

FREEWAY SIGNING NEEDS FOR HOV USERS

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ABSTRACT

In a number of urban areas HOV lanes are successfully being utilized to increase freeway capacity and improve the ability of commuters to move through congested corridors during peak periods. The continued success of HOV facilities will depend on the development of national standards in order to optimize the operations of these HOV facilities. The motorist information system is critical to this objective.

Driver expectancy requires that motorist information for an HOV lane be provide in the same manner used on other types of roadways. Driver information needs should be arranged according to a hierarchy in the same way that driver tasks can be arranged with basic tasks of control at the top of the hierarchy, followed by guidance tasks, with navigation tasks at the bottom of the hierarchy.

The same signs should not be intended for both HOV and freeway operations. Distinctions should be made between parallel signing systems for freeways and HOV lanes so that users of the two facilities will not be confused. This distinction can be achieved with use of the diamond symbol, the HOV abbreviation, and placement of HOV signs over their lanes.

The unique characteristics of HOV lanes require special treatment in order to meet motorist information needs. This report address the following important issues of an HOV information system: entrance information (including vehicle occupancy requirements, types of vehicles permitted, time of day restrictions, and entrance location information), exit information (including exit location and exit identification), and intermediate information (including speed control, enforcement policies, and changes in lane geometrics). The report also examines the unique information needs of each of the various types of HOV lanes; barrier separated, contra-flow lanes, concurrent flow lanes, and queue bypass lanes.

The goal of HOV signing in the future will be to develop standards that fulfill the specific needs of all the various HOV facilities while maintaining a consistency throughout the nation. This consistency in HOV signs can be encouraged by selecting a name for these facilities, by placing the diamond symbol in the top left corner of all HOV signs, and by utilizing certain types of signs to transmit particular types of information.

Signing alone is not an adequate teaching device, and enforcement is not a pleasant teaching device for motorists; therefore, driver education should be used in meeting the information needs of HOV users.

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INTRODUCTION

In an increasingly urban and mobile society, high-occupancy vehicle (HOV) lanes have become an attractive method of maximizing the movement of people on congested freeways - where space and resources often prevent major highway expansion. In a number of urban areas HOV lanes are successfully being utilized to increase freeway capacity and improve the ability of commuters to move through congested corridors during peak periods. However, HOV technology is fairly new to the transportation field, and national standards have not been developed for the design and operation of HOV lanes. The continued success of HOV facilities will depend on the development of these standards in order to optimize the operations of these HOV facilities. The motorist information system is critical to this objective.

HOV facilities are fairly complicated in nature. Increased amounts of information are required by motorists traveling in the vicinity of HOV facilities. This information includes hours of use, vehicle types, and vehicle occupancy. Signing is the key to transmitting the needed information to motorists. HOV signing is unique, and effective signing is difficult to provide due to the fact that an HOV lane has specialized information requirements and is located within a parallel facility, normally a freeway, which possesses its own information requirements (1).

Objectives

The first objective of this report is to determine users information needs on HOV facilities. The second objective is to address important issues regarding HOV signing and its special requirements. The final objective is to make suggestions for HOV signs that will meet the information needs of motorists and address the specific signing issues of freeway HOV lanes.

Scope

This report focuses on the information needs of HOV freeway users; therefore, the paper does not contain information on arterial HOV signing. The signing of various types of HOV facilities will be addressed, along with signing for part-time HOV lanes. The information contained on the sign, the location of the sign on the facility, the placement of the sign in regard to the lane, and the color of the sign, are all factors that will be addressed because of their significance to the transfer of information to the motorist. Both dynamic and static HOV signs will be discussed.

The readability of the signs is not included in the scope of this paper; therefore, lighting and letter size will not be examined.

EVIDENCE OF INSUFFICIENT MOTORIST INFORMATION ON HOV LANES

A report conducted by the Texas Transportation Institute (TTI) on motorist information needs on HOV facilities (2) notes that a lack of sufficient information for HOV users is evident from the following:

- The Manual on Uniform Traffic Control Devices (MUTCD) does not contain a detailed signing policy for high-occupancy vehicle facilities.
- Sign design, signal operation and traffic control of HOV lanes have been developed on a region-by-region basis. Standards were designed to conform with general practices, and local practices whenever possible. But, an HOV user who feels comfortable on a Houston HOV lane may be thoroughly confused if placed on the Shirley HOV lane outside of Washington, D.C. As the number of HOV facilities increases, motorist information needs to be presented in a uniform and consistent manner so that drivers will have a clear understanding of HOV lane operations.
- HOV users range from highly informed drivers to uninformed and unfamiliar drivers. This variance in driver education suggests the need for straightforward information systems.

HOV MOTORIST INFORMATION NEEDS

High-Occupancy vehicle lanes have been the subject of much research in recent years. Most of this research has focused on the design, operation, or evaluation of the facilities. Little research has specifically addressed motorist information needs on preferential lanes.

Hierarchy of Information Needs

In 1971 King and Lunenfeld conducted a study on the information requirements of highway users (3). A team of psychologists and engineers studied the information needs of drivers and the means for satisfying these needs. By analyzing tasks, information needs were identified. Satisfaction of these information needs allows a driver to travel safely, conveniently, efficiently, and comfortably. This study organized the needs into functional classifications.

