in a manner consistent

with the information needs of the drivers on the facility. The most appropriate location for transitway signing is over the lane. Because of high speeds, the observation times of transitway signs is short and sign legends should contain few words. Symbols may reduce comprehension time, but vehicular symbols which were evaluated were not understood by the test participants. Therefore, vehicular symbols should not be used on transitway signing. Important information should not be located in areas where the driver's attention is focused on other driving tasks.

All transitway signs should be easily distinguishable from similar signs which may apply to adjacent roadways. The diamond symbol is recognized as an identifier of this type of facility. Due to the limited access, entrances and exits must be clearly marked and guide the driver to the desired location. Possible confusion requires a clear distinction between transitway guide signs and parallel freeway guide signs. This can best be achieved by a combination of sign placement, sign appearance, and showing the diamond symbol.

Lane-use control signals are not well understood by transitway users. The meanings of the signal indications used in Houston should be modified and efforts should be made to educate the drivers as to the proper meaning of various indications.

RECOMMENDATIONS

General

The transitways in Houston have developed into a complex transportation system with their own specific set of problems relating to motorist information requirements. Addressing these problems requires attention to local viewpoints as well as national policies. It is important to note that any facility requires consistent expectancies with similar facilities across the nation.

Meeting the information needs of motorists on transitways requires attention to all methods of transmitting the information, from signs to surveillance. As with requirements on other types of roadways, the requirements for these facilities must be narrow enough to be consistent from one facility to another, but broad enough to allow adaptation to various special situations which may occur.

This study examined motorist information needs on barrier separated high-occupancy vehicle lanes, or transitways, by examining previous research, conducting an engineering analysis of various operating and design concepts, performing a field evaluation of existing transitway signing, and conducting a laboratory evaluation of various signing and control strategies for transitways. From the results of this analysis, a set of recommended guidelines has been developed. The implementation of these recommendations and guidelines to all barrier separated HOV lanes will insure that the need for consistency in meeting driver expectations is achieved.

General Recommendations

Transitway signs related to usage should use words instead of vehicular symbols in the sign legend. The results of this study indicate that vehicular symbols are not well understood. If it is desired to use symbols in the legends, an educational plaque is recommended.

A diamond symbol should appear on all signs which specifically apply to the transitway. This will help all motorists identify signs which relate to transitway operations. This symbol may be displayed as part of the sign or as an advisory plate. If part of the legend, the diamond symbol should be located in the upper left corner of the sign. It may also be displayed by attaching an advisory plate above the sign. This advisory plate should show the diamond symbol, and "HOV" may be added with the symbol.

Signs which specifically apply to the users of the transitway should be located directly over the lane, whenever possible. All overhead sign installations should normally be illuminated in a manner consistent with the MUTCD.

Regulatory signs located in advance of the facility should be mounted on the side of the approach road. The first regulatory sign visible to the driver should be a sign indicating which vehicles are prohibited. Signs indicating which vehicles are permitted and the times of transitway operation should be located just before and also at the entrance.

Guide signs for barrier separated high-occupancy vehicle facilities should be distinguishable from freeway guide signs. Currently, two schemes are used in the United States; white on green (guide sign format) with a white diamond on black in the upper left corner, and black on white (regulatory sign format). The guide sign format is more consistent with the nature of the sign; however, the regulatory format is more distinguishable from freeway guide signs. A national policy decision is needed on this matter. It is recommended that guide signs be located over the transitway or adjacent to the approach lane and contain the diamond symbol as part of the sign. The information contained in these overhead transitway guide signs may include the following:

- Advance notice of entrance.
- Park-and-ride destinations and distance to destination.
- Transitway interchange destinations and distance to destination.
- Exit to street or freeway system destination and distance to destination.

Route marker signs are recommended for each facility. These will be used to guide motorists to the facility and, once on the transitway, provide continual confirmation of the route.

Any facility which is not open to a particular direction of traffic should have the entrance barricaded in accordance with section 3F-1 of the MUTCD.

The definition of lane-use control indications currently in use in Houston should be changed to correspond to selected MUTCD definitions and additional new definitions should be added to the MUTCD. Educational plaques should be erected at the entrance to HOV facilities explaining the meaning of the lane control indications. In addition, information on lane-use control signals should be added to the Texas Drivers Handbook.

Guidelines for Transitway Traffic Control Devices

The guidelines that follow were developed from the findings of this study and follow the basic format of the MUTCD. The key concern in developing a set of guidelines is to provide information that is consistent with the drivers' expectations and easy to understand. The application of these guidelines when determining signing and control strategies for transitways will ensure that drivers encounter a consistent driving environment and will greatly assist in meeting the information needs of drivers.

Regulatory Signing

The Texas MUTCD (2) contains the following section about regulatory signs:

> *SECTION 2B-1 Application of Regulatory Signs*
>
> *Regulatory signs inform highway users of traffic laws or regulations and indicate the applicability of legal requirements that would not otherwise be apparent. These signs shall be erected whenever needed to fulfill this purpose, but unnecessary mandates should be avoided.*

Regulatory signs normally shall be erected at those locations where regulations apply. The sign message shall clearly indicate the requirements imposed by the regulation and shall be easily visible and legible to the vehicle operator.

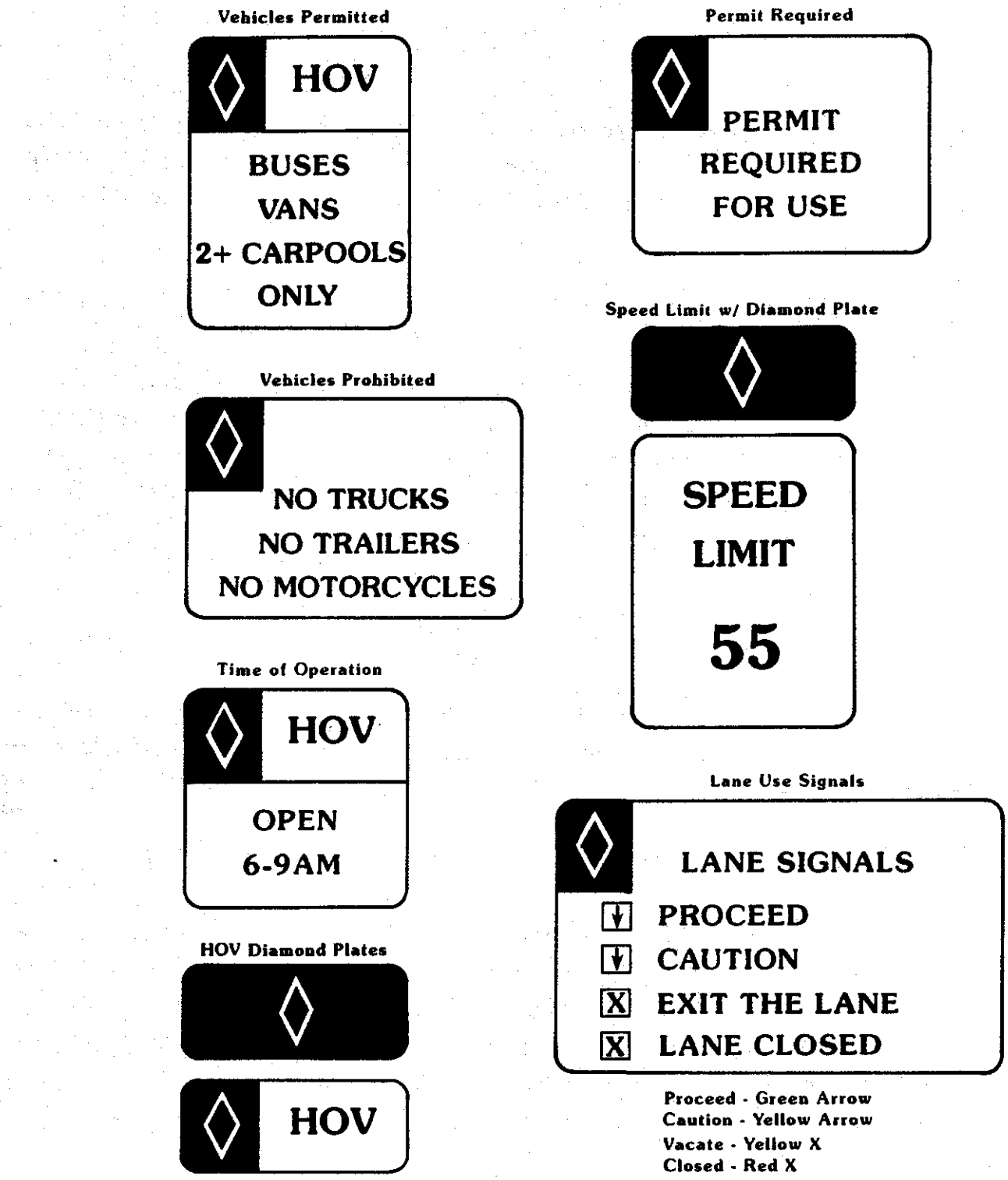
Regulatory signs which may be used on transitways include the signs described below. All recommended signs should follow the standard regulatory signing principles: black legend on white background, rectangular shape, and reflectorized or illuminated if applicable during periods of reduced visibility. The diamond symbol should be incorporated in the upper left corner of the sign, as a white symbol on a black background, or a diamond symbol advisory plate should be displayed above the sign.

VEHICLES PERMITTED Sign

This sign should be used to indicate what types of vehicles are permitted to use the high-occupancy vehicle lane. The sign should be displayed immediately upstream of the entrance to the facility and further upstream near the advance notice sign. Whenever possible, the sign should be located directly over the lane to which it applies. The sign should list the vehicles permitted with the word "ONLY" following. The sign should have a maximum of four lines of legend. The legend for this sign should be words only. If the use of symbols in the legend is necessary, an educational plaque should be used explaining the meaning of the symbols. This plaque should be placed according to the requirements of the MUTCD. An example of this sign is shown in Figure 15.

VEHICLES PROHIBITED Sign

This sign should be used to indicate what types of vehicles are prohibited from using the transitway. The sign should be displayed in advance of the VEHICLES PERMITTED sign at the entrance to the facility. Whenever possible, the sign should be located directly over the lane to which it applies. The sign should list the vehicles prohibited with the word "NO" preceding each vehicle type. The sign should have a maximum of four lines of legend. The legend for this sign should be words only. If the use of



Note: All signs are black on white or white on black

Figure 15. Examples of Proposed Transitway Regulatory Signs

symbols in the legend is necessary, an educational plaque should be used explaining the meaning of the symbols. This plaque should be placed according to the requirements of the MUTCD. An example of this sign is shown in Figure 15.

