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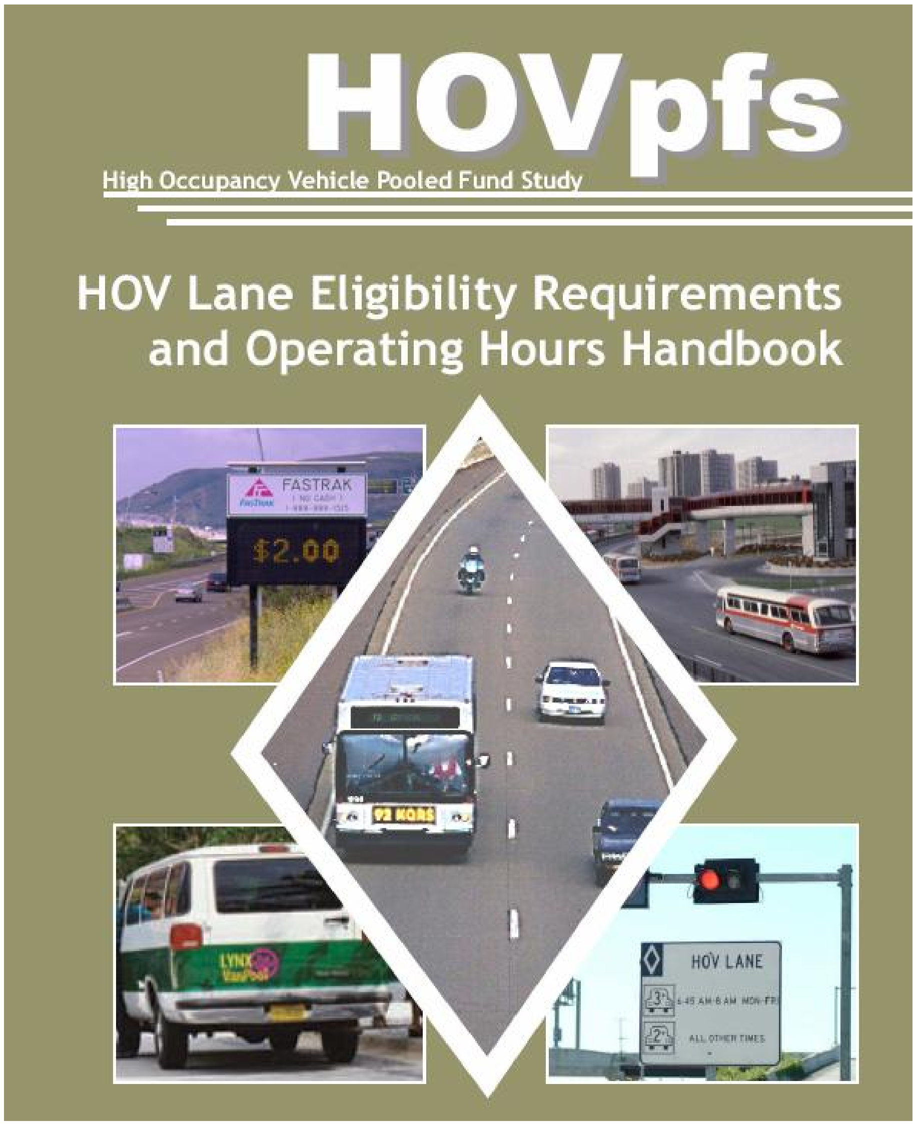

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16. Abstract

This handbook provides a guide to assessing the potential impacts of changes in vehicle-eligibility requirements, vehicle-occupancy levels, and operating hours on high-occupancy vehicle (HOV) lanes. Information on the impacts of allowing different types of HOVs, as well as high-occupancy toll (HOT) vehicles and low-emission and energy-efficient vehicles, is presented.

The handbook describes the federal interest in operational changes on HOV lanes and the agencies typically involved in managing the operation of HOV facilities. The link to HOV performance monitoring programs and HOV operation and enforcement plans is summarized. Possible issues associated with managing the operation of HOV lanes are discussed. A process for assessing potential changes in HOV lane operation is presented.

Common vehicle-eligibility requirements, vehicle-occupancy levels, and operating hours associated with different types of HOV lanes are highlighted. Assessing possible changes in vehicle-eligibility requirements, vehicle-occupancy levels, and operating hours are discussed.

Case study examples are used throughout the document highlighting key points. More detailed case study information is also presented on documented examples of changes in vehicle-eligibility requirements, vehicle-occupancy levels, and operating hours on HOV lanes.

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Current HOV Pooled-Fund Study members include:

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TTI researchers David Ungemah, Linda Cherrington and Jeff Arndt provided input and review comments on selected chapters. Gary Lobaugh provided editorial review and Bonnie Duke was responsible for word processing and formatting the document. The assistance of each of these individual is greatly appreciated.

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CHAPTER ONE – INTRODUCTION

Welcome to the Handbook

Welcome to the *HOV Lane Eligibility Requirements and Operating Hours Handbook*. This handbook provides a guide to assessing the potential impacts of changes in vehicle-eligibility requirements, vehicle-occupancy levels, and operating hours on high-occupancy vehicle (HOV) facilities. While the handbook focuses on assessing potential changes in the operation of existing HOV lanes, it may also be used in planning new HOV facilities.

The handbook is a one-stop reference for transportation professionals. It is also of benefit to policy makers responsible for funding transportation facilities.

The handbook is intended to meet the needs of various audiences. The primary audience of the handbook is transportation professionals responsible for planning, designing, funding, operating, enforcing, and managing HOV facilities. The secondary audience includes agency management personnel, policy makers, and other individuals interested in the effective and efficient operation of HOV lanes.

The *HOV Lane Eligibility Requirements and Operating Hours Handbook* is one of the projects sponsored by the HOV Pooled-Fund Study group and the Federal Highway Administration (FHWA). Participating state transportation agencies include California, Georgia, Maryland, Massachusetts, Minnesota, New Jersey, New York, Tennessee, Virginia, and Washington. Other handbooks of use to transportation professionals and policy makers sponsored by the Pooled-Fund Study group include the *HOV Performance Monitoring, Evaluation, and Reporting Handbook*, the *HOV Lane Safety Considerations Handbook*, and the *HOV Lane Enforcement Handbook*.

The goal of the HOV Pooled-Fund Study (HOV PFS) is to assemble regional, state, and local agencies, and the Federal Highway Administration (FHWA) to:

- identify issues that are common among agencies;
- suggest projects and initiatives;
- select and initiate projects;
- disseminate results;
- assist in solution deployment; and
- track innovations and practice.