Driver information needs should be arranged according to a hierarchy in the same way that driver tasks can be arranged with basic tasks of control (starting, stopping, speed control and steering) at the top of the hierarchy, followed by guidance task (maneuvering the vehicle on the road in response to roadway elements, traffic, environmental factors, legal requirements, etc.), with navigation task (direction finding, trip planning, and route following tasks) at the bottom of the hierarchy (3). HOV information systems should satisfy this priority of information with control needs having the highest priority, followed by guidance needs, and then navigation needs.

The information needs of the various driving tasks are obtained from various sources. For the control task, the driver obtains information relative to vehicle operation and keeping his vehicle in motion on the road (3). Vehicle control must be maintained throughout the trip, therefore, the driver must always have this information at his disposal. The guidance task, involves the motorist maintaining a safe and efficient course in relation to events on the roadway (3). Roadway elements are not consistent, motorist do not need continuous guidance information, but do need guidance information in sufficient time to make the 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 (3). The typical information needs of a HOV motorist are described in Table 1.

This hierarchy of information needs plays an important role in developing and installing a HOV motorist information system. For example, in locations where drivers will be concentrating on the task of controlling the speed of the car or the task of avoiding an obstacle, drivers should not be overloaded with guidance information (2). Directional signs should be planned and installed in areas where only "simple" steering and speed control maneuvers are required. HOV users should not be overly burdened with complex or unexpected events (3).

Table 1. Typical HOV Information Needs (3).

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

Driver Expectancy

Driver expectancy is another key factor in performing the driving task (3). Drivers have expectations regarding the roadway conditions, signs, access, etc. Driver expectations also include what type of information is to be expected, when the information is to be expected, and what it should look like. These expectations provide the driver with the basis for planning his trip. Consistency in meeting driver expectations is vital to the successful transmission of information to the HOV user (3).

Information Needs of HOV Users

In 1981 the Federal Highway Administration conducted a study specifically addressing the information needs of the users of HOV lanes (4). The three objectives of the report follow:

- 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 findings of the report contain the following three points of information:

- 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. There was little variance in the results for different geographic regions. The project results, therefore, suggests that it is both desirable and feasible to promote uniform Special Use Lane (SUL) signing across the country.
- The current MUTCD does not contain a list of all the different SUL information requirements or signs applicable to these needs.
- For drivers who have not been exposed to HOV lanes, the diamond symbol is not sufficiently understood. Signs and pavement markings alone, do not appear to be adequate teaching devices; therefore, greater emphasis needs to be placed on driver education and awareness via other media. In the study information systems improved driver awareness considerably, but up the 50 percent of the drivers still did not notice the SUL's.

Available Manuals

In 1985 a manual was prepared by TTI for the Texas State Department of Highways and Public Transportation, now referred to as the Texas Department of Transportation (5). The goal of the manual was to promote uniformity of design and operational efficiency for HOV facilities in Texas. The manual addresses signing and delineation as part of operational considerations, and contains the following statements:

- Efficient HOV lane management and operational integrity depend on proper application of traffic control devices on HOV mainlanes and connections.
- The information system should be developed as an integral part of the HOV design.
- Design, placement, operation, maintenance, and uniformity of all HOV signs should be considered. HOV signing should also be in compliance with the MUTCD.

HOV user information needs are similar to the information need of freeway motorists, however there is a distinct difference in the purpose of HOV lanes as compared to freeway lanes. Freeway lanes are intended to safely move high volumes of *vehicles* at high speeds, while HOV lanes are intended to safely move high volumes of *people* at high speeds (2). The number of vehicles on an HOV lane is restricted by *who* is allowed to use the lane rather than how many vehicles the lane can handle at a certain speed.

IMPORTANT ISSUES OF AN HOV INFORMATION SYSTEM

Each HOV facility has its own unique information needs based on the design and operational features of the HOV lane. An effective information system is difficult to provide due to the fact that an HOV lane has specialized information requirements and is located within a parallel facility, normally a freeway, which possesses its own information requirements (1).

HOV Information at Access Points

All HOV facilities require information at access points to aid in the collection and distribution of vehicles (6). Access points allow motorist information needs to be focused at these locations. Classification of HOV access points includes entry and exit points, terminal and intermediate access, and at-grade and grade-separated ramps. HOV access points can also be a combination of these feature resulting in various geometric configurations (2).

Studies have found that most drivers were comfortable driving on transitways, barrier separated HOV lanes; however, confusion often occurs when motorist enter or exit the facility (2). This confusion can be attributed to sign location, sign clutter, and sign meaning or application (2). Changing geometrics can also create confusion by diverting the driver's attention.

HOV Entrance Information

Motorists have extensive information needs at the entrances of HOV lanes (2). The restrictions of an HOV lane must be communicated to motorists in a clear and concise manner. Motorist information needs at entrances of freeway HOV lanes include: occupancy of permitted vehicles, type of permitted vehicles, hours of operation, the direction of flow during these hours, and location of future access points. This information needs to be available in advance in order for the motorist to choose and execute a safe maneuver if he or she wishes to enter the HOV lane. Motorists must be able to easily determine their eligibility and maneuver into the entrance of the HOV lane with little difficulty (2).

While motorist information needs are extensive at the entrance of an HOV facility, care should be taken not to overload the motorist with information prior to gaining access to the facility. Only a certain amount of information can be comprehended as the driver enters the HOV lane (1). Information that is not critical to the driver should not appear at the entrance (1). Instead, this information should be supplied in an area of minimal conflict, where motorist can devote attention to the sign (1). The priority of information to be transmitted at the entrance to an HOV lane should be consistent with the hierarchy of tasks the driver must perform.