TIME OF OPERATION Sign

This sign should be displayed at the entrance to a transitway if there are any time restrictions on the use of the facility. It should contain the word "OPEN" with the appropriate time below. This sign should be displayed upstream of the VEHICLES PERMITTED sign. Whenever possible, the sign should be located above the lane to which it applies. An example of this sign is shown in Figure 15.

PERMIT REQUIRED FOR USE Sign

This sign should be displayed at the entrance to any high-occupancy vehicle lane which requires a permit to use. The legend should state "PERMIT REQUIRED FOR USE." An example of this sign is shown in Figure 15.

DIAMOND SYMBOL ADVISORY PLATE Sign

This sign should be placed above any regulatory sign which applies to a transitway if the sign does not have the diamond symbol as part of the legend. The diamond should be white on a black background. "HOV" or "Transitway" may be added with the diamond, if desired. The STOP, YIELD, DO NOT ENTER, and WRONG WAY signs should not have an advisory plate displayed with the sign. An example of this sign is shown in Figure 15.

LANE USE CONTROL SIGNAL Sign

This sign should be used to indicate the meaning of the various lane control signal indications which may be used. For the lane control signal indications currently used on Houston transitways, the sign would contain the following information:

Symbol	Meaning
GREEN ARROW	PROCEED
YELLOW ARROW	CAUTION
YELLOW X	EXIT THE HOV LANE
RED X	HOV LANE CLOSED

Other Regulatory Signs

Other existing regulatory signs may be used on transitways as the need dictates. These signs should be used in the manner described in the MUTCD. In addition, all regulatory signs used on transitways should have the diamond symbol as part of the sign legend or displayed above the sign as an advisory plate. Regulatory signs which may be used on a high-occupancy vehicle facility include:

STOP SIGN (advisory plate should not be used with this sign)
YIELD SIGN (advisory plate should not be used with this sign)
SPEED LIMIT SIGN
REDUCED SPEED AHEAD SIGN
TURN PROHIBITION SIGN
LANE USE CONTROL SIGN
DO NOT ENTER SIGN (advisory plate should not be used with this sign)
WRONG WAY SIGN (advisory plate should not be used with this sign)
ONE WAY SIGN
Other regulatory signs as appropriate

Warning Signing

The Texas MUTCD (2) contains the following section about warning signs:

SECTION 2C-1 Application of Warning Signs

Warning signs are used when it is deemed necessary to warn traffic of existing or potentially hazardous conditions on or adjacent to a highway or street. Warning signs require caution on the part of the vehicle operator and may call for reduction of speed or a maneuver in the interest of his own safety and that of

other vehicle operators and pedestrians. Adequate warnings are of great assistance to the vehicle operator and are valuable in safeguarding and expediting traffic. The use of warning signs should be kept to a minimum because the unnecessary use of them to warn of conditions which are apparent tends to breed disrespect for all signs.

When used on barrier separated high-occupancy vehicle facilities, warning signs are necessary to inform the user of geometric changes and converging lanes. Warning signs which may be used on transitways include the signs described below. All recommended signs should follow the standard warning sign principles: black legend on yellow background, typically a diamond shape, and reflectorized or illuminated if applicable during periods of reduced visibility. A diamond symbol should be displayed in the upper left corner of rectangular warning signs, or a diamond symbol advisory plate should be displayed above the sign. Warning signs may be mounted above or to the side of the lane to which they apply.

END HIGH-OCCUPANCY VEHICLE LANE Sign

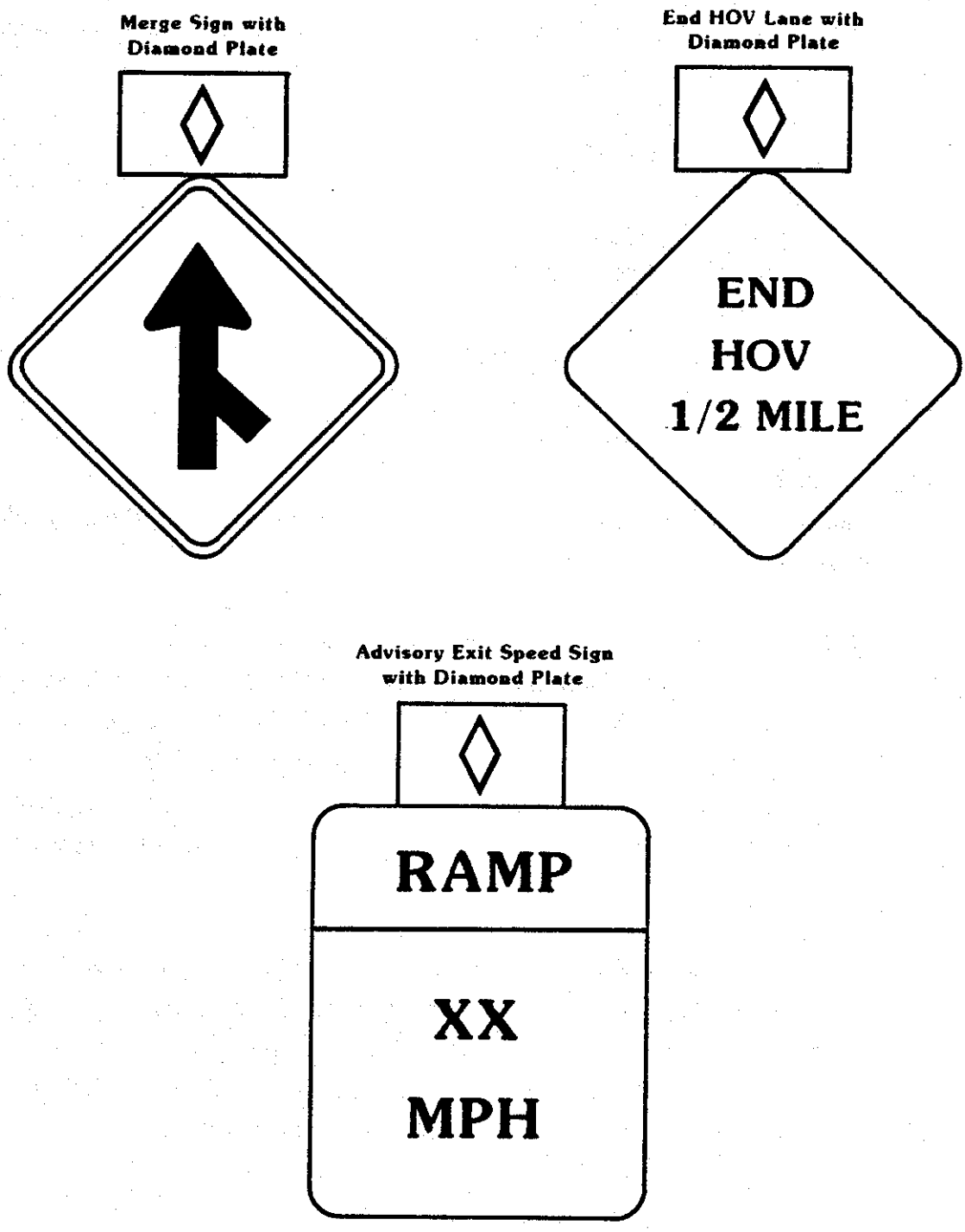
This sign may be used to warn of the transition from a high-occupancy vehicle facility to a roadway with a lesser degree of access control. The diamond symbol advisory plate should be displayed above the sign. An example of this sign is shown in Figure 16.

DIAMOND SYMBOL ADVISORY PLATE Sign

This sign should be placed above any warning sign which applies to a transitway. The sign should have a black legend and border on a yellow background. The legend should be a diamond symbol. "HOV" may be added below the diamond. An example of this sign is shown in Figure 16.

Other Warning Signs

Other existing warning signs may be used on high-occupancy vehicle lanes as the need dictates. These signs should be used in the manner described in



Note: All signs are black on yellow

Figure 16. Examples of Proposed Transitway Warning Signs

the MUTCD. In addition, all warning signs used on a high-occupancy vehicle facility should have the diamond symbol advisory plate displayed above the sign. Warning signs which may be used on a high-occupancy vehicle facility include:

SIGNAL AHEAD SIGN
MERGE SIGN
ADDED LANE SIGN
LANE REDUCTION TRANSITION SIGNS
CLEARANCE SIGNS
ADVISORY EXIT SPEED SIGNS
Other warning signs as appropriate

Guide Signing

The Texas MUTCD (2) contains the following section about guide signing for expressways and freeways:

SECTION 2F-2 Expressway and Freeway Signing Principles

The development of a signing system for freeways must be approached on the premise that the signing is primarily for the benefit and direction of drivers who are not familiar with the route or area. The signing must furnish drivers with clear instructions for orderly progress to their destinations.

Sign installations are an integral part of the expressway or freeway facility and, as such, must be planned concurrently with the development of highway location and geometric design. Plans for signing must be analyzed during the earliest stages of preliminary design and details correlated as final design is developed.

There are several functions for freeway guide signs listed in the MUTCD. Those which apply to barrier separated high-occupancy vehicle facilities include:

- Give directions to destinations, streets, or highway routes at intersections or interchanges.
- Furnish advance notice of the approach to intersections or interchanges.
- Direct drivers into appropriate lanes in advance of diverging on merging movements.
- Identify routes and directions on those routes.
- Show distances to destinations.

Guide signs for HOV facilities should be distinguishable from freeway guide signs. Current national practice achieves this by one of two methods: guide sign format and regulatory sign format. The guide sign format has white letters on a green background with a white on black diamond symbol in the upper left corner. It may be supplemented with a HOV ONLY panel above the sign. The regulatory sign format has black letters on a white background with a white on black diamond in the upper left corner. Both schemes appear to accomplish the desired objective. The guide format is more consistent with the message being conveyed, while the regulatory format is more distinguishable.

Regardless of the color scheme used in HOV guide signs, a black diamond symbol should be located in the upper left corner. Guide signs should be displayed over the HOV lane(s), whenever possible. All overhead sign installations should normally be illuminated. The signs may be mounted on the same sign structure as freeway guide signs. The signs should otherwise follow the guidelines for Expressway/Freeway guide signs contained in the MUTCD.

The following information is suggested for overhead HOV guide signs:

- Park-and-ride destination(s) and distance to destination(s).
- Transitway interchange destination(s) and distance to destination(s).
- Exit to street or freeway destination(s) and distance to destination(s).