Participating state transportation agencies include California, Georgia, Maryland, Massachusetts, Minnesota, New Jersey, New York, Tennessee, Virginia, and Washington.

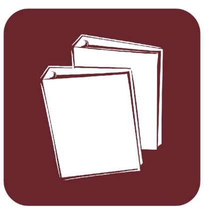
Handbook Features

The handbook includes a number of user-friendly features. The following icons are used throughout the handbook to highlight the handbook at-a-glance and chapters-at-a-glance, good ideas, keys to successful practices, and case study examples.

This icon highlights **at-a-Glance** previews of the handbook and each chapter.

This icon highlights **Good Ideas** based on experience with establishing and changing vehicle-eligibility requirements, vehicle-occupancy levels, and operating hours.

This icon highlights **Keys to Successful Practices** related to vehicle-eligibility requirements, vehicle-occupancy levels, and operating hours.



This icon highlights **Case Study Examples** of changing vehicle-eligibility requirements, vehicle-occupancy levels, and operating hours. More detailed information on specific case studies is provided in Chapter Seven.

Chapters-at-a-Glance

Chapter Two – Executive Summary

This chapter provides a summary of the handbook. It begins with an overview of HOV facilities and the relationship of HOV lanes to other elements of the transportation system. The major topics addressed in the remaining chapters are highlighted. These topics include managing the operation of HOV lanes, and assessing vehicle-eligibility requirements, vehicle-occupancy levels, and HOV operating hours. The primary audience for the chapter is policy makers and agency management personnel, although it is appropriate for all groups interested in HOV facilities.

Chapter Three – Managing HOV Lanes

This chapter summarizes the federal interest in HOV operations and highlights the roles and responsibilities of the agencies typically involved in managing HOV lanes. The link to HOV performance monitoring programs and the connection to HOV operation and enforcement plans is discussed. Possible issues associated with operating HOV lanes are described. A general process for assessing possible changes in the operation of an HOV lane is presented.

Chapter Four – Assessing Vehicle-Eligibility Requirements

This chapter highlights the types of vehicles usually considered for use of an HOV facility. The provisions of SAFETEA-LU addressing exempt vehicles use of HOV lanes, including high-occupancy toll (HOT) vehicles and low-emission and energy-efficient vehicles, are described. The advantages of allowing different vehicles are highlighted along with some of the limitations associated with various user groups. Assessing possible changes in vehicle-eligibility requirements are discussed.

Chapter Five – Assessing Vehicle-Occupancy Requirements

This chapter provides an overview of possible vehicle-occupancy requirements. Potential advantages and limitations of different occupancy requirements are summarized. Assessing possible changes in vehicle-occupancy requirements are discussed.

Chapter Six – Assessing HOV Operating Hours

This chapter describes the operating hours scenarios typically used with HOV facilities. The advantages and limitations of different operating scenarios are discussed. Factors which may influence consideration of HOV operating hours are highlighted. Assessing possible changes in HOV operating hours are discussed.

Chapter Seven – Case Studies

This chapter highlights case study examples related to changing vehicle-eligibility requirements, vehicle-occupancy levels, and operating hours on HOV facilities. The case studies provide available information on the impact of different approaches, including allowing HOT vehicles and low-emission and energy-efficient vehicles, and changing vehicle-occupancy requirements and operating hours.

Appendix A – References and Additional Resources

This appendix contains the references used in the handbook. It also provides additional resources related to topics associated with HOV vehicle-eligibility requirements, vehicle-occupancy levels, and operating hours.

Appendix B – Glossary of Terms

This appendix contains a glossary of terms associated with HOV vehicle-eligibility requirements, vehicle-occupancy levels, and operating hours. It focuses on terms used in the handbook.

Appendix C – List of Abbreviations

This appendix contains a list of abbreviations associated with HOV vehicle-eligibility requirements, vehicle-occupancy levels, and operating hours.

Appendix D – Agency Contacts

This appendix contains contact information for agency personnel participating in the HOV Pooled-Fund Study.

CHAPTER TWO – EXECUTIVE SUMMARY

Chapter-at-a Glance

This chapter provides an overview of HOV facilities and highlights the topics presented in the handbook. It is intended primarily for agency management personnel and policy makers. It also provides a useful overview for technical staff. The chapter contains the following sections.

- **Defining HOV Facilities**. This section provides an overview of HOV facilities in operation in North America. It highlights the role of HOV lanes and the types of facilities in operation.
- **Managing HOV Lanes**. This section summarizes the federal interest in HOV operations and highlights the roles and responsibilities of the agencies typically involved in managing HOV lanes. The link to HOV performance monitoring programs and to HOV operation and enforcement plans is discussed. Potential issues associated with operating HOV lanes are described. A general process for assessing possible changes in the operation of an HOV lane is presented.
- **Assessing Vehicle-Eligibility Requirements**. This section highlights the types of vehicles usually considered for use of an HOV lane. The provisions of SAFETEA-LU relating to HOV lane exempt vehicles, including HOT vehicles and low-emission and energy-efficient vehicles, are summarized. The advantages of allowing different vehicles are highlighted along with some of the limitations associated with various user groups. Assessing possible changes in vehicle-eligibility requirements are discussed.
- **Assessing Vehicle-Occupancy Requirements**. This section provides an overview of possible vehicle-occupancy requirements. Potential advantages and limitations of different occupancy requirements are summarized. Assessing possible changes in vehicle-occupancy requirements are discussed.
- **Assessing HOV Operating Hours**. This section describes the operating hours scenarios typically used with HOV facilities. The advantages and limitations of different operating scenarios are discussed. Factors to consider in assessing potential changes in HOV operating hours are highlighted. Assessing possible changes in HOV operating hours are presented.
- **Case Studies**. This section highlights case study examples related to changing vehicle-eligibility requirements, vehicle-occupancy levels, and operating hours. The case studies summarize available information on the impact of different approaches, including HOT lanes and value pricing,

low-emission and energy-efficient vehicles, and changes in vehicle-occupancy requirements and operating hours.

Defining HOV Facilities

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

The development and operation of HOV facilities have evolved over the past 30 years. The opening of the bus-only lane on the Shirley Highway (I-395) in northern Virginia/ Washington, D.C. in 1969 and the contraflow bus lane on the approach to the New York-New Jersey Lincoln Tunnel in 1970 represents the first freeway HOV applications in the country. Today there are some 130 HOV freeway projects in the 31 metropolitan areas in North America highlighted in Figure 2-1.