Advance Information. A regulatory sign on the entrance ramp to the freeway may be helpful in guiding HOV motorists to the left-most freeway lane so that they may easily enter the HOV facility (1). This sign should contain the term "High Occupancy Vehicle," written with larger size "HOV" letters to enhance motorists understanding of the abbreviation. Occupancy requirement information is not necessary on this sign since that information is not important at this location.

A guide sign is suggested to appear over the left-most freeway lane one mile prior to the entrance of an HOV lane. This sign should again contain the term "High Occupancy Vehicle" to enhance motorists understanding of the abbreviation. Motorists understanding of the abbreviation HOV is necessary at this location because information needs at the entrance of the HOV lane do not allow for the abbreviation to be expanded (1). A similar sign should appear over the lane 1/2 of a mile prior to the entrance. This sign should utilize the HOV abbreviation, contain the distance to the entrance, and contain the words "Left Exit" to indicate to motorists that the HOV access point is located on the left side of the freeway if that is the case. Other information should not be included on these signs because of their low observation rate. The TTI study of motorist information needs on transitways revealed that few drivers (approximately 40 percent) saw the first advance information sign (2). A larger percentage (approximately 70 percent) noticed the second advance information sign (2). These signs are intended to notify motorists of the upcoming facility and encourage the motorist to focus his or her attention on the information that follows.

As motorists continue to approach the HOV lane entrance, speed limit signs should be utilized if a slower traveling speed is required (1). These speed limit sign should resemble a standard speed limit sign with the addition of the HOV diamond in the top left corner.

Approximately 1/4 of a mile prior to the entrance a regulatory overhead sign should be used to indicate the HOV requirements in effect (1). The sign utilizes the HOV abbreviation and indicates vehicle occupancy and eligible types of vehicles. The sign should contain the term "occupancy," since the meaning of the terms "rider" and "carpool" are easily disputable (9). The types of eligible vehicles should also be contained on the sign, for example, "buses vans cars."

A sign indicating the types of vehicles that are not permitted should follow the occupancy sign. A truck weight limit should be included to distinguish between heavy trucks, which are not permitted, and light trucks, such as pickups, which usually are permitted.

If the HOV facility is reversible a changeable message sign (CMS) should be located at the beginning of the transition lane to indicate if the HOV lane is open for use (1). If the facility is open the CMS also should display the hours of operation, for example, "6 AM - 9 AM MON - FRI." If the facility is closed the sign only needs to indicate this fact.

A regulatory sign containing occupancy and vehicle requirements should be located over the entrance to the HOV lane. It is vital that this sign be large enough to be easily read and easily comprehensible by motorists who may not have noticed or understood the previous signs. The size and readability of this sign is also important because motorists in the mixed-flow lanes need to know that the lane is designated for special use.

Lane Conditions. Several HOV facilities are able to provide their users with real time information through surveillance, communications, and control systems. Motorists are warned about HOV lane conditions with the use of lane control signals that appear over the lane. Four messages are conveyed with these signals: it is safe to proceed, one should proceed with caution and/or exit, the lane is closed, or the motorist is traveling in the wrong direction.

A sign should appear prior to the location of lane-use control signals to supply the drivers with information to interpret these signals. The sign should be located downstream of the entrance in an area with low demand on the driver. The sign legend should indicate the appropriate meaning for each of the lane-use control symbols: a green arrow indicates that it is safe to proceed, a yellow arrow means that the motorist should proceed with caution, a yellow "X" indicates that the motorist should exit the facility when possible, and a red "X" indicate the HOV lane is closed or that the motorist is traveling in the wrong direction.

HOV Exit Information

A motorist also needs information prior to the exit of an HOV facility. Confusion can occur if a driver misses a desired exit, or in the case of a barrier separated HOV lane, extreme delay can occur because of the extensive distance between exits; approximately four to six miles (2). Advanced signing of exits, similar to that used on freeways, should assist exiting drivers. Exit signs should include information identifying the location of the exit, the distance to the exit, and the destination of the exit.

Prior to an exit, an HOV guide sign should be used to inform motorists of the upcoming exit point. The signs should contain the distance to the next exit, and provide an identifiable name for the exit, for example the name of a cross street or a park-and-ride lot. Guide signs with arrows should be use to indicate that a motorist needs to exit the HOV lane at that specific point to reach a certain destination. This type of guide sign may also include the words "Last Chance" to stress to the motorist that he or she must leave the HOV facility at that exit to reach a certain destination.

Intermediate Access Point Information

An access point may occur at the beginning, end, or at some intermediate point on an HOV lane. The access points at the beginning and end of the lane are referred to as terminal points (2). Intermediate ramps allow a motorist to enter or leave the HOV lane between terminal points (2). Maneuvering on and off of an HOV facility via intermediate ramps is similar to entering or leaving a freeway with ramps. The motorist must move from one facility to another and merge with traffic which may be traveling at a different speed.

In addition to the motorists leaving the facility, other motorists need to be made aware of these access points in order to prepare themselves for merging or slowing traffic.

At intermediate access points, warning signs containing a geometric illustration should be used to alert the vehicles already in the HOV lane that other vehicles will be merging into the HOV lane. This sign can be composed of two signs, one containing the diagram, with a sign containing the HOV diamond above it.