Exit only panels (Section 2F-42 of MUTCD) should be used on these signs when necessary. These panels should be black legend on yellow background.

A diamond symbol advisory plate should be used with route markers to indicate directions to the transitway. The diamond symbol advisory plate should correspond to the colors used in the route marker sign. The legend should consist of the diamond symbol located with the letters "HOV" or "transitway." This sign should be placed above route markers. The route markers should be used in the manner described in the MUTCD to indicate the proper direction to gain access to the transitway.

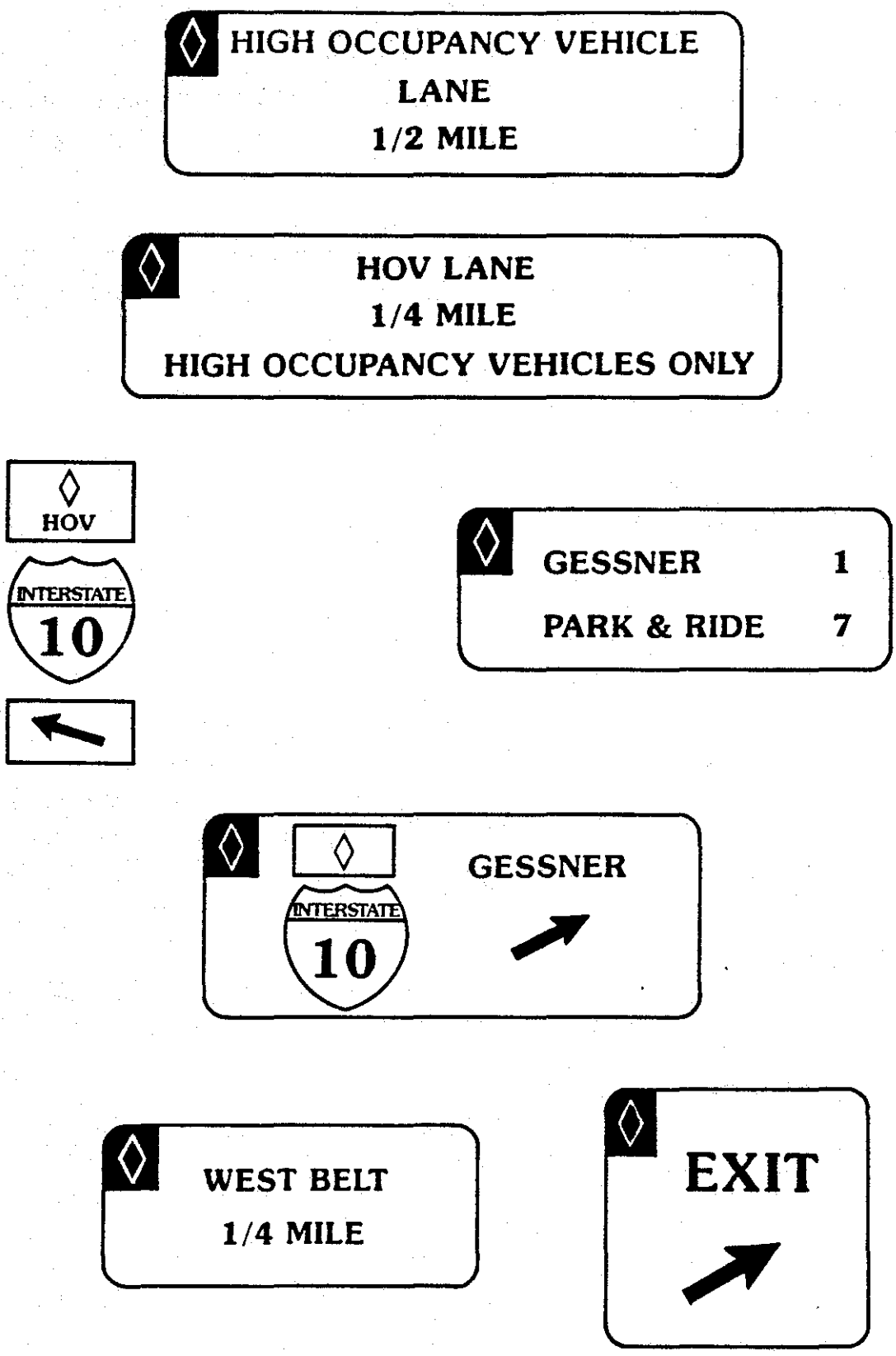
Several examples of proposed guide signing for transitways are shown in Figure 17.

Pavement Markings

The Texas MUTCD (2) contains the following section addressing markings:

SECTION 3A-1 Functions and Limitations

> *Markings have definite and important function to perform in a proper scheme of traffic control. In some cases, they are used to supplement the regulations or warnings of other devices such as traffic signs or signals. In other instances, they are used alone and produce results that cannot be obtained by the use of any other device. In such cases they serve as a very effective means of conveying certain regulations and warnings that could not otherwise be made clearly understandable.*
>
> *Pavement markings have definite limitations. They are obliterated by snow, may not be clearly visible when wet, and may not be very durable when subjected to heavy traffic. In spite of these limitations, they have the advantage, under favorable conditions, of conveying warnings or information to the driver without diverting his attention from the roadway.*



Note: Guide signs are black on white or white on green with white on black diamond

Figure 17. Examples of Proposed Transitway Guide Signs

No changes are needed in the section of the MUTCD addressing pavement markings. The use of pavement markings on barrier separated HOV facilities will be the same as on conventional roadways.

There are specific applications where pavement markings may aid in meeting motorists' information needs on transitways. These applications include:

- Edge lines
- Channelizing lines
- Marking of interchange ramps
- Approach to an obstruction
- Pavement word markings
- Supplementary speed limit
- Diamond symbol marking

The use of pavement markings for these applications should follow the guidelines stated in the MUTCD. However, a reversible lane in a barrier protected facility cannot comply with yellow on the left side and white on the right side. The double dashed yellow recommended for reversible lanes without barriers may not be appropriate.

Lane-Use Control Signals

The Signals section of the Texas MUTCD (2) contains the following section about this type of control device.

SECTION 4A-1 Types of Signals

> *A highway traffic signal is any power-operated traffic control device, other than a barricade warning light or steady burning electric lamp, by which traffic is warned or directed to take some specific action.*

There are several types of traffic signals. The types that are involved in the operations of a transitway include traffic control signals (intersection signals) and lane-use control signals. The use of intersection signals on transitways is limited to areas at or near access points. These

locations operate in the same manner as a regular intersection. Therefore, no changes are needed in the MUTCD sections related to the operation of intersection signals.

The use of lane-use control signals has specific application to a transitway. The Texas MUTCD (2) contains the following section addressing lane-use control signals:

SECTION 4E-8 Lane-use Control Signals

Lane-use control signals are special overhead signals having indications used to permit or prohibit the use of specific lanes of a street or highway or to indicate the impending prohibitions of use. Installations are distinguished by placement of these special signals over a certain lane or lanes of the roadway and by their distinctive shapes and symbols. Supplementary signs are often used to explain their meaning and intent.

Lane-use control signals are most commonly used for reversible-lane control. This type of control should be used only when a competent engineering study shows that there is a need and also that the planned operation is practicable. Reversible-lane operation may be appropriate at toll-booth areas.

The following signal indications apply specifically to transitways and their meaning should be added to or changed in the MUTCD as described below:

- A STEADY DOWNWARD GREEN ARROW means that a driver is permitted to drive in the lane over which the arrow signal is located.

This indication should be used when driving in the transitway is permitted and there are no known obstructions on the transitway. The green arrow indication should be displayed only on one side of the signal. The

opposite side should display a steady red "X". The meaning of this indication is not changed.

- A FLASHING DOWNWARD YELLOW ARROW means that a driver is advised to proceed with caution because speeds are reduced ahead.

The indication should be used to warn the driver that a hazard is located ahead and that he should exercise caution as he proceeds. This is a new indication.

- A STEADY YELLOW X means that a driver should exit or vacate the facility, in a safe manner, at the earliest opportunity because the facility has been closed ahead.

This indication should be displayed when it is necessary to divert traffic off the transitway due to lane blockage or congestion. This is a new meaning for an existing indication.

- A STEADY RED X means that a driver shall not drive in the lane over which the signal is located, and that this indication shall modify accordingly the meaning of all other traffic controls present.

This indication should be displayed on both sides of the signal when the facility is closed and on the one side facing the wrong direction when the facility is operating. The steady red "X" can also be used to close a portion of the transitway when congestion or an incident requires such action. The meaning of this indication is not changed.

The flashing red "X" currently used on transitways in Texas indicates that a motorist is traveling in the wrong direction. As this indication is not clearly understood by motorists, its use should be discontinued. The steady red "X" can be used for the same purpose.

In addition to the changes in definitions recommended above, the following actions are recommended to improve motorist understanding of lane control signals:

- Erect educational plaques at the entrance to transitways explaining the meaning of the lane control indications.
- Include information on lane control signals in the Texas Drivers Handbook.

FUTURE RESEARCH

This research effort has identified and addressed many of the problems associated with signing for transitway facilities. HOV signing is a largely unexplored area with many questions still remaining. Three of the areas examined in this study require additional research which was beyond the scope of this effort. Those areas requiring additional research are described below.

Pavement Markings for Reversible Transitway Lanes

It is impossible for a reversible lane to provide a yellow line on the left side and a white line on the right side. The MUTCD states that a double yellow dashed line should be used for a reversible center lane on an arterial where the actual center line changes with time. This does not seem appropriate for use on a barrier separated facility. Current practice is to provide solid white lines on both sides of the lane. The presence of a barrier on each side of the lane suggest that solid yellow lines should be used to indicate the edge of the travel way. Additional research is needed to determine the most appropriate method of providing edge lines and delineation for the reversible transitway lane.

Signal Indications for Lane-Use Control Signals

The laboratory study indicated motorists are confused about the indications used on lane-use control signals. Current signal indications are not in complete agreement with those found in the MUTCD. However, the MUTCD indications are intended for use on arterial reversible lanes with continuous access. Additional research is needed to determine what signal indications are appropriate for use on transitway facilities.

Sign Colors for HOV Guide Signs

This research project established the need to differentiate between freeway guide signs and transitway guide signs. Currently, this is accomplished with the use of two color schemes for guide signs on HOV

facilities; white on green with a white on black diamond symbol, and black on white with the diamond symbol. Different schemes are used in different parts of the country. The evaluation of guide sign colors and the determination of the most effective colors for transitway signing was beyond the scope of this study. Therefore, additional research is needed to determine the best method for separating HOV guide signs from freeway guide signs. This research should strive toward the establishment of a national practice for HOV guide signing.