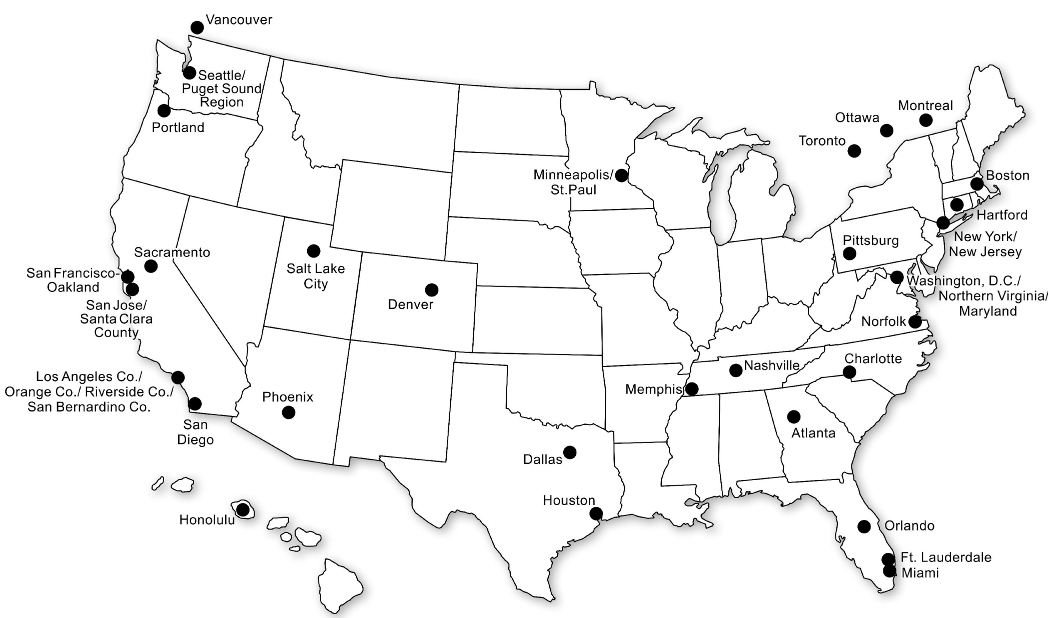


Figure 2-1. Metropolitan Areas with Freeway HOV Facilities.

HOV facilities are developed and operated to provide buses, carpools, and vanpools with travel time savings and more predictable travel times to encourage individuals to choose one of these modes over driving alone. As illustrated in Figure 2-2, the person movement capacity of a roadway increases when more people are carried in fewer vehicles. HOV facilities are usually found in heavily congested corridors where the physical and financial feasibility of expanding the roadway is limited. Supporting services, facilities, and incentives are also used to further encourage individuals to carpool, vanpool, or ride the bus.

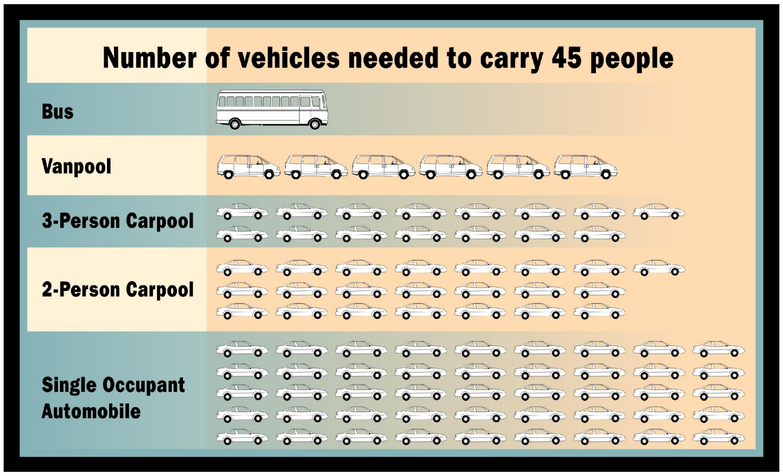


Figure 2-2. Number of Vehicles Needed to Carry 45 People.

Rather than creating disincentives to discourage drivers who travel alone, HOV lanes are developed to provide a cost-effective travel alternative that commuters will find attractive enough to change from driving alone to taking the bus, carpooling, or vanpooling.

HOV facilities on freeways or in separate rights-of-way are typically classified into four categories. These categories are described below and illustrated in Figure 2-3.

- **Busway or Exclusive HOV Facility, Separate Right-of-Way**. A roadway or lane(s) developed in a separate right-of-way and designated for the exclusive use by high-occupancy vehicles. Most facilities of this type are designed and utilized by buses only. Most are two-lane, two-direction facilities. Busways are in operation in Pittsburgh, Miami, Minneapolis/St. Paul, and Ottawa, Canada.
- **Exclusive HOV Facility, Freeway Right-of-Way**. A lane(s) constructed within the freeway right-of-way that is physically separated from the general-purpose freeway lanes and used exclusively by HOVs for all, or a portion, of the day. Most exclusive HOV facilities are physically separated from the general-purpose freeway lanes by a concrete barrier, but a few facilities are separated by a wide painted buffer. Facilities of this type are usually open to buses, vanpools, and carpools. Exclusive HOV lanes are in operation in Houston, northern Virginia, Minneapolis, San Diego, and Los Angeles.

Exclusive – US 290, Houston, TX

Busway – East Transitway, Ottawa

Contraflow – I-30, Dallas, TX

Figure 2-3. Categories of HOV Facilities.

- **Concurrent HOV Flow Lane**. A freeway lane in the peak direction of travel, not physically separated from the general-purpose freeway traffic lanes, designated for the exclusive use by HOVs for all or a portion of the day. Concurrent flow lanes are usually, although not always, located on the inside lane or shoulder. Paint striping is a common means used to delineate these lanes. HOV facilities of this type are usually open to buses, vanpools, and carpools. This is the most common type of HOV lane, with projects in operation in Seattle, the San Francisco Bay Area, Los Angeles and Orange County, Denver, Salt Lake City, Phoenix, Dallas, Houston, Minneapolis, Atlanta, Miami and Ft. Lauderdale, Orlando, northern Virginia, Maryland, New York/New Jersey, and other areas.
- **Contraflow HOV Lane**. A freeway lane in the off-peak direction of travel, commonly the inside lane, designated for exclusive use by HOVs traveling in the peak direction. The lane is typically separated from the off-peak direction general-purpose freeway travel lanes by some type of changeable treatment, such as plastic posts or pylons that can be inserted into holes drilled in the pavement, or a moveable barrier. Contraflow lanes are usually operated during the peak periods only; many operate only during the a.m. peak period and then revert back to normal use in non-

peak periods. Contraflow HOV lanes may be open to buses-only, buses and vanpools-only, or may also allow carpools. Examples of this type of facility include the approach to the Lincoln Tunnel on Route 495, the Long Island Expressway, and the Gowanus Expressway; all of these are located in the New York/New Jersey area. A moveable barrier is used to create a contraflow lane on the I-30 (East R.L. Thornton) Freeway in Dallas and the Southeast Expressway in Boston.