Terminal Point Information

Motorists traveling on HOV facilities also need to be warned of the termination of the HOV lane in order to prepare themselves for merging or slowing traffic. Instead of informing the motorists that the lane is ending, HOV signs should convey that the HOV restrictions are ending and that the lane will continue as a mixed-flow lane. The message "Restricted Use Ends" may be appropriate for situations where the travel lane does not end.

Intermediate HOV Information

Once the motorist has successfully negotiated the entrance of an HOV facility, he or she needs certain information in order to travel smoothly and safely on the facility. This intermediate information includes speed limit signs, warning signs of changes in horizontal and vertical alignment, signs or signals to convey lane conditions, and additional motorist information that is not essential at the entrance of the facility.

Speed Control Information

Once the motorist has successfully entered the HOV lane speed limit signs allowing higher travel speeds should appear (1). HOV speed limit signs should follow the same format as a standard speed limit sign, with the addition of the HOV diamond in the top left corner to identify the sign as applicable to the HOV lane. The task of controlling a vehicle is continuous; therefore, speed control information should appear throughout an HOV facility.

In theory, HOV speed limit sign are preferably located over the HOV lane to reduce confusion with the adjacent freeway (2). However, the overhead location conflicts with current practice for locating speed limit signs; therefore, speed limit signs should be located at the edge of the HOV lane.

Alignment Information

The information needs of motorists traveling on HOV lanes may either increase or decrease due to the geometric design of the facility. Information needs may be minimized by providing adequate sight distance and following driver expectancy (3). For example, a motorist approaching a right-handed exit ramp with visible geometrics requires less information than a motorist approaching a left-handed exit ramp that occurs over the crest of a vertical curve.

HOV users should be warned of changes that occur in the horizontal or vertical alignment of the HOV lane with warning signs, in the same manner as on conventional roadways since the information needs regarding changes in geometrics are the same for HOV lanes and conventional roadways. The warning signs should follow those described in the MUTCD for changes in design features.

Emergency Response Information

The typical cross section of a reversible barrier separated HOV in Houston, Texas is normally 19.5 feet wide (2). The actual travel lane is 12 feet wide; the extra footage is to allow a motorist to pass a disabled vehicle. Most HOV signs on these facilities indicate that a motorist should pull over into the left shoulder in case of a breakdown; this violates driver expectancy. Studies indicate that approximately 80% of test subjects reacting to emergency situations would stop in the right shoulder in case of a breakdown (2). In the TTI study, the signs indicating that drivers should pull over to the left shoulder may also not have been obeyed because they appeared at the entrance of the HOV facility, where drivers are preoccupied with the task of entering the facility and unable to devote attention to the sign. Emergency response signs on barrier separated HOV lanes should appear after the motorist has entered the facility and should follow driver expectancy, indicating that impaired vehicles should pull into the right shoulder.

Emergency response signs for contra-flow lane should follow the same suggestions as for a barrier separated HOV lane if a right shoulder is available. Contra-flow lanes are separated from the general flow lanes on the left side with pylons; no left shoulder is available.

Concurrent flow HOV emergency response signs need to indicate that impaired vehicles should pull into the left shoulder. This variation is due to the fact that concurrent flow lanes are separated on the right side of the lane from the general purpose lanes with pavement markings or buffers. Even if the separating buffer is wide enough to accommodate a vehicle, the vehicle would be placing itself in between to lanes of moving vehicles. The impaired vehicle could find safer refuge in the left shoulder of the concurrent flow lane; safety is a higher priority than following driver expectancy.

Enforcement Policy Information

Motorists should be informed of enforcement regulations and their consequences (6). Signs containing the amounts of fines for violations should be posted. It may be appropriate for these signs to appear upstream of the first exit so that uninformed motorists may exit the facility before they receive a citation from a police officer.

Motorists can assist in enforcement through the Hero Program. Program phone numbers should be available on signs for motorists who wish to report violators on the HOV lanes.

Lane Control Signals

The lane control signals that may appear at the entrance of an HOV facility should also appear at certain intermediate locations throughout the facility. These intermediate lane control signals could warn motorists of changes in lane conditions, for example, a yellow arrow could be displayed upstream of a disabled vehicle, indicating that motorists should proceed with caution. Lane control signals would also be helpful at intermediate access points on a reversible HOV lane to indicate to entering motorists that it is safe to proceed, on that they are traveling in the wrong direction.

Special Information Requirements of Various Types of HOV Facilities

The design of a motorist information system for an HOV lane is dependent on the type of HOV facility. The information needs of a motorist traveling on a barrier separated HOV lane differ from those of a motorist traveling on a concurrent flow lane; therefore, the signing will vary also. This report will examine four distinct types of HOV's: barrier separated lanes, concurrent-flow lanes, contraflow lanes, and queue bypass lanes.

Barrier Separated

General. Barrier separated HOV lanes, or transitways, are usually located in the freeway median and reserved for the exclusive use of high-occupancy vehicles. The key element in the design of a barrier separated HOV lane is access (2). Access for a barrier separated HOV lane is more limited than for a concurrent flow lane and much more limited than freeway access. Barrier separated HOV lanes usually have access points at four to six mile intervals (2). Motorists information needs are focused at these access points.

Motorist information needs are also defined by the manner in which the facility operates. Many possible variables in the operating plan exist, including: the number of lanes, one-way or two-way traffic flow, geometric segment, and reversible or non-reversible flow (2). Combinations of these factors provide a variety of operational schemes each with unique information needs.