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APPENDIX A
TYPICAL FIELD EVALUATION QUESTIONNAIRE

Start the subject at freeway entrance ramp. Interviewer tells the driver that he/she will be driving through the transitway and that he/she should enter the transitway as soon as possible.

Interviewer lets the subject be guided to the entrance only by signs or his/her own intuition. If driver misses the entrance, let him/her proceed until there is an opportunity to stop. Ask him/her why they missed the entrance. Start the trip again, this time help guide him/her to enter safely at the entrance. If driver takes the wrong exit, let him/her proceed and ask him/her later why he/she made the wrong decision.

(prior to beginning of trip)

1. Are you aware of the existence of the Katy Transitway?
   Yes No (Do you know what a transitway is?)
2. Is "transitway" a good name? Have you any suggestions for a name?
3. Do you know who is allowed to use the Katy Transitway?
4. At this moment, are you qualified to use the Katy Transitway?
   Yes No Not Sure

   (as soon as subject starts driving)
5. Have you <u>driven</u> on the Katy Transitway? (interviewer also observes whether driver is comfortable)
   Yes, More than once Yes, Once No
6. Are you comfortable driving?
   Yes No Somewhat
7. Do you know where to enter the Transitway?
   Yes (How?) No
8. Interviewer takes note of the lane the subject is driving in.
   Shoulder Lane Middle Lane Median Lane
9. Did you notice any advance signs for the transitway? What did the signs say? (repeat this question after each sign)
10. At the entrance, did you notice transitway signs, pavement markings, or signals? What did they indicate?
11. What helped to guide you into the transitway?

12. Who has the right of way when merging?
    I They Don't Know
13. Was it easy to merge with traffic?
    Yes (Why?) No (Why Not?)
14. Were you confused at the entrance of the transitway?
    Yes (Why?) No
15. Did you apply the brakes while entering the transitway?
    Yes, once Yes, more than once No
16. What did you do upon entering the transitway?
17. Are your headlights on?
    Yes No
18. How fast do you think a vehicle can safely travel on the transitway?
19. What do you think the speed limit on the transitway is? Have you seen speed limit signs on the transitway?
    Yes No
20. Would you overtake slow vehicles?
    Yes No
21. Would you know what to do if your vehicle broke down?
    Yes No
22. Do you feel like using a cruise control on the transitway?
    Yes No
23. Are you nervous driving?
    Yes (Why?) No
24. Did you notice the lane control signals above the lane?
25. Do you know what the signal means?
26. Were you hesitant going over the flyover?
    Yes (Why?) No
27. Did you see any directional signs?
    Yes No
28. Were the signs helpful in deciding which roadway to take?
    Yes No
29. Was it easy to decide which roadway to take?
    Yes (Why?) No (Why Not?)

30. Were the signs helpful in exiting?

    Yes No

(approaching exit)

31. Interviewer observes braking, as well as how driver reacts to the exit.

(after exiting and merging with mainlane traffic)

32. Did you notice any transitway signs, pavement markings, or signals? What did they indicate? (ask this question every time driver passes a sign or signs)
33. Did you apply the brakes while exiting?

    Yes, More than Once Yes, Once No

34. Was it easy to exit?

    Yes (Why?) No (Why Not?)

(overall impression of the transitway; ask the following after the subject is off of the transitway)

35. Were you comfortable driving on the transitway?

    Yes No (Why Not?)

36. Was the transitway too winding? Was it too narrow?
37. Was the pavement very slick? (asked in wet weather!)

APPENDIX B-1
LABORATORY STUDY SCRIPT

Introduction

Welcome - Please make sure you are comfortable and can see the screen clearly. If you require any adjustments to the air temperature, lights, or sound, notify the study monitor.

This study is being conducted by the Texas Transportation Institute for the State Department of Highways and Public Transportation to evaluate freeway facility motorist information techniques -- i.e., signs, markings. For the next 30 minutes you will be shown a series of slides depicting freeway facility operations and associated traffic communication devices (signs, signals, markings). Depending on the specific situation presented, you will be asked to give your opinion on the best or most appropriate technique for providing the required motorist information. You will record your responses in the questionnaire before you. Now, let's begin with Question #1.

Question 1

(Slide A - Aerial of Katy Transitway)

The facility you see before you is a part of the freeway system in Houston, Texas.

(Slide B - Ground Shot of Katy Transitway)

Please take note of the physical and operating characteristics of this facility.

(Slide C - Vehicles on Katy Transitway)

As well as the type of vehicles utilizing this facility.

(Slide D - Signs)

If you were approaching this facility and needed to be given information about this facility, which of the following signs would best name or describe by name this type of freeway facility to you. Please mark your answer by the designated letter in your questionnaire for Question #1.

Question 2

Let us assume that you are approaching the entrance to this freeway facility. There are a number of signs conveying information about the operation of this type of roadway. Please observe and take note of these signs.

(Slides E, F, G - Approach to Post Oak Entrance)

Please note in the space provided in your questionnaire for Question #2 all the information you can recall given to you on the approach signs to the entrance to this freeway facility.

Question 3

Now that you have completed Questions 1 and 2, let us refer to this type of freeway facility that you just described by name as a "commuter lane" for the remainder of the study.

(Slide H - Katy Transitway)

As you can see, this commuter lane is located in the median of the freeway and is one-way reversible -- inbound toward downtown Houston in the morning and outbound away from downtown Houston in the afternoon. Not all vehicles are allowed to use this commuter lane. Which of the following signs best conveys to you whether you can use this commuter lane, based on the type of vehicles allowed? Please mark your answer by the designated letter in your questionnaire for Question #3.

(Slide I - Vehicles Allowed Signs)

Question 4

Which of the following signs best conveys to you the type of vehicles restricted from using the commuter lane. Please mark your answer by the designated letter in your questionnaire for Question #4.

(Slide J - Vehicles Prohibited Signs)

Question 5

Which of the following signs best conveys to you that buses, vans, and 3+ carpools are allowed to use the commuter lane. Please mark your answer by the designated letter in your questionnaire for Question #5.

(Slide K - Buses, Vans, 3+ Signs)

Question 6

(Slide L - Approach to Transitway Entrance)

Let us assume once again that you are approaching the commuter lane and need information as to location and distance ahead to the entrance. Which of the following sign locations would be preferred to convey to you this information. Please mark your answer by the designated letter in your questionnaire for Question #6.

(Slide M - Approach Sign Locations)

Question 7

(Slide N - Driving on Transitway)

You are now driving on the commuter lane and see the following symbol on

signs and on the pavement. Please state what this diamond symbol means in the space provided in your questionnaire for Question #7.

(Slide O - Diamond Symbols)

Question 8

(Slide P - Driving Ahead on Transitway)

As you proceed driving ahead along the commuter lane, you notice a single traffic signal above the lane.

(Slide Q - Lane Control Signal with Green Arrow)

The solid green arrow indicates the commuter lane is open and clear and that you are driving in the proper direction. Please state what the following three indications on the commuter lane traffic signal indicate and what is the proper driving action to take if these indications are displayed. Please write your response in the space provided in your questionnaire for Question #8.

(Slide R - Lane Control Indications)

Question 9

You continue to drive along the commuter lane. You need to know the posted or advised operating speed. Which of the following techniques do you prefer to convey to you this information? Please mark your answer by the designated letter in your questionnaire for Question #9.

(Slide T - Speed Limit Signs, Pavement Markings)

Question 10

(Slide U - Approach to Slip Ramp Exit)

You are now approaching an exit ramp from the commuter lane in the median to the freeway mainlanes. You need information describing the location of the commuter lane exit, the distance ahead to the exit, and the exit point itself. Which of the following positions would be the best sign location to present this exit information to you? Please mark your answer by the designated letter in your questionnaire for Question #10.

(Slide V - Median, Side, Ground Mounted Signs)

Question 11

(Slide W - Gore Area of Slip Ramp Exit)

You are near the exit ramp from the commuter lane to the freeway mainlanes. If you were needing to exit the commuter lane at this point, which of the following signing techniques best and most clearly conveys to you the information you need to exit. Please mark your answer by the designated letter on your questionnaire for Question 11.

(Slide X, Y, Z - Transitway Exit Sign Techniques)

Question 12

(Slide AA - Further Along Transitway)

You are again proceeding ahead along the commuter lane and you need to exit into the Addicks park-and-ride lot. Please observe the following signs providing you information about this exit point from the commuter lane.

(Slide BB, CC, DD - Approach Signs to Addicks Exit)

Please state in the space provided in your questionnaire for Question #12 whether the signing for the exit to the Addicks park-and-ride was adequate or inadequate with respect to the motorist information you needed to make this maneuver properly and safely. If the signing was inadequate, please comment also in the space provided.

Question 13

(Slide EE - Approaching Transitway Terminus)

You are approaching the end of the commuter lane. Please indicate by the designated letter in your questionnaire for Question #13 which of the following signs should be used to convey that the commuter lane ends ahead.

(Slide FF - Commuter Lane Ends Signs)

Ending

This completes the lab study. Your assistance in this research effort is greatly appreciated. If you would like a copy of the study results, when available, please leave your name with the study monitor. Thank you again.