Many of the initial HOV lanes were bus-only applications or allowed buses and vanpools. In an effort to maximize use, carpools became the dominant use group on most projects during the 1970s and 1980s. The vehicle-occupancy requirements for carpools have evolved over time. A three-person per vehicle (3+) occupancy level was initially used on many projects, but most current facilities use a two-person per vehicle (2+) carpool designation.

More recently, value pricing projects including high-occupancy toll (HOT) lanes, have been implemented. These approaches are part of a broader managed lanes concept that employs market forces to help maximize use of the facilities. Value pricing and HOT lanes allow single-occupant or lower occupancy vehicles to use an HOV lane for a fee, while maintaining free travel to qualifying HOVs. The I-15 FasTrack™ Express Lanes in San Diego and the I-394 MnPASS program in Minneapolis allow single-occupant vehicles to use the HOV lanes for a fee, while the QuickRide program on the I-10 West and US 290 HOV lanes in Houston allows access by 2+ carpools for a fee during the 3+ restricted period.

Managing HOV Lanes

Federal Interest in HOV Operational Changes

Federal funding is typically used to support the design, right-of-way acquisition, construction, and operation of freeway HOV lanes. The FHWA Program Guidance on HOV Operations is intended to help protect the federal investment in these facilities and to promote the efficient use of HOV lanes while maintaining the intent of maximizing the person-movement capacity of these facilities. It also provides guidance on HOV-related provisions included in the Safe, Accountable, Flexible, and Efficient Transportation Equity Act – A Legacy for Users (SAFETEA-LU) and other federal legislation.

FHWA provides periodic HOV Program Guidance to support the federal investment in freeway HOV facilities and to help promote their effective use, while maintaining the intent of maximizing the person-movement capacity. The guidance supports performance monitoring programs, which provide the information needed to make sound decisions on operating HOV facilities.

The Program Guidance identifies the circumstances under which federal action is required to initiate changes in the operation of an HOV facility, and the federal review process and requirements to be used in these situations. It also includes information on the requirements for monitoring, evaluating, and reporting on the use of HOV lanes by certain exempt vehicles. The Program

Guidance and other recent information on federal activities related to HOV facilities are available on the FHWA Internet site at http://www.fhwa.dot.gov/legsregs/ directives/ policy/index.htm.

As noted in the Program Guidance, the source of federal funds used on an HOV project will influence the ability to make changes in the operation of an HOV facility. Some funding categories cannot be used for additional general-purpose roadway capacity. These categories include the Congestion Mitigation and Air Quality (CMAQ) program, the Interstate Maintenance Program, and Mass Transit Capital Investment Grants. Other federal funding sources may have requirements that limit consideration of possible changes in user groups or operating strategies.

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

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

SAFETEA-LU contains a number of provisions related to HOV lanes. These provisions include requirements for monitoring, evaluating, and reporting on the use of HOV lanes by certain exempt vehicles. The provisions of SAFETEA- LU related to vehicle-eligibility requirements, vehicle-occupancy levels, and operating hours are described in the appropriate sections of the handbook.

Involvement of All Appropriate Agencies

A key to the successful management of HOV facilities is to involve staff from all appropriate agencies and groups in the development of an operation and enforcement plan and in the ongoing monitoring of a project. Individuals from these agencies should be involved in managing the operation of an HOV lane and in discussing possible changes in operations.

Agencies Involved in Managing the Operation of HOV Lanes

The agencies typically involved with managing the operation of HOV lanes include state departments of transportation, public transportation agencies, state and local law enforcement agencies, and local jurisdictions. In addition, FHWA and FTA have a role in providing federal oversight in maintaining the effective and efficient operation of HOV lanes. Other agencies and groups, including MPOs, regional rideshare agencies, emergency response agencies, and the judicial system may also be involved. In addition, policy makers and elected officials at the local, state, and federal levels may influence the management of HOV facilities.

Multi-Agency Teams

Multi-agency teams or committees have been used in many areas to help coordinate planning, designing, funding, implementing, operating, marketing, monitoring, and managing HOV facilities. A subgroup, comprised of the operation and enforcement personnel from various agencies, may be formed to focus on managing the operation of an HOV lane. Multi-agency teams can ensure that all appropriate agencies are involved in managing the operation of HOV projects, considering possible issues and opportunities, and assessing potential changes.

The state department of transportation or the state highway department is usually the lead agency for HOV facilities on freeways. These agencies have overall responsibility for HOV lanes, including developing the operation and enforcement plan, managing operation of the facility, performance monitoring, and assessing potential changes in operations. In many areas, state departments of transportation have been responsible for organizing, staffing, and chairing the multi-agency project management team associated with HOV facilities. Public transportation agencies, law enforcement agencies, MPOs, local jurisdictions, rideshare organizations, and federal agencies typically play important supporting roles with managing freeway HOV lanes and assessing possible changes in vehicle-eligibility requirements, vehicle-occupancy levels, and operating hours.

In addition, minimum and maximum HOV lane operating thresholds may be established as part of a performance monitoring program, operations plan, or highway performance monitoring program. These thresholds provide guidance for determining if changes in the operation of an HOV lane need to be considered.

Some state departments of transportation have developed guidelines to help identify when changes in vehicle-eligibility or vehicle-occupancy requirements may be needed. In addition, SAFETEA-LU requires that agencies responsible for operating HOV lanes conduct monitoring programs if certain exempt vehicles are allowed to use the lanes. These exempt categories include tolled vehicles and low-emission and energy-efficient vehicles. The operating agency is required to limit or discontinue use of the HOV lane by these vehicles if allowing access has degraded the operation of the HOV lane. The operation of the HOV lane is defined as being degraded if vehicles using the facility fail to maintain a minimum average operating speed 90 percent of the time over a consecutive 180-day period during the morning or evening weekday peak-hour periods. The minimum operating speeds are defined as 45 mph when the posted speed limit is 50 mph or greater and not more than 10 mph below a posted speed limit of 50 mph. Additional information on monitoring requirements is available in the FHWA HOV Program Guidance.