Access. Classification of transitway access points includes entry and exit points, terminal and intermediate access, and slip and direct entry ramps (2). Transitway access points can also be a combination of these features resulting in various geometric configurations. Although the geometry of the access points may vary, the informational needs remain fairly consistent (1). The information needs of motorists at access points on barrier separated HOV lanes are consistent with those previously discussed for entrances, exits, and intermediate access points.

The barrier separating the HOV lane from the general purpose deters unfamiliar or unformed drivers from entering the facility because the motorists fear that they will be unable to leave the HOV lane at their desired destination. Drivers will be less apprehensive about entering the HOV lane if they are clearly informed of the upcoming access points. Signing should appear prior to the entrance containing the distance and destination of upcoming access points, for example, a guide sign that reads "Next Exit Interstate 10 6 miles."

Two types of ramps exist at access points: slip ramps, and direct ramps (2). A slip ramp is an at-grade connection between the left most freeway lane and the barrier separated HOV lane (2). The vehicles move from the freeway into the transitway by slipping through a gap in the transitway barrier. Slip ramp information must be provided on the freeway, a sufficient distance prior to the access point, in order to guide the motorist to the inside lane so that he or she may safely "slip" into the HOV lane. It may be advantageous for guidance information to appear on arterials so that motorists will know at what location they need to enter the freeway in order to gain access to the transitway (2). At slip ramp entrances warning signs containing a geometric illustration should be used to warn the vehicles already in the HOV lane that other vehicles will be merging into the HOV lane.

A direct ramp is a grade-separated connection between the barrier separated HOV lane and number of other types of facilities (2). These various types of facilities include freeways, frontage roads, arterial streets, park-and-ride lots, transit centers, or other transitways (2). Flyover ramps and three- and four-way elevated interchanges are examples of direct ramps (2). Direct ramps are more complex than slip ramps because of the lack of controlled access on surface streets and the various directions of travel for motorist (2). Direct ramps may have geometric features that require special signing. Signs for ramps may compete with typical signs on surface streets, freeways, transit facilities, or other transitways.

Reversibility. The reversible nature of some barrier separated HOV lanes creates difficulties in signing. The entrance of a transitway in the morning may be an exit in the evening; therefore, the signing needs vary according to the time of day (2). In order not to confuse motorists, signs applicable to only one time period should not be visible during other hours of operation (2). If the signs that apply to one direction of flow are visible to traffic moving in the opposite direction, then a motorist may enter the HOV lane and find themselves faced with head-on high-occupancy vehicle traffic.

For reversible barrier separated HOV lanes it is also important that motorists understand whether or not the transitway is open, and if it is open, the direction of travel on the transitway during that time period. HOV facility status at an entry point is provided through signing and barricades (2). Changeable message signs (CMS) should clearly state if the lane is open or closed. A sign indicating whether the HOV lane is open for use should be located at the beginning of the transition lane. The sign should be a CMS and contain the times of HOV operation. Lane-use signals can also be used to convey the status of the lane to motorists. A green arrow above the HOV lane indicates that the motorist is traveling in the correct direction, while a red "X" over the lane indicates that the motorist is either traveling in the wrong direction, or that the lane is closed. When closed, barricades should also be used to physically block the entrance of the lane (2).

The most difficult transitway operating plan to communicate to motorists is encountered on elevated interchanges with two reversible lanes (2). This operating procedure is difficult for motorists because it requires that vehicles which occupy the left lane during one period to occupy the right lane during the other operation period. This operating plan violates driver expectancy and requires addition signing. Motorists must be supplied with adequate and repeated advanced notice of the upcoming change in traffic flow (2). If possible motorists should be physically restricted from entering the incorrect lane. Once the vehicle is in the correct lane, correct vehicle position signing needs to be supplied throughout the facility. All possible invitations to use the incorrect lane should be eliminated from the motorist's field of vision. A physical separation is the easiest way to discourage improper use of lanes. The use of permanent signs is not possible because of the reversible feature of this type of lane, instead changeable message signs should be utilized for this type of operation.

Summary of Information Needs on Barrier Separated HOV Lanes. The following table summarizes the information needs that apply to the different portions of the barrier separated HOV lane.

Table 2. Motorist Information Needs at Transitway Connections (2).

Entrances	Advanced notice of entrance point Guidance to entrance Transitway entry requirements
Exits	Advance notice of exit points Correct lane of exiting Maneuver needed to reach desired exit End HOV lane 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 Speed limits

Contraflow Lanes

On a contraflow lane high-occupancy vehicles operate in the opposite direction of adjacent traffic during the entire day or during certain hours of the day. For freeway applications the lane is usually separated by pylons or moveable barriers (6).

Contraflow lanes poses some safety risk because opposing traffic operates on the same side of the freeway. Generally, accident rates have not worsened with the implementation of contraflow projects; however, no pylon separated contraflow projects have been opened to inexperienced drivers (6).

Motorists who utilize pylon separated HOV lanes are required to familiarize themselves with the facility in order to obtain a permit to use the lane. This education is an important factor in the design of an information system for this type of facility. Since the drivers are familiar with the facility and informed about its operation, they need less information; therefore, fewer signs are required.