APPENDIX B-2
LABORATORY STUDY QUESTIONNAIRE

Name_____ Date_____

Question #1

Transitway Ahead	AVL Ahead
Authorized Vehicle Lane Ahead	Express Lane Ahead
High-Occupancy Vehicle Lane Ahead	HOV Lane Ahead
Restricted Vehicle Lane Ahead	Busway Ahead

Question #2

I recall the following information. _____

Question #3

Authorized Vehicle Lane Only
Buses, Vans and 2 or More Person Carpools Only
Buses Two or More Person Carpools Only
Buses Vans Carpools Only

Question #4

Vehicles Prohibited (Words Only)
Vehicles Prohibited (Words and Symbols)
Vehicles Prohibited (Symbols Only)

Question #5

Buses, Vans, 3+ Carpools (Words)
Buses, Vans, 3+ Carpools (Symbols)

Question #6

Commuter Lane Entrance (Overhead Mounted)
Commuter Lane Entrance (Ground Mounted)

Question #7

The diamond symbol is _____

Question #8

The flashing yellow arrow signal means _____

The solid red "X" signal means _____

The flashing red "X" signal means _____

Question #9

Speed Limit Pavement Marking Only

Speed Limit Sign Only

Speed Limit Pavement Marking and Sign

Question #10

Overhead Median Mounted

Overhead Side Mounted

Side Ground Mounted

Question #11

Overhead AVL, Gessner Exit, I.H. 10 West, West Belt Exit

Overhead AVL, Gessner Exit

Ground Mounted AVL, Exit Only

Question #12

Adequate Signing

Inadequate Signing

If Inadequate, Why? _____

Question #13

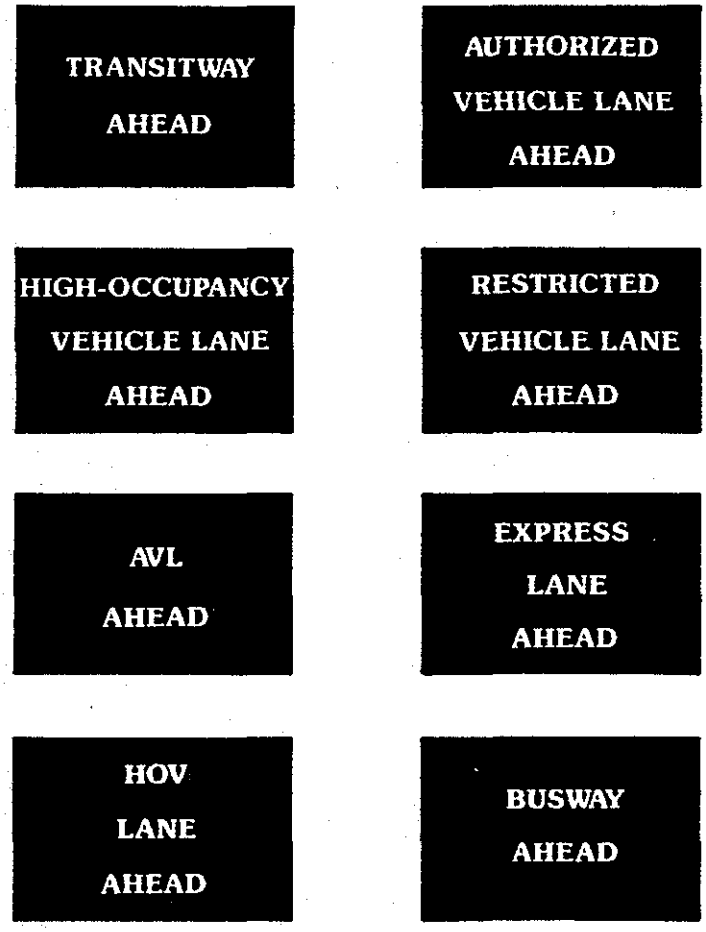
Commuter Lane Ends 1/2 Mile (White on Green)

Commuter Lane Ends 1/2 Mile (Black on Yellow)

Commuter Lane Ends 1/2 Mile (Black on White)

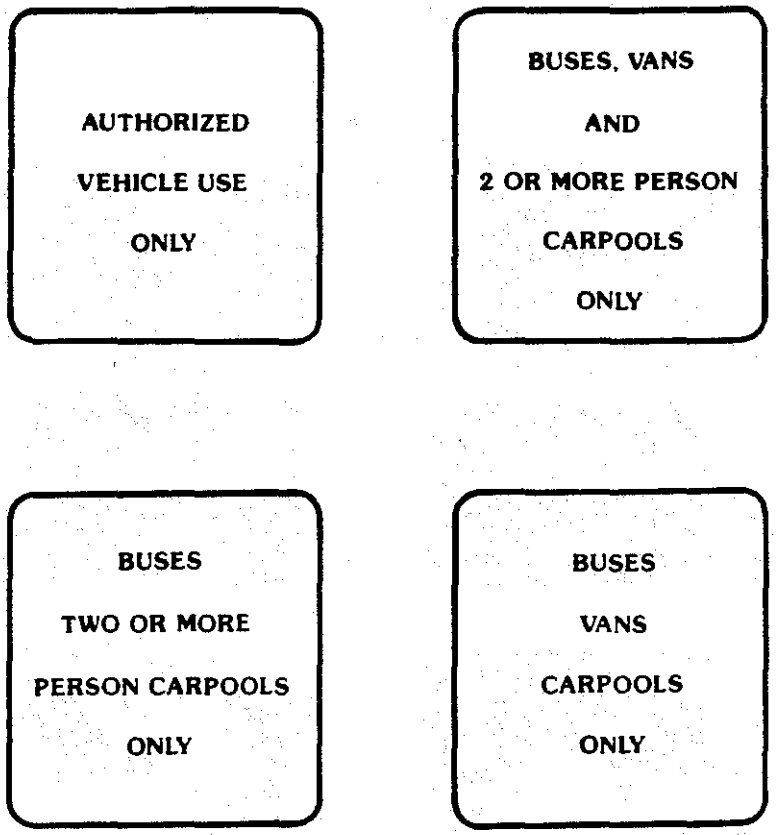
APPENDIX B-3
LABORATORY STUDY GRAPHICS

The following graphics are reproductions of selected slides used in the laboratory study presentation. Not all the slides used in the presentation are reproduced in this appendix. Standard signing practices were used for all signs, i.e., black on white for regulatory signs, black on yellow for warning signs, and white on green for guide signs. The type of sign used is indicated for each slide.



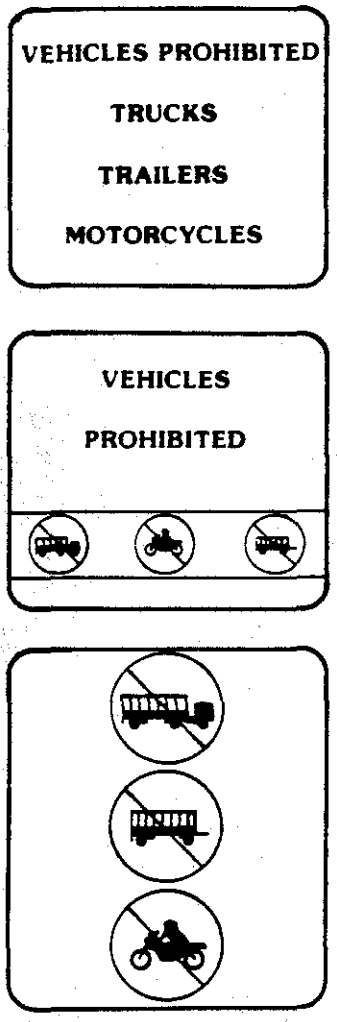
Question 1, Slide D

Which of the following signs would best name or describe by name this type of freeway facility to you? All eight signs are guide signs.



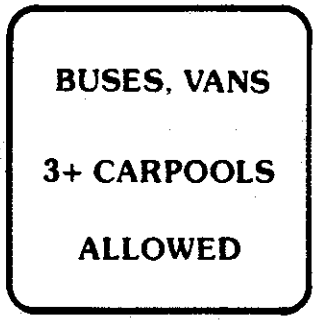
Question 3, Slide I

Which of the following signs best conveys to you the type of vehicles restricted from using the commuter lane? All four signs are regulatory signs.



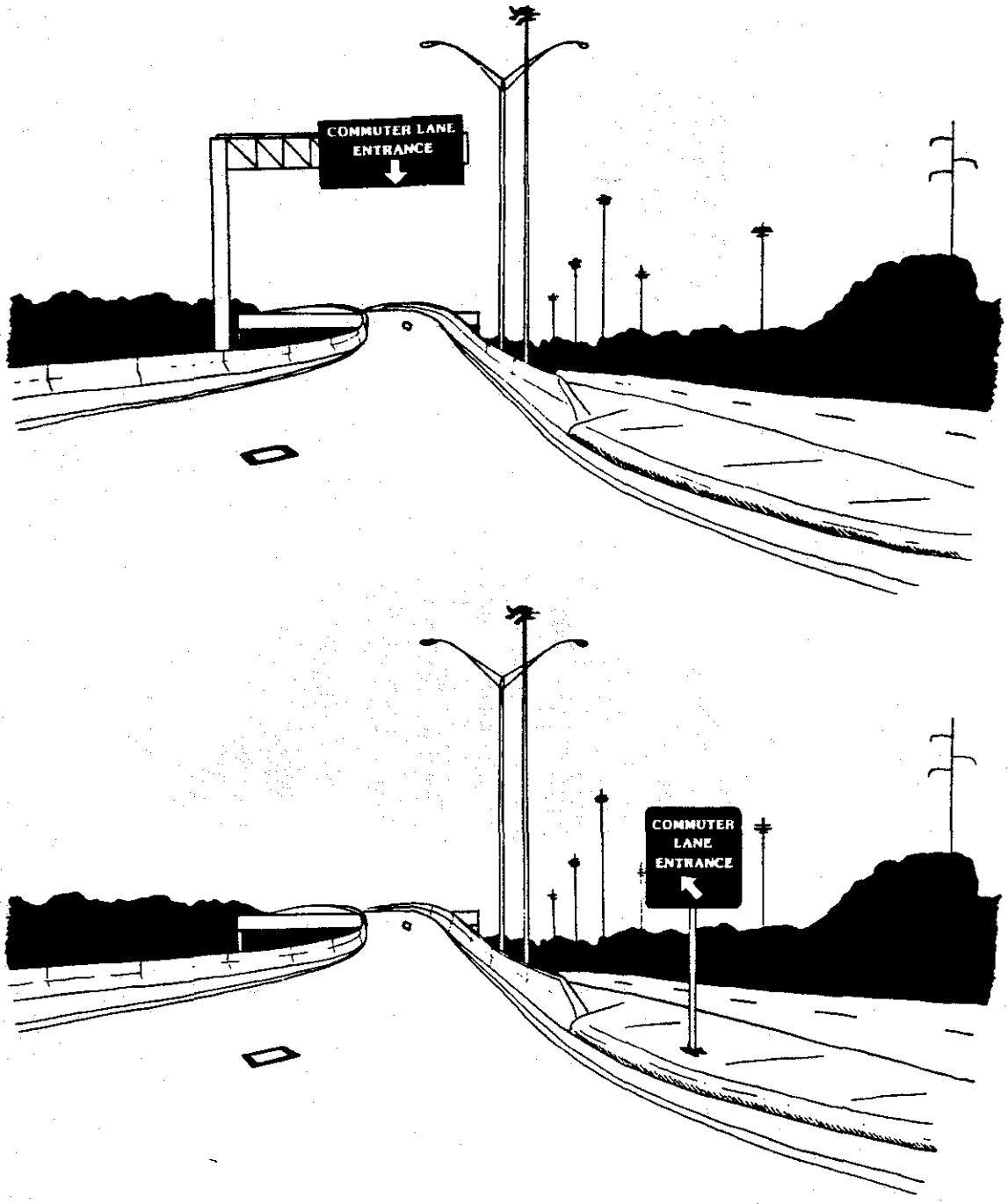
Question 4, Slide J

Which of the following signs best conveys to you the type of vehicles restricted from using the commuter lane? All three signs are regulatory signs.