Link to HOV Performance Monitoring Process

The *HOV Performance Monitoring, Evaluation, and Reporting Handbook* provides a complete guide to developing and conducting HOV performance monitoring programs. Managing the operation of HOV lanes requires accurate information about the performance of the lanes, the general-purpose freeway lanes, and other supporting services and facilities. Thus, there is a close link between monitoring and evaluating HOV facilities and proactively managing the operation of HOV lanes. The information provided through HOV monitoring programs is also critical for assessing the impacts of possible changes in vehicle-eligibility requirements, vehicle-occupancy levels, and operating hours.

SAFETEA-LU requires that operating agencies limit or discontinue use of an HOV lane by exempt vehicles, including tolled vehicles and low-emission and energy-efficient vehicles, if allowing access has degraded the operation of an HOV lane. Degraded operation is defined as vehicles failing to maintain a peak-hour minimum average operating speed 90 percent of the time over a consecutive 180-day period. The minimum operating speeds are defined as 45 mph when the posted speed limit is 50 mph or greater and not more than 10 mph below a posted speed limit of 50 mph.

HOV performance monitoring programs follow the same process used to evaluate any transportation project. As illustrated in Figure 2.4, the first step in the process is to identify the goals and objectives for the HOV facilities in an area. These goals and objectives should flow from those articulated in state, metropolitan, and local transportation policies and plans. Measures of effectiveness are then identified for each objective, along with the corresponding data requirements. Data collection efforts are undertaken and the results are processed and analyzed. The results of the monitoring and analysis process are reported to the various stakeholder groups through a variety of methods. The results are used to make operating decisions, to determine if the project objectives are being met, and to enhance future planning activities and investment decisions.

Following this general approach will result in the development, implementation, and conduct of a meaningful HOV performance monitoring program. While some elements of this approach may vary in different areas, the basic procedures are appropriate for consideration in monitoring and evaluating all types of HOV facilities.

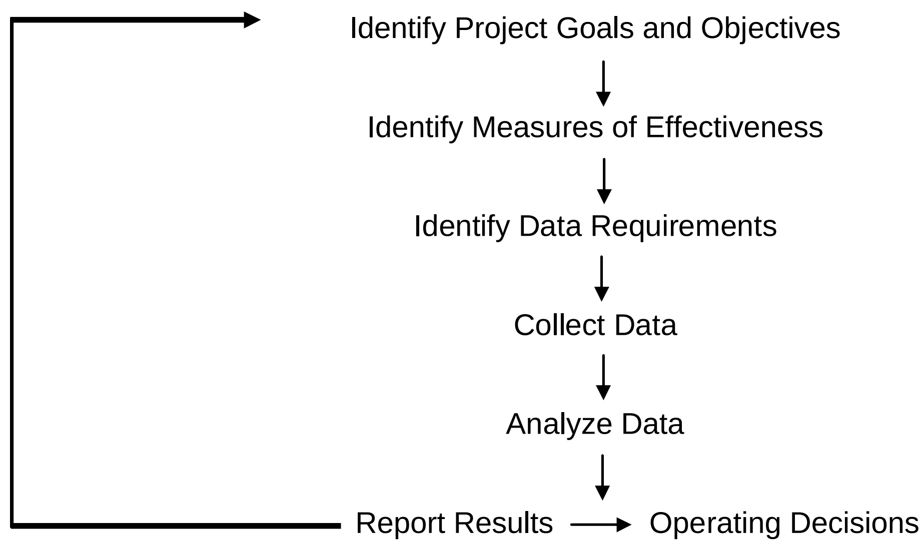


Figure 2-4. Steps in Developing and Conducting an HOV Performance Monitoring Program.

Link to HOV Operation and Enforcement Plans

Assessing changes in HOV eligibility requirements, vehicle-occupancy levels, and operating hours also has a link to HOV operation and enforcement plans. Elements commonly found in an HOV operation and enforcement plan related to the type and design of a project, the vehicles allowed to use the facility, the vehicle-occupancy requirement, the type and orientation of the transit services provided, the hours of operation, enforcement techniques and strategies, and incident management techniques. Developing and using an HOV operation and enforcement plan, along with a performance monitoring program, forms the basis for proactively managing the operation of an HOV lane.

Possible Issues with Managing the Operation of HOV Facilities

Possible issues may arise with the operation of HOV lanes. Examples of potential issues include demand exceeding capacity at a 2+ vehicle-occupancy level, not enough vehicles at a 3+ occupancy level, exempt vehicle demand exceeding capacity, and use by unauthorized vehicles.

An HOV facility with a 2+ vehicle-occupancy requirement may be at or reaching capacity. In this situation, recurring congestion in the HOV lane causes a reduction in travel speeds, travel time savings, and trip time reliability that HOV lane uses have come to expect. Possible approaches to address this situation include increasing the occupancy requirement to 3+, varying occupancy requirements by time-of-day, and tolling two-person vehicles while allowing 3+ vehicles to travel for free.

An HOV lane may be underutilized at a 3+ vehicle-occupancy level. Lowering a 3+ vehicle-occupancy requirement to 2+ may be considered in response to underutilization of an HOV facility at the 3+ level. Another approach would be to allow exempt tolled or low-emission and energy-efficient vehicles with 2 persons or with only the driver, while maintaining the 3+ HOV requirement.

Use of an HOV lane by exempt vehicles, including HOT vehicles and low-emission and energy-efficient vehicles, may cause the facility to become congested. As required by SAFETEA-LU, operating agencies must limit or restrict use of these exempt vehicles if their use degrades the operation of an HOV lane. Possible approaches for addressing this issue include variable pricing to reduce use during peak times, instituting a vehicle-occupancy requirement for these vehicles, and allocating use by other methods.

Issues may be encountered with the use of HOV lanes by unauthorized vehicles. These vehicles may include lower-occupant vehicles, non-qualifying hybrid vehicles, and law enforcement personnel in their own vehicles or in unmarked enforcement vehicles while not on duty. Enforcement of vehicle-occupancy requirements and other policies are critical to the successful operation of HOV facilities. Visible and effective enforcement promotes fairness and maintains the integrity of the HOV facility to help gain acceptance of the project among users and non-users. Strategies to address these issues include adding extra enforcement personnel, increasing the level of fines or adding other penalties, targeted compliance outreach efforts, and public information and outreach programs.