Contraflow lanes also require fewer signs because the lanes do not contain intermediate access points. The information needs are focused at the entrances and exits of the facilities. Guide signs should be used prior to the entrance of the facility to indicate the location of the entrance and to assist motorists entering the facility. Regulatory signs containing occupancy and vehicle restrictions are probably not necessary for this type of facility since the motorists who qualify to use the facilities are aware of the lanes restrictions. Instead, a signing is needed throughout the facility to indicate to motorists in the mixed-flow lanes that the lane is restricted during certain times of the day, and that a permit is required for use of the facility. Since contraflow lanes operate in one direction during the mornings, and in the opposite direction during the evenings, permanent signs cannot be utilized. Flip panels are suggested for this type of signing, for example, a sign can state that the lane has restricted use during the morning peak period, and can be "flipped" to state that the shoulder can be used during the other time periods.

Concurrent Flow Lanes

On a concurrent flow lane high-occupancy vehicles operate in the same direction as the adjacent mixed flow of traffic during the entire day or during certain hours of the day (6). Concurrent flow lanes are separated from the general purpose lanes with either a standard lane stripe or buffer. The key difference between the concurrent flow lane and the other types of lanes discussed is access. While some concurrent flow lanes have wide buffers and very distinguishable access points, other concurrent flow lanes only have a lane stripe that does not deter all motorists from moving in and out of the lane. If a standard pavement stripe is used, signs also need to appear to explain to the motorists that they are not allow to cross the stripe. In addition to pavement markings, signs are needed to communicate to motorists in the general purpose lanes that the lane has restricted use.

Concurrent flow lanes should follow the signing practices previously recommended for entrance, exits, and access points on HOV facilities. It is especially important that these signs all contain the HOV diamond symbol to distinguish them from mixed-flow freeway signing.

Queue Bypass Lanes

Queue bypasses are short-distance lanes operating in a concurrent flow fashion during at least a portion of the day (6). Queue bypasses are often located at ramp meters, isolated bottlenecks, and through toll plazas (6).

Queue bypasses are normally associated with some sort of metering. Metering is a procedure used to reduce congestion on the freeway by managing vehicle flow, either from upstream ramps or along the mainline (6). Queue bypasses offer a facility for HOVs to bypass the meter, or to be metered at a preferential rate over mixed-flow traffic. The HOV motorists entering the bypass ramp need to know whether they are going to be required to stop at the end of the ramp or not. If a signal at the end of the ramp is utilized, the HOV motorists need to be warned of the upcoming signal in order to prepare themselves to stop.

HOV SIGNS

Facility Name

Various names have been used to describe an HOV facility. A study performed by TTI (2) found that "Authorized Vehicle Lane" and "High Occupancy Vehicle Lane" were the preferred names of the participants in the study. The term "Transitway" was not nearly as accepted as the two terms mentioned. A Virginia DOT study (7) found the "HOV" abbreviation was understood by virtually all motorists on the 1-66 HOV facility. However, this study did not consider the motorists in the general purpose lanes of the freeway that would have used the HOV lane if they had understood the abbreviation. Surveys from the Virginia DOT study (7) indicated that a large number of motorists preferred the term "Carpool" on HOV signs. The term "Carpool Lane" may not be appropriate because buses, vans, and motorcycles are allowed to use the facility along with passenger cars. There are also discrepancies over the term "carpool;" some people believe that a carpool only contains the passengers that have been collected, not passengers from the same household. For example, a family on vacation may not be considered to be a carpool; therefore, the term occupants is more descriptive.

A study performed by TTI for the Metropolitan Transit Authority of Harris County, Texas (1) selected the abbreviation "HOV" to appear on signs at the entrances of HOV lanes for the following reasons:

- The HOV abbreviation is used throughout the country more often than any other term to describe facilities which accommodate carpools, vanpools, buses, or any combination of these vehicle types.
- The HOV abbreviation is desirable because it is short enough to be used in signing. HOV requires less space than longer descriptions and requires less time to comprehend.
- Occupancy requirements of a facility can be combined with the HOV abbreviation (for example HOV-3 or HOV-2+).

MUTCD Requirements

The term HOV does not appear in the 1988 national Manual of Uniform Traffic Control Devices (MUTCD) (11). Signing for HOV lanes is addressed in Section 2B-20, Preferential Lane Signing. The manual defines a preferential lane as "*lanes where usage is limited according to class of vehicle occupancy.*" This section states that preferential lane signing should follow the standard regulatory signing principles (11).

According to the MUTCD there are 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 (1). All traffic control devices used on HOV lanes must meet these requirements.

HOV Sign Classification

The MUTCD also provides three different functional classifications for traffic control signs (11). These classifications include regulatory signs, warning signs, and guide signs. Regulatory signs give notice of traffic laws or regulations (3). Warning signs call attention to conditions on, or adjacent to, a highway or street that are potentially hazardous to traffic operations (3). Guide signs show route designations, destinations, directions, distances, services, points of interest, and other general information (3). HOV signs should be grouped into one of these categories and each sign should be in accordance with the principles for that classification. HOV signs containing occupancy requirement, permitted vehicles, time of day restriction, etc. would be considered regulatory signs. HOV signs warning motorists of changes in geometrics, or merging vehicles would be categorized as guide signs, and HOV signs notifying motorists of upcoming HOV entrances, exits, or access points, would be classification as navigation signs.