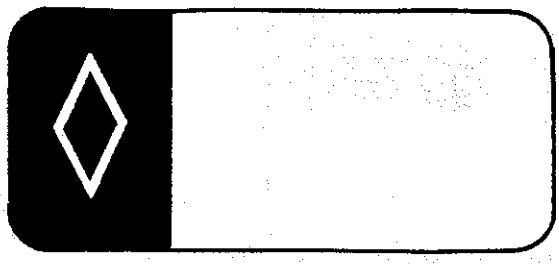
Question 5, Slide K

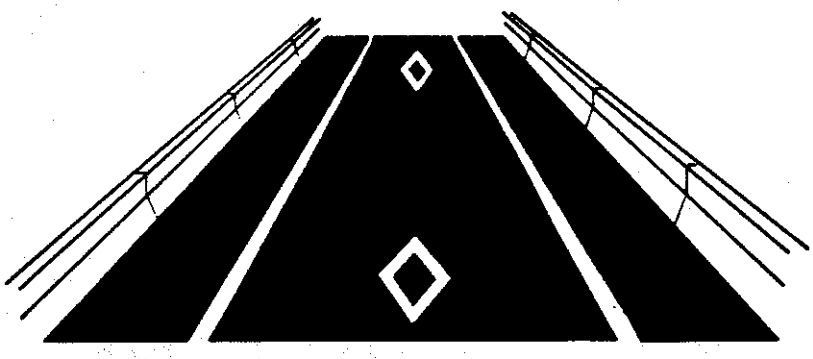
Which of the following signs best conveys to you that buses, vans, and 3+ carpools are allowed to use the commuter lane? Both signs are regulatory signs.



Question 6, Slide M

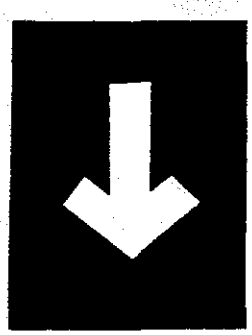
Which of the following sign locations would be preferred to convey to you this information? Both signs are guide signs.





Question 7, Slide 0

Please state what this diamond symbol means in the space provided in your questionnaire for Question #7. Diamond symbol is white on black sign background.



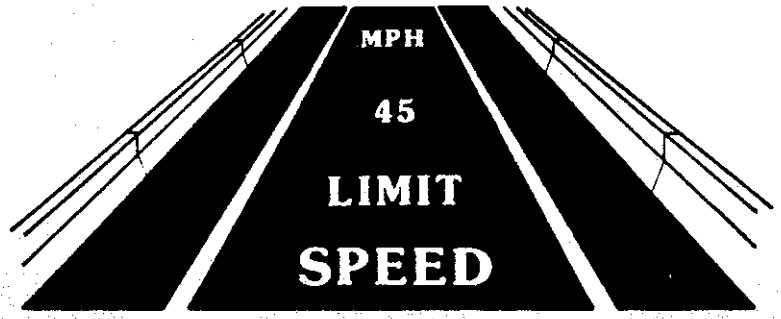
"FLASHING" YELLOW ARROW

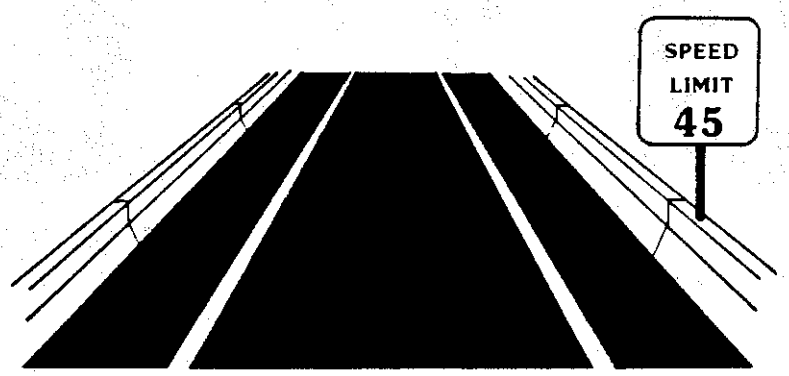
"SOLID" RED X

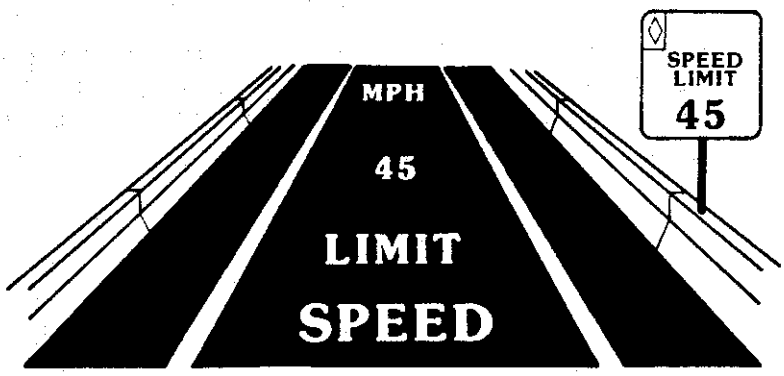
"FLASHING" RED X

Question 8, Slide R

Please state what the following three indications on the commuter lane traffic signal indicate and what is the proper driving action to take if these indications are displayed. Signal background is black; color of indication is indicated below signal.

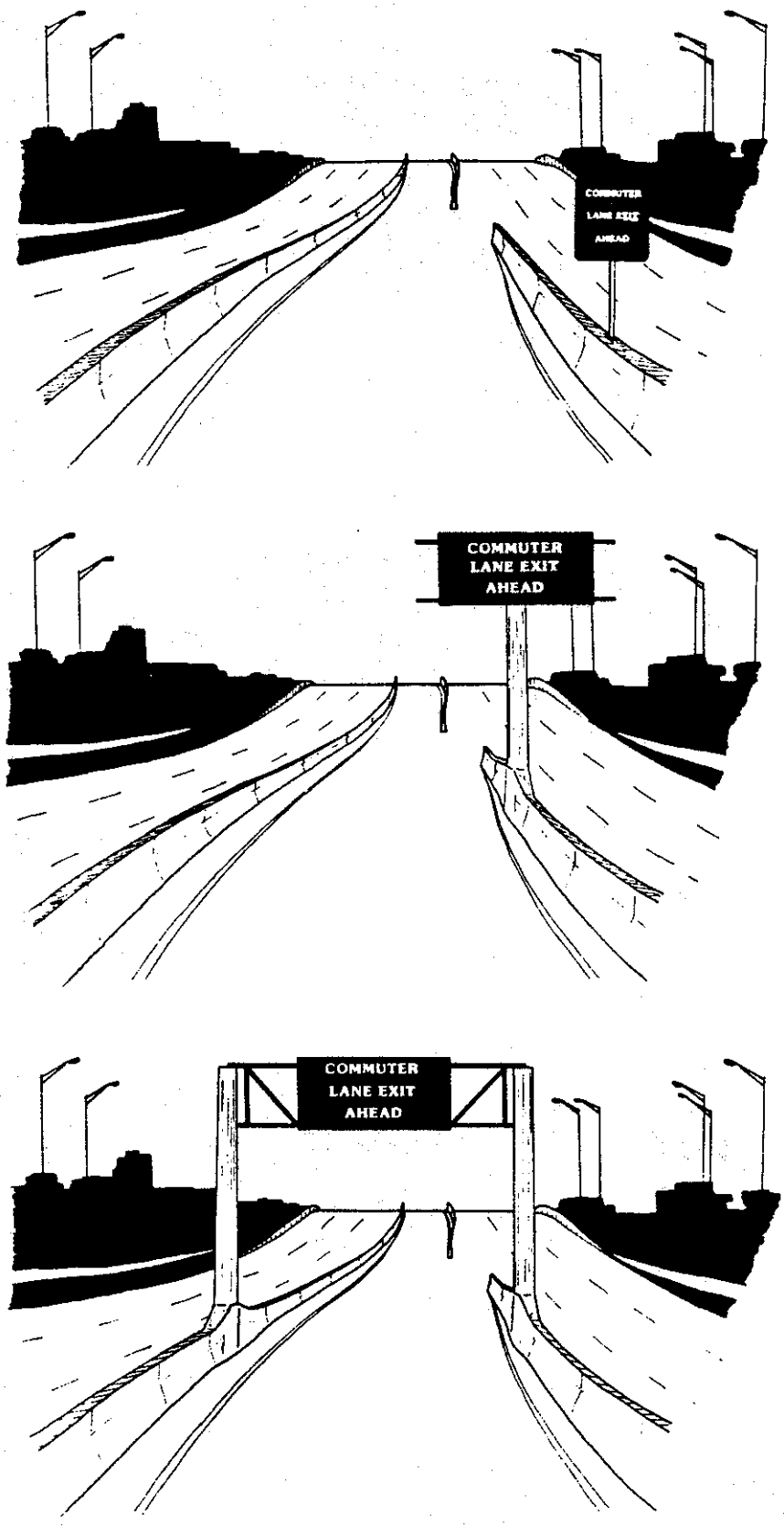






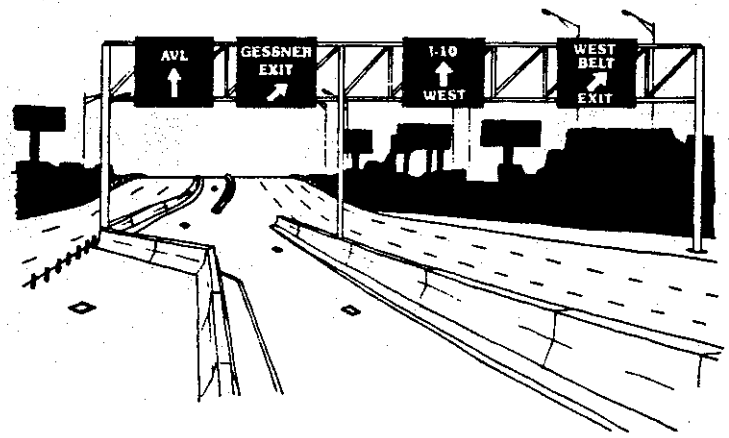
Question 9, Slide T

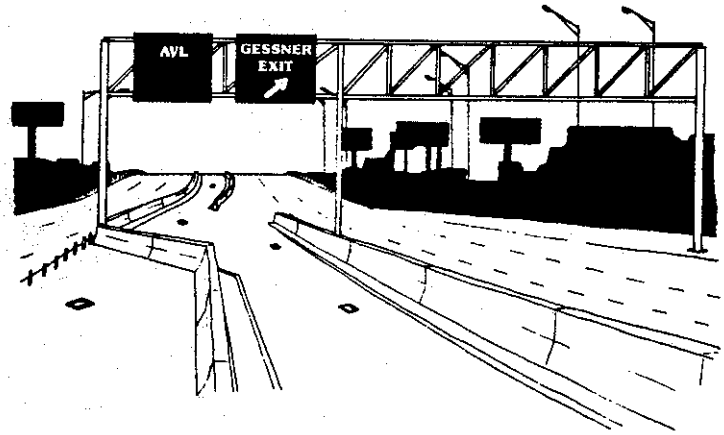
Which of the following techniques do you prefer to convey to you this information? Signs are regulatory signs; pavement markings are white.