Process for Assessing Possible Changes in HOV Lane Operation

The process for assessing possible HOV operating strategies should be similar to the one used to plan a project and should emerge from an established monitoring program. Information on vehicle and passenger volumes, travel speeds, travel-time savings, violation rates, and crashes should form the basis of an ongoing monitoring and evaluation program. This information can be used to identify possible problems and potential changes in the operation of an HOV facility.

Figure 2.5 shows the key elements in the process for assessing, implementing, and monitoring possible changes in HOV operations. The exact steps may vary depending on the local situation. The multi-agency operation team typically plays an important role in identifying possible issues, analyzing alternatives, and implementing and monitoring changes.

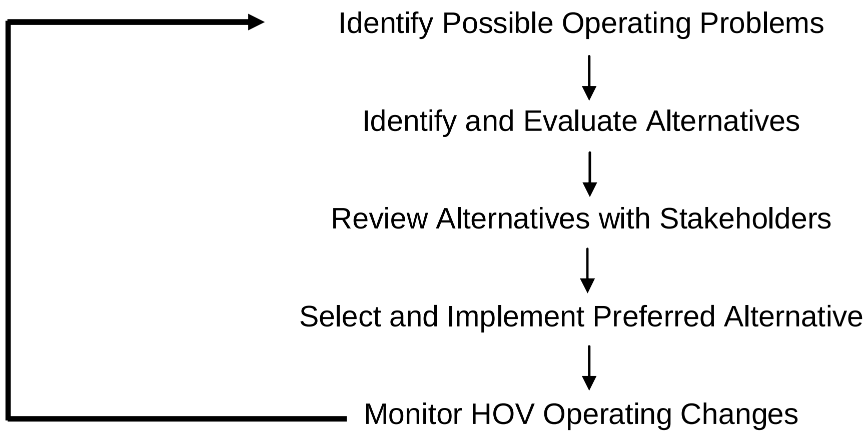


Figure 2.5. Process for Assessing, Implementing, and Monitoring Changes in HOV Operations.

Assessing Vehicle-Eligibility Requirements

Vehicle-Eligibility Requirements

Vehicle-eligibility requirements identify the types of vehicles allowed to use an HOV lane. Determining vehicle-eligibility is important, as it influences other decisions relating to the operation of an HOV facility. Potential vehicles may be classified as those meeting occupancy requirements, vehicles exempt from occupancy requirements, and vehicles not usually allowed regardless of occupancy levels.

HOV facilities are designed and operated to provide travel time savings and trip time reliability to buses, vanpools, and carpools to encourage individuals to use these modes over driving alone. Rather than creating disincentives to discourage drivers who travel alone, HOV lanes provide incentives and benefits to encourage commuters to change from driving alone to riding a bus, joining a vanpool, or carpooling.

In an attempt to maximize the use of HOV facilities and to meet other goals, operating agencies in some areas have expanded HOV lane use to include HOT vehicles, low-emission and energy-efficient vehicles, and other exempt vehicles not meeting occupancy requirements. Examples of these types of vehicles include motorcycles, bicycles, designated public transportation vehicles with only a driver, and marked law enforcement and emergency vehicles. SAFETEA-LU includes provisions related to the use of HOV lanes use by some types of exempt vehicles.

Commercial vehicles or semi-trucks are not allowed to use any HOV facility in North America, regardless of the number of passengers. This restriction has been applied for safety reasons and because allowing trucks would not encourage ridesharing or reduce VMT. Potential concerns with opening HOV facilities to commercial vehicles during peak and off-peak periods include lack of compatibility with policies and objectives to increase ridesharing and vehicle occupancy levels, lack of access points to meet the origins and destinations of trucks, design limitations which may not accommodate truck movements, and conflicts between commercial vehicles and HOVs.

Factors to Consider in Changing Vehicle-Eligibility Requirements

A number of factors may need to be considered in assessing possible changes in vehicle-eligibility requirements for an HOV facility. The exact factors and issues will vary by metropolitan area and by the type of change in the vehicle-eligibility requirements being considered. Typical factors include HOV project goals and objectives, facility type and length, design treatments, congestions levels in the HOV lane and the general-purpose freeway lanes, bus operations, system connectivity, and supporting services and facilities. Other important factors to consider include safety, enforcement, and perceptions of HOV lane users, non-users, and policy makers. Additional factors associated with considering HOT vehicles include target markets, pricing alternatives, the cost of the tolling infrastructure and operating strategies, use of revenues generated from the project, identifying qualifying vehicles, potential equity concerns, and methods to restrict use. Equity issues may also need to be considered with allowing low-emission and energy-efficient vehicles along with techniques to identify qualifying vehicles, and methods to restrict use. The elements discussed in this section can be used to help guide consideration of changes in vehicle-eligibility requirements on HOV facilities.

Assessing Possible Changes in Vehicle-Eligibility Requirements

The factors noted previously can be used to assess possible changes in vehicle-eligibility requirements, including adding other HOVs, adding HOT vehicles, and adding low-emission and energy-efficient vehicles. Allowing vanpools and carpools to use a bus-only freeway HOV lane or adding carpools to an HOV lane open to buses and vanpools represents the first scenario. All of these user groups qualify as HOVs. This scenario may be considered if there is available capacity on an HOV lane that does not yet allow all types of HOVs. Key issues to consider in this scenario include congestion levels in the HOV lane and the general-purpose freeway lanes, possible design and operation limitations, and safety concerns. The need for additional enforcement to monitor carpool occupancy requirements should also be examined.

Allowing lower or single-occupant vehicles to use an HOV lane for a fee represents a second scenario. Allowing HOT vehicles to use an HOV lane may be considered for a number of reasons. These reasons may include using available capacity and managing congestion in an HOV lane with a 2+ vehicle-occupancy requirement. In this case, two-person carpools may continue to be able to use the HOV lane for a fee, while the vehicle-occupancy level for non-paying HOVs is increased to 3+. In other cases, HOT project may be implemented to increase use on an HOV lane with available capacity, to generate revenues for transit and transportation improvements, and to provide additional travel options.