Colors of HOV Signs Based on Their Classification

The MUTCD does not address the use of guide signs with HOV facilities. However, in 1984, the Federal Highway Administration solicited comments from the National Committee on Uniform Traffic Control Devices (NC) on specific proposed changes (8). One of these changes included language relative to guide signs placed over preferential lanes. This specific proposal was not adopted because guide signs were already covered in the MUTCD, and did not need to be additionally addressed in the Preferential Lane section, implying that HOV guide signs should utilize a white legend on a green background, with the diamond symbol used to identify the sign as an HOV sign. The only exception to the green and white color combination for guide signs is when the ramps are provided exclusively for HOV traffic. In this case, the sign should follow the black and white color format of HOV regulatory signs (1).

In the same context, HOV warning signs should follow the standard black on yellow. Regulatory signs should follow the prescribed black on white, as contained in the MUTCD.

Diamond Symbol

The MUTCD states that the diamond lane marking symbol used to designate preferential lanes should be incorporated in the body of the signs, as a white symbol on a black background (11). Unfortunately, the MUTCD also states that the diamond symbol should be used with preferential bicycle lanes. As a result, the diamond symbol is not reserved solely for use on HOV lanes.

All HOV signs should contain the diamond symbol for motorists to be able to distinguish HOV signs from other freeway signs. In order to achieve uniformity, the diamond symbol needs to appear in the same location on all HOV sign, preferably in the top left corner of the sign.

Sign Legend

The legend of the sign is the major communicative device of the sign (1). HOV facilities are designed to operate at high speeds, requiring legends which are easy to read and comprehend. Therefore, sign should contain the minimal amount of words or letters necessary to convey a clear meaning. Multiple signs are preferred to signs with a large amount of information (1).

Motorists may also find that information presented in a left-to-right fashion is easier to comprehend than text written in a top-to-bottom fashion. For example, guide signs that appear on the center barrier of a concurrent flow lane have clearance requirements that restrict their width; therefore, the text is read from top to bottom. In order to create more legible signs, signs should be placed over the HOV lane when possible.

Sign Mounting

Previous research has identified the potential for confusion between HOV signs and general use signs (2). The study recommended using an overhead location for HOV signs whenever possible to eliminate confusion to motorist in nearby general use lanes. One exception to this guideline would be speed limit signs that should be located along the side of the lane. A second exception would be guide signs containing few words that could be mounted on barriers beside the lanes.

Changeable Message Signs

Changeable message signs can be used to provide variable information to HOV motorists. There are two classification of CMSs: those that have the appearance of a standard sign, but in which all or a part of the message can be changed, and the electronic dot matrix type which can display any message (1).

Standard appearance CMSs utilize flip panels to change the sign message. A popular example of this type of CMS appears prior to truck weighing stations to communicate whether the station is open or closed. The use of these signs is limited because they can typically only display two messages. One advantage of this type of CMS is that they can be manually changed during power outages. Another advantage is that standard appearance signs are much less expensive than dot matrix CMSs. The standard appearance signs would be ideal for use on reversible HOV lanes that have two distinct types of information needs, based on the time of day, for the same lane.

Dot matrix CMSs are usually used to provide motorist with information and not used as regulatory signs (1). The use of these signs is restricted by their size and cost. The messages on dot matrix CMSs are required to be short and easy to read because of the high speeds on HOV facilities.

CMSs usually appear at the entrances of HOV facilities where driver information needs are the greatest. Caltrans is also beginning to implement CMSs on connectors as well as entrances to HOV facilities (10).

HOV Sign Comprehension Study

In 1987, TTI conducted a study assessing motorist understanding of traffic control devices (9). As part of the study the comprehension of the HOV restriction sign, R3-14, contained in the Texas Manual of Uniform Traffic Control Devices, was tested. The pilot study found this HOV sign (Figure 1) to be poorly understood by participants.

Participants were asked the following question:

It is 7:30 a.m. what vehicles are allowed to enter the HOV lane?

1. ___ Carpools with 2 or more people
2. ___ Carpools with 3 or more people
3. ___ Carpools with more than 3 people
4. ___ Not sure

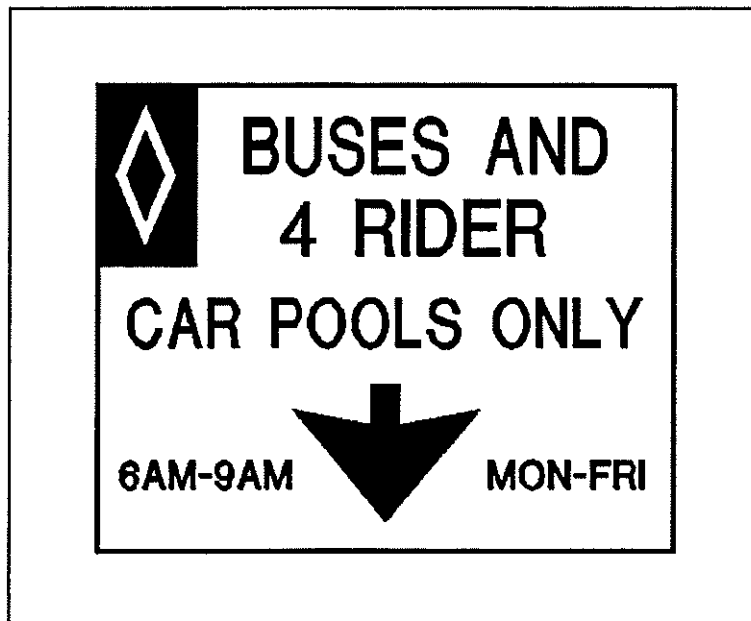


Figure 1. HOV Restriction Sign R3-14 (11).