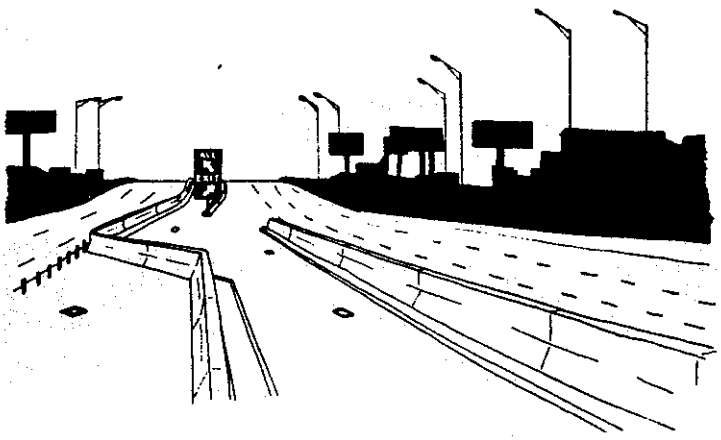


Question 10, Slide V

Which of the following positions would be the best sign location to present exit information to you? All three signs are guide signs.

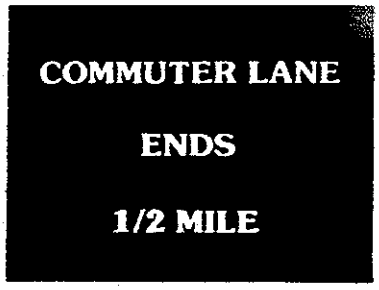


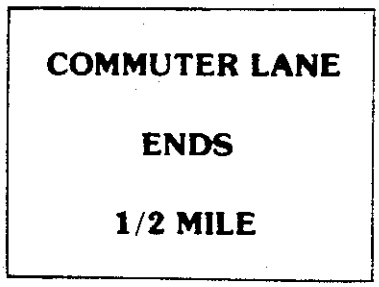


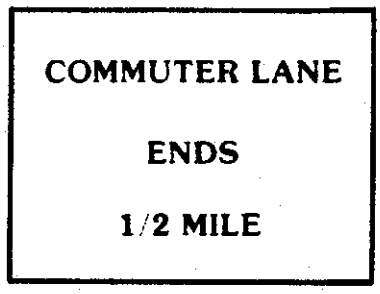


Question 11, Slide X, Y, Z

If you were needing to exit the commuter lane at this point, which of the following signing techniques best and most clearly conveys to you the information you need to exit. All three signs are guide signs.

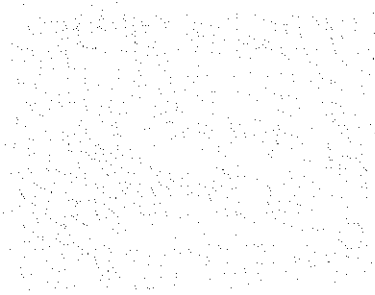






Question 13, Slide FF

Please indicate by the designated letter in your questionnaire for Question #13 which of the following signs should be used to convey that the commuter lane ends ahead. The top sign is a guide sign, the middle sign is a warning sign, and the bottom sign is a regulatory sign.



APPENDIX C
SUMMARY OF LABORATORY STUDY ANSWERS

All answers are given as a percent of the total number of responses for that category. Totals which add up to greater than 100 percent are the result of round-off error or multiple answers to individual questions.

QUESTION 1 SUMMARY

How would you best describe or name this type of facility?

	Transitway	Authorized Vehicle Lane	High Occupancy Vehicle Lane	Restricted Lane	AVL	Express	HOV Lane	Busway Lane
Total	14	28	27	19	2	11	0	1
Familiar	21	24	28	17	1	8	0	1
Unfamiliar	4	33	26	22	2	14	0	0
College Station	6	32	29	19	2	12	0	0
Houston	22	22	24	19	2	9	0	2
Male	17	24	31	17	1	9	0	0
Female	8	33	21	21	2	13	0	2
Male Familiar	23	20	32	16	2	7	0	0
Male Unfamiliar	0	37	26	21	0	16	0	0
Female Familiar	13	38	13	19	0	13	0	6
Female Unfamiliar	6	31	25	22	3	13	0	0
Young (16-30)	23	31	25	8	2	12	0	0
Mid-Age (31-45)	7	23	37	26	0	5	0	2
Older (46-70)	0	26	11	37	5	21	0	0
Young Familiar	32	29	24	5	3	8	0	0
Young Unfamiliar	9	35	26	13	0	17	0	0
Mid-Age Familiar	11	19	33	26	0	7	0	4
Mid-Age Unfamiliar	0	31	44	25	0	0	0	0
Older Familiar	0	14	19	43	0	14	0	0
Older Unfamiliar	0	33	0	33	8	25	0	0

QUESTION 2 SUMMARY

Please describe all approach signs shown on the slides.

	2+ Carpools	Van/Bus Only	HOV	No Motor-cycles	HOV 500' Ahead	HOV 1000' Ahead
Total	72	63	61	50	46	33
Familiar	63	65	53	53	40	33
Unfamiliar	71	61	73	45	53	33
College Station	74	66	69	52	54	35
Houston	69	60	52	47	36	31
Male	76	61	60	52	45	36
Female	65	67	63	46	46	29
Male Familiar	73	61	52	55	45	38
Male Unfamiliar	84	63	84	42	47	32
Female Familiar	69	81	56	44	25	19
Female Unfamiliar	63	59	66	47	56	34
Young (16-30)	74	69	57	56	46	36
Mid-Age (31-45)	65	54	72	44	40	26
Older (46-70)	79	68	47	42	58	42
Young Familiar	82	76	53	58	39	34
Young Unfamiliar	61	57	65	52	57	39
Mid-Age Familiar	52	48	67	44	30	19
Mid-Age Unfamiliar	88	63	81	44	56	38
Older Familiar	100	71	0	57	86	86
Older Unfamiliar	67	67	75	33	42	17

QUESTION 2 SUMMARY CONTINUED

Please describe all approach signs shown on the slides.

	No Trailers	No Trucks	Other	Authorized Vehicles Only	Transitway	HOV Approach	No Pedestrians
Total	24	19	12	7	2	1	1
Familiar	25	17	10	7	3	1	1
Unfamiliar	22	22	16	6	2	0	0
College Station	26	25	17	5	3	0	1
Houston	21	12	7	9	2	2	0
Male	31	21	15	8	1	0	0
Female	13	15	8	1	1	2	2
Male Familiar	32	20	13	9	2	0	0
Male Unfamiliar	26	26	21	5	0	0	0
Female Familiar	0	6	0	0	6	6	6
Female Unfamiliar	19	19	13	6	3	0	0
Young (16-30)	25	15	13	8	3	0	2
Mid-Age (31-45)	26	21	14	7	2	2	0
Older (46-70)	16	26	5	0	0	0	0
Young Familiar	24	13	11	8	3	0	3
Young Unfamiliar	26	17	17	9	4	0	0
Mid-Age Familiar	26	15	11	7	4	4	0
Mid-Age Unfamiliar	25	31	19	6	0	0	0
Older Familiar	29	43	0	0	0	0	0
Older Unfamiliar	8	17	8	0	0	0	0

QUESTION 3 SUMMARY

What is the best message to convey which vehicles are permitted?

	Authorized Vehicle Lane	Buses, Vans, 2+ Carpools	Buses, 2+ Carpools	Buses, Vans, Carpools Only
Total	11	52	16	21
Familiar	7	60	17	17
Unfamiliar	16	41	16	28
College Station	12	39	17	32
Houston	7	67	16	9
Male	11	51	19	20
Female	10	54	13	23
Male Familiar	7	54	20	20
Male Unfamiliar	21	42	16	21
Female Familiar	6	81	6	6
Female Unfamiliar	13	41	16	31
Young (16-30)	5	81	6	6
Mid-Age (31-45)	16	58	12	14
Older (46-70)	16	42	16	26
Young Familiar	5	55	16	24
Young Unfamiliar	4	43	26	26
Mid-Age Familiar	11	67	15	7
Mid-Age Unfamiliar	25	44	6	25
Older Familiar	0	57	29	14
Older Unfamiliar	25	33	8	33

QUESTION 4 SUMMARY

What is the best way to convey which vehicles are prohibited?

	Words Only	Words and Symbols	Symbols Only
Total	46	24	29
Familiar	39	26	35
Unfamiliar	57	22	22
College Station	60	19	22
Houston	31	31	38
Male	43	25	32
Female	52	23	25
Male Familiar	39	27	34
Male Unfamiliar	53	21	26
Female Familiar	38	25	38
Female Unfamiliar	59	22	19
Young (16-30)	46	26	28
Mid-Age (31-45)	40	28	33
Older (46-70)	63	11	26
Young Familiar	39	29	32
Young Unfamiliar	57	22	22
Mid-Age Familiar	30	30	41
Mid-Age Unfamiliar	56	25	19
Older Familiar	71	0	29
Older Unfamiliar	58	17	25

QUESTION 5 SUMMARY

What is the best way to convey which vehicles are permitted?