As noted previously, SAFETEA-LU includes specific provisions addressing HOV vehicle use of HOV lanes. Key issues to consider with allowing HOT vehicles include project goals and objectives, congestion levels in the HOV lane and the general-purpose freeway lanes, and enforcement of both toll payments and vehicle-occupancy requirements. Other factors to consider focus on the target markets, the toll collection infrastructure costs and operation, pricing levels, the use of revenues, potential equity concerns, and methods to limit use if the HOV becomes congested.

Allowing low-emission or energy-efficient vehicles to use an HOV lane represents a third scenario. As noted previously, the Clean Air Act Amendments of 1990 and the Transportation Equity Act for the 21st Century (TEA-21) allowed states to exempt Inherently Low-Emission Vehicles (ILEVs) from HOV occupancy requirements. SAFETEA-LU continues to allow states to provide ILEVs access to HOV lanes without meeting occupancy requirements until September 30, 2009. SAFETEA-LU also expands the exempt vehicle classification to include other low-emission and energy-efficient vehicles, including some types of hybrids as defined by EPA. These vehicles must be certified by EPA and marked according to EPA guidance. States must establish a program for identifying vehicles and for enforcing regulations related to their use. These vehicles may be allowed before September 30, 2009 if they pay a toll. The SAFETEA-LU language states that this toll could be “no toll” or a toll lower than the fee charged for other exempt vehicles.

Allowing low-emission and energy-efficient vehicles to use an HOV lane may be considered if an HOV lane is underutilized. Based on the experience to-date, however, it appears that the interest in allowing low-emission and energy-efficient is coming from state legislators and other policy makers, rather than from individuals at operating agencies. Factors to consider in assessing low-emission and energy-efficient vehicle use of an HOV lane include the project goals and objectives, congestion levels, establishing a method to certify and identify eligible vehicles, enforcement, and the perceptions of HOV lane users, non-uses, and policy makers. A method to restrict use is also needed based on the requirements of SAFETEA-LU.

Assessing Vehicle-Occupancy Requirements

Possible Vehicle-Occupancy Requirements

If carpools are allowed to use an HOV facility, the vehicle-occupancy requirement must be established. The planning process for an HOV lane typically includes an analysis of the demand for a facility at different vehicle-occupancy levels and the impact these requirements will have on traffic flow. The goal is to set the occupancy requirement at a level that will encourage the use of carpooling, vanpooling, and taking the bus, but will not create a level of demand that makes the lane congested.

During the late 1970s and early 1980s, FHWA used a 3+ definition for carpools on HOV projects funded through federal programs. As a result, HOV projects opened during that time period, including the Shirley Highway HOV lanes in northern Virginia and the El Monte busway on the San Bernardino Freeway in Los Angeles, used a 3+ vehicle-occupancy requirement. SAFETEA-LU defines the occupancy requirement for use of HOV lanes as no fewer than two occupants per vehicle, with exceptions for specific exempt vehicles.

Changes in vehicle-occupancy levels may be needed over the life of an HOV facility. For example, some HOV lanes using a 2+ requirement have experienced congestion resulting in reductions in trip time reliability and slower travel times. This situation happened on both the I-10 West and U.S. 290 HOV lanes in Houston. To address this problem, the vehicle-occupancy requirements were increased to 3+ during the morning and afternoon peak-hours. Increasing vehicle-occupancy levels is not an easy change to make. Public and political pressure may limit the ability of operating agencies to consider increasing occupancy levels.

Currently, the majority of operating HOV facilities use a 2+ vehicle-occupancy requirement. A 3+ occupancy requirement is in use on a few facilities. Three projects – the El Monte Busway on the San Bernardino Freeway in Los Angeles and the I-10 West and U.S. 290 HOV lanes in Houston – use a 3+ occupancy requirement during the morning and afternoon peak-hours and a 2+ requirement at other times. Although no HOV facility currently requires four or more (4+) occupants, this level has been used in the past.

Two or more persons (2+) per vehicle represent the lowest level of carpooling. SAFETEA-LU uses a two-person occupancy definition for use of an HOV lane. Forming a two person carpool is much easier than forming a three- or four-person carpool. Many two person carpools are comprised of family members, co-workers, or friends. While infants and children qualify as the second person, a pregnant woman does not qualify as two. The vast majority of HOV lanes open to carpoolers use a 2+ occupancy requirement. If an HOV lane becomes too congested at the 2+ occupancy level, increasing the requirement to 3+ may be considered. As noted previously, public and political perceptions are critical to consider in assessing the potential for increasing vehicle occupancy levels.

The next level for defining a carpool is to require three or more persons (3+) per vehicle. Vehicle volumes at the 3+ level are usually lower than at a 2+ requirement, as it is more difficult for individuals to form three-person carpools, so some potential carpoolers may not be able to use a facility at a 3+ requirement.

A four or more (4+) persons per vehicle requirement was used during the initial stages of the Shirley Highway HOV lanes in northern Virginia and the I-10 West HOV lane in Houston. No HOV lane in North America currently uses this occupancy level. It is difficult for most individuals to not only form carpools with four or more persons, but also to sustain four-person carpools over time. Many metropolitan areas probably may not have enough demand at the 4+ level to make this a viable option, especially during the early stages of a project.

Another approach is to change the HOV occupancy requirement by time-of-day. This technique represents one approach to managing demand on an HOV lane. This approach is used on the El Monte Busway in Los Angeles and the I-10 West and U.S. 290 HOV lanes in Houston. This approach may initially be confusing to users and to enforcement personnel. The experience with the three current projects indicates that regular users understand the requirements, although additional enforcement is still typically needed during the transition periods.

Factors to Consider in Changing Vehicle-Occupancy Requirements

Many of the factors to be considered in assessing possible changes in vehicle-occupancy levels are similar to those described previously with changes in vehicle-eligibility requirements. There are differences, however, as changes in occupancy levels focus on carpool use of HOV facilities. Since carpools are already included in the vehicle-eligibility requirements, the factors associated with the type and length of an HOV lane, design limitations, and safety, are not typically considered in assessing possible changes in vehicle-occupancy requirements, unless a higher occupancy level was used as a way of limiting vehicle volumes due to design or safety concerns. Potential factors to consider in changing vehicle-occupancy requirements include the project goals and objectives, the level of congestion in the HOV lane and the general-purpose freeway lanes, the number of two-person and three-person carpools, bus operations, system or regional connectivity, enforcement, and the perceptions of users, non-users, and policy makers.