According to the report, the correct meaning of the sign was "(2) Carpools with 3 or more people." This correct answer was only selected by 63.6% of the participants. 17.6% selected "(1) Carpools with 2 or more people." 11.5% selected my answer, "(3) Carpools with more than 3 people," and 7.3% admitted that they were not sure.

The discrepancy with both the sign and the question is the meaning of the words being used. Does the word "Rider" include the driver of the vehicle, or does it only refer to the non-driver passengers? The same question can apply to the word "carpool." Does a carpool of 3 or more people mean that there are three or four occupants?

The words "Rider" and "carpool" should not be used on HOV signs because of the variance in meaning of the words to motorists. Instead HOV signs should utilize the word "occupants" when referring to the number of people in a vehicle.

SUGGESTED MUTCD CHANGES

Many of discrepancies in HOV signing may be resolved through minor changes in the MUTCD (1). Suggested MUTCD changes include the following:

- "HOV lane" to distinguish HOV lanes from other types of preferential lanes, for example, bicycle lanes.
- Reserve the diamond exclusively for HOV lanes; the diamond symbol should not be used with preferential bike lanes.
- The addition of text explaining that HOV regulatory signs are those signs that impose a restriction on use. Other sign messages should follow the appropriate signing guidelines (such as warning and guide signs). The clarification would allow guide signs to appear as white on green signs instead of as white on black signs as specified for regulatory signs.
- Allow all HOV signing to appear over the HOV lane when possible.
- Include a typical HOV signing layout which addresses vehicle restrictions, occupancy restrictions, guide signing, regulatory signing, and warning signs.

CONCLUSIONS

The information needs of motorists traveling in a freeway HOV lane are similar to those of motorists travel in general purpose freeway lanes. The freeway HOV signing should provide the same information as a freeway, and additional information regarding vehicle restrictions, occupancy of vehicles, and times of operation. HOV information should be distinguishable from information intended for the parallel freeway system.

Successful transmission of information through signing requires that information be provided according to hierarchy in the same way that driver tasks can be arranged with basic tasks of control at the top of the hierarchy, followed by guidance tasks, with navigation tasks at the bottom of the hierarchy. HOV signing should be consistent with this hierarchy of information needs.

Successful transmission of information to the driver also depends on consistently meeting driver expectations. Driver expectancy on an HOV lane is no different from driver expectancy on any other type of roadway.

High speeds on HOV lanes reduces the amount of time the motorist is exposed to the sign; therefore, signs should include few words per sign to increase driver comprehensibility. Multiple signs are suggested for locations where extensive amounts of information needs to be communicated to the motorists.

The reversible characteristics of some HOV facilities requires that information applicable only to one operating period not be visible during the periods to which it does not apply. This signing requirement can be achieved with the use of CMSs. Flip panels are especially advantageous because of their low cost, and ability to display two messages; one for each time period.

RECOMMENDATIONS

The subject of HOV signing is still in its infancy stage requires much more research. The goal of HOV signing in the future will be to develop standards that fulfill the specific needs of all the various HOV facilities while maintaining a consistency throughout the nation. This consistency in HOV signing can be encouraged by selecting one name for these facilities, by placing the diamond symbol in the top left corner of all HOV signs, and by utilizing certain types of signs to transmit particular types of information.

HOV signs should follow the hierarchy of motorist information needs with control information at the top of the hierarchy, followed by guidance information, with navigation task at the bottom of the hierarchy. Black on white regulatory signs should be utilized for control task information. Black on yellow warning signs should be used to provide the motorists will guidance information. White on green guide signs should convey navigation information to the motorists. With consistency in appearance, motorists will be able to associate a certain type of information with each of the different coloring schemes.

If the term high-occupancy vehicle lane is selected as the name for the facilities, then the abbreviation "HOV" should appear on signs throughout the facility and should be defined at the entrance of the HOV lane.

The diamond symbol should be reserved exclusively for HOV lanes and should be included on all signs that apply to HOV facilities. A unique symbol that represents only one type of restriction will, in time and through greater use, gain better public recognition of the HOV concept. The diamond symbol will also distinguish HOV signs from other freeway signs.

The same signs should not be intended for both HOV and freeway operations. Distinctions should be made between parallel signing systems for freeways and HOV lanes so that users of the two facilities will not be confused. This distinction can be achieved with use of the diamond symbol, the HOV abbreviation, and placement of HOV signs over the HOV lanes. HOV signs should be mounted overhead using median supports whenever possible, with the exception of speed limit signs, and guide signs in advance of an access point. The overhead positioning of the HOV signs is beneficial to the transmission of information to HOV motorists, and conveys to motorists in the mixed-flow lanes that the lane has restricted use.

Signing alone is not an adequate teaching device; and enforcement is not a pleasant teaching device for motorists. Driver education should be used in meeting the information needs of HOV users. Drivers knowledge of HOV lanes could also be encouraged by including HOV principals on driver licensing tests.

FURTHER RESEARCH

This research was intended to identify and address many of the problems associated with the signing of HOV facilities. HOV signing is a largely unexplored area with many questions still remaining. Additional research would assist in determination a preferred name for the HOV facility. The use of pavement markings to transfer information to motorists should also be examined. Future studies should also explore the use to diagrammatic signs to transmit occupancy and vehicle requirements on HOV lanes.

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