	Words Only	Symbols Only
Total	79	21
Familiar	75	25
Unfamiliar	84	16
College Station	85	15
Houston	72	28
Male	79	21
Female	79	21
Male Familiar	75	25
Male Unfamiliar	90	11
Female Familiar	75	25
Female Unfamiliar	81	19
Young (16-30)	84	16
Mid-Age (31-45)	67	33
Older (46-70)	90	11
Young Familiar	84	16
Young Unfamiliar	83	17
Mid-Age Familiar	56	44
Mid-Age Unfamiliar	88	13
Older Familiar	100	0
Older Unfamiliar	83	17

QUESTION 6 SUMMARY

Where is the best location for the entrance sign?

	Overhead Mount	Ground Mount
Total	72	29
Familiar	69	31
Unfamiliar	75	25
College Station	77	23
Houston	66	35
Male	72	28
Female	71	29
Male Familiar	70	30
Male Unfamiliar	79	21
Female Familiar	69	31
Female Unfamiliar	72	28
Young (16-30)	75	25
Mid-Age (31-45)	67	33
Older (46-70)	68	32
Young Familiar	71	29
Young Unfamiliar	83	17
Mid-Age Familiar	70	30
Mid-Age Unfamiliar	63	38
Older Familiar	57	43
Older Unfamiliar	75	25

QUESTION 7 SUMMARY

What is the meaning of the diamond symbol?

	HOV Lane	Two Direction	On the Lane	Restricted Vehicles	Other	Don't Know
Total	33	17	6	25	11	7
Familiar	31	14	6	33	11	6
Unfamiliar	37	22	6	14	12	10
College Station	40	19	5	20	8	9
Houston	26	16	7	31	16	5
Male	35	20	4	28	9	4
Female	31	13	8	21	15	13
Male Familiar	32	16	4	34	9	5
Male Unfamiliar	42	32	5	11	11	0
Female Familiar	25	6	13	31	19	6
Female Unfamiliar	34	16	6	16	13	16
Young (16-30)	36	15	8	23	12	7
Mid-Age (31-45)	30	12	5	33	14	7
Older (46-70)	32	37	0	16	5	11
Young Familiar	39	11	5	26	13	5
Young Unfamiliar	30	22	13	17	9	9
Mid-Age Familiar	22	11	7	41	11	7
Mid-Age Unfamiliar	44	13	0	19	19	6
Older Familiar	14	43	0	43	0	0
Older Unfamiliar	42	33	0	0	8	17

QUESTION 8 SUMMARY

What do the following lane control signal indications mean?

Question 8A - Flashing Yellow Signal

	Caution	Slow Down	Lane Closing	Congestion	Other
Total	65	29	17	12	11
Familiar	72	25	13	13	8
Unfamiliar	55	35	24	12	16
College Station	65	31	20	17	14
Houston	66	28	14	7	9
Male	65	29	20	12	8
Female	65	29	13	13	17
Male Familiar	70	25	14	13	9
Male Unfamiliar	53	42	37	11	5
Female Familiar	81	25	6	13	6
Female Unfamiliar	56	31	16	13	22
Young (16-30)	69	28	20	13	8
Mid-Age (31-45)	61	26	16	9	12
Older (46-70)	63	52	11	16	21
Young Familiar	82	24	13	11	5
Young Unfamiliar	48	35	30	17	13
Mid-Age Familiar	63	22	11	11	11
Mid-Age Unfamiliar	56	31	25	6	13
Older Familiar	57	43	14	29	14
Older Unfamiliar	67	42	8	8	25

Question 88 - Solid Red "X" Signal

	Wrong Direction	Lane Closed	Stop	Congestion	Other
Total	48	37	24	7	3
Familiar	43	38	29	7	0
Unfamiliar	55	37	17	6	8
College Station	62	29	20	6	6
Houston	33	48	29	7	0
Male	49	40	20	8	1
Female	46	33	31	4	6
Male Familiar	46	38	21	9	0
Male Unfamiliar	58	47	16	5	5
Female Familiar	31	38	56	0	0
Female Unfamiliar	53	31	19	6	9
Young (16-30)	48	38	21	8	2
Mid-Age (31-45)	40	49	23	7	0
Older (46-70)	68	11	37	0	16
Young Familiar	42	39	26	11	0
Young Unfamiliar	57	35	13	4	4
Mid-Age Familiar	41	44	26	4	0
Mid-Age Unfamiliar	38	56	19	13	0
Older Familiar	57	0	57	0	0
Older Unfamiliar	75	17	25	0	25

Question 8C - Flashing Red "X" Signal

	Stop	Wrong Direction	Other	Lane Closed	Congestion
Total	29	24	20	17	11
Familiar	29	11	15	18	10
Unfamiliar	28	41	28	16	12
College Station	29	35	20	17	14
Houston	28	10	21	17	7
Male	25	21	16	20	9
Female	33	27	27	13	13
Male Familiar	25	11	16	20	11
Male Unfamiliar	26	53	16	21	5
Female Familiar	44	13	13	13	6
Female Unfamiliar	28	34	34	13	16
Young (16-30)	28	26	20	23	10
Mid-Age (31-45)	26	19	19	12	14
Older (46-70)	37	26	26	11	5
Young Familiar	34	8	16	24	11
Young Unfamiliar	17	57	26	22	9
Mid-Age Familiar	22	15	15	11	7
Mid-Age Unfamiliar	31	25	25	13	25
Older Familiar	29	14	14	14	14
Older Unfamiliar	42	33	33	8	0

QUESTION 9 SUMMARY

What is the preferred location of speed limit information?

	Pavement Markings	Sign Only	Pavement and Sign	Neither
Total	12	47	40	1
Familiar	18	44	36	1
Unfamiliar	4	51	45	0
College Station	8	52	40	0
Houston	17	41	40	2
Male	16	41	41	1
Female	6	56	38	0
Male Familiar	20	43	36	2
Male Unfamiliar	5	37	58	0
Female Familiar	13	50	38	0
Female Unfamiliar	3	59	38	0
Young (16-30)	16	49	33	2
Mid-Age (31-45)	7	49	44	0
Older (46-70)	11	37	53	0
Young Familiar	21	39	37	3
Young Unfamiliar	9	65	26	0
Mid-Age Familiar	11	48	41	0
Mid-Age Unfamiliar	0	50	50	0
Older Familiar	29	57	14	0
Older Unfamiliar	0	25	75	0

QUESTION 10 SUMMARY

What is the preferred location for commuter lane exit signing?

	Overhead Median	Overhead Side	Ground Mount	No Preference
Total	70	25	4	1
Familiar	72	22	4	1
Unfamiliar	67	29	4	0
College Station	68	29	3	0
Houston	72	21	5	2
Male	76	20	3	1
Female	60	33	6	0
Male Familiar	75	20	4	2
Male Unfamiliar	79	21	0	0
Female Familiar	63	31	6	0
Female Unfamiliar	59	34	6	0
Young (16-30)	72	23	3	2
Mid-Age (31-45)	72	23	5	0
Older (46-70)	58	37	5	0
Young Familiar	79	13	5	3
Young Unfamiliar	61	39	0	0
Mid-Age Familiar	70	26	4	0
Mid-Age Unfamiliar	75	19	6	0
Older Familiar	43	58	0	0
Older Unfamiliar	67	25	8	0

QUESTION 11 SUMMARY

What exit signing technique best conveys the information needed to exit?

	Overhead w/ Frwy	Overhead w/o Frwy	Ground Mount
Total	47	46	7
Familiar	43	51	6
Unfamiliar	53	39	8
College Station	59	35	6
Houston	35	59	7
Male	47	45	8
Female	48	48	4
Male Familiar	48	46	5
Male Unfamiliar	42	42	16
Female Familiar	25	69	6
Female Unfamiliar	59	38	3
Young (16-30)	51	46	3
Mid-Age (31-45)	42	49	9
Older (46-70)	47	42	11
Young Familiar	42	55	3
Young Unfamiliar	65	30	4
Mid-Age Familiar	44	48	7
Mid-Age Unfamiliar	38	50	13
Older Familiar	43	43	14
Older Unfamiliar	50	42	8

QUESTION 12 SUMMARY

Question 12A - Is the Park-and-Ride exit signing adequate?

	Adequate	Inadequate
Total	27	96
Familiar	19	53
Unfamiliar	8	43
College Station	10	55
Houston	17	41
Male	20	55
Female	7	41
Male Familiar	16	40
Male Unfamiliar	4	15
Female Familiar	3	13
Female Unfamiliar	4	28
Young (16-30)	15	46
Mid-Age (31-45)	8	35
Older (46-70)	4	15
Young Familiar	12	26
Young Unfamiliar	3	20
Mid-Age Familiar	6	21
Mid-Age Unfamiliar	2	14
Older Familiar	1	6
Older Unfamiliar	3	9

Question 12B - REASONS SIGNS WERE INADEQUATE (as a % of inadequate responses)

	Exit Unclear	P&R Unclear	Bad Sign Location	Other
Total	19	61	23	17
Familiar	15	58	28	17
Unfamiliar	23	65	16	16
College Station	24	67	15	15
Houston	12	54	34	20
Male	15	62	24	16
Female	24	61	22	17
Male Familiar	10	60	23	20
Male Unfamiliar	27	67	27	7
Female Familiar	31	54	46	8
Female Unfamiliar	21	64	11	21
Young (16-30)	17	57	24	24
Mid-Age (31-45)	23	63	14	11
Older (46-70)	13	73	40	7
Young Familiar	23	50	27	23
Young Unfamiliar	10	65	20	25
Mid-Age Familiar	10	62	24	14
Mid-Age Unfamiliar	43	64	0	7
Older Familiar	0	83	50	0
Older Unfamiliar	22	67	33	11

QUESTION 13 SUMMARY

Which sign colors should be used to convey that the commuter lane ends ahead?

	White on Green	Black on Yellow	Black on White
Total	38	55	7
Familiar	36	57	7
Unfamiliar	41	51	8
College Station	43	51	6
Houston	33	59	7
Male	35	59	7
Female	44	48	8
Male Familiar	36	55	9
Male Unfamiliar	32	68	0
Female Familiar	38	63	0
Female Unfamiliar	47	41	13
Young (16-30)	30	59	12
Mid-Age (31-45)	42	54	5
Older (46-70)	58	42	0
Young Familiar	26	66	8
Young Unfamiliar	35	48	17
Mid-Age Familiar	48	44	7
Mid-Age Unfamiliar	31	69	0
Older Familiar	43	57	0
Older Unfamiliar	67	33	0