Assessing Vehicle-Occupancy Levels

As discussed previously, the goal of an HOV facility is to provide travel time savings and travel time reliability to buses, vanpools, and carpools. The vehicle-occupancy requirement should be maintained at a level that will encourage use of the facility and the formation of new carpools, but that will not create a demand level that would make the lane congested. An ongoing HOV performance monitoring program provides the information needed to proactively manage the operation of an HOV lane and to assess possible changes in vehicle-occupancy requirements. The sketch planning and travel forecasting models used in the initial planning process for an HOV project may also be appropriate for use in assessing possible changes in occupancy requirements.

The factors noted above can be applied to assess possible changes in vehicle-occupancy requirements. Three scenarios are presented for changes in vehicle-occupancy requirements. These scenarios are increasing vehicle-occupancy levels from 2+ to 3+, decreasing occupancy requirements from 3+ to 2+, and implementing variable time-of-day occupancy requirements (3+ peak-hours/2+ off-peak). These scenarios will have different impacts on different user groups.

The first scenario focuses on increasing the vehicle-occupancy requirements on an HOV lane from 2+ to 3+ during all operating hours. This option may be considered when an HOV lane with a 2+ requirement becomes congested on a recurring basis, resulting in HOV lane users losing the travel time savings and the trip time reliability they have come to expect. As discussed previously, the exact measures that trigger considerations of increasing vehicle-occupancy levels may vary by area. The measures, which may focus on vehicle volumes, LOS, slower travel speeds, longer travel times, and loss of trip time reliability, should be included in an HOV performance monitoring program.

The key issues to be examined in assessing an increase in vehicle-occupancy levels are the level of congestion in the HOV lane and the general-purpose freeway lanes, the number of two-person and 3+ carpools, the number of buses and the level of bus service operated on the lane, and the perceptions of HOV lane users and policy makers. Other important factors include enforcement, regional connectivity, HOV goals and policies, and the perceptions of motorists in the general-purpose freeway lanes. There are no case study examples of increasing the vehicle-occupancy level on an

HOV lane from 2+ to 3+ during all operating periods. It appears that concerns over possible negative reactions from HOV lane users and policy makers have limited consideration of increasing occupancy levels in some areas.

The second scenario focuses on lowering the occupancy level on an HOV lane from 3+ to 2+ during all operating hours. This option may be considered in response to low volumes of HOVs at the 3+ level. This situation was experienced on the I-10 West HOV lane in Houston in the mid-1980s, when a 4+ authorized carpool designation was initially used. The requirement was changed to 3+ authorized carpools and then to 2+ carpools with no authorization requirement. Lowering the occupancy level may also be considered based on the perception that an HOV lane is underutilized. Key factors that may need to be considered in lowering the vehicle-occupancy requirement include vehicle volumes in the HOV lane, the number of two-person carpools in the general-purpose freeway lanes, possible design or operating limitations, bus operations, enforcement needs, and the perceptions of users, non-users, and policy makers.

The third scenario focuses on the use of variable vehicle-occupancy requirements by time-of-day. This option would use a 3+ occupancy requirement during the morning and afternoon peak-hours and a 2+ requirement during the other operating periods. This option may be considered in response to congestion occurring in the HOV lane during the peak-hours, but not at other times. Variable occupancy requirements are currently in use on the I-10 West and the US 290 HOV lanes in Houston and the El Monte Busway in Los Angeles. The use of a variable-occupancy requirement may be more acceptable to both HOV lane users and policy makers than increasing from a 2+ to a 3+ occupancy level during all operating hours. Variable occupancy requirements may require higher enforcement levels, especially during the transition periods.

Assessing HOV Operating Hours

Alternative HOV Operating Hour Scenarios

Three general operating hour scenarios are typically used with HOV facilities. These scenarios are 24 hour/7 days a week, extended hours, and peak-only. The first approach maintains the HOV designation and operation of a facility on a 24-hour basis, seven days a week (24/7). In these cases, the HOV lane is open during all operating periods. Continuous 24/7 operation tends to be found with busways in separate rights-of-way and with freeway concurrent flow and exclusive two-way facilities. As could be expected, this approach is not used with contraflow or exclusive reversible HOV facilities. Examples of HOV facilities operating on a 24/7 basis include the bus-only facilities in Pittsburgh and Ottawa; the exclusive two-directional HOV lanes on I-84 in Hartford and the El Monte Busway in Los Angeles; and most of the concurrent flow HOV lanes in Southern California and many of the concurrent flow HOV lanes in the Puget Sound region.

The 24/7 operating scenario is based on the premise or policy that HOVs should be provided with priority treatment at all times. Since congestion or incidents may occur at any time, the 24/7 designation provides HOVs with travel time savings and trip time reliability throughout the day and night. This operating scenario also allows travelers to use the HOV facility during non-commute hours. For example, recreational trips often include more than one person in a vehicle. The 24/7 operating scenario allows individuals making recreational or other non-work trips to use the HOV lanes, which may promote wider acceptance of the facility. Off-peak use by some of these travelers may help encourage them to change to carpooling, vanpooling, or taking the bus to be able to use the HOV lanes for work trips during the peak-periods.

The 24/7 designation may also help to minimize potential motorist confusion on whether or not the HOV designation is in effect. Since the vehicle-occupancy requirement is always in effect, motorists know they should not use the lane unless they have the correct number of passengers. As a result, the continuous HOV designation makes enforcement easier, as there is no question on the operating requirements. Twenty-four hour operation may simplify signing and lane markings.

Limitations and issues associated with 24/7 operation of an HOV facility include possible negative public perception if the facility is not well used during off-peak-hours, the need for ongoing enforcement, and potential safety concerns.

Extended operating hours encompass a major portion, but not all, of the day. In most cases, HOV lanes using extended hours are open for major portions of the morning and afternoon into the early evening. Although the exact hours of operation vary by facility, this scenario often encompasses the time periods from 6:00 a.m. to 11:00 a.m. and 3:00 p.m. to 7:00 p.m. These times correspond to the major commuting periods, when traffic congestion is heaviest.

Extended operating hours are typically used with exclusive reversible HOV lanes and contraflow lanes. Examples of specific facilities using this operating approach include the exclusive reversible HOV lanes in Houston, San Diego, Denver, Minneapolis, and northern Virginia, and the contraflow lanes in Dallas and Boston.

Extended operating hours provide HOVs with travel time savings and travel time reliability during the periods when the general-purpose freeway lanes are most likely to be congested. This approach may also represent the most logical or the only realistic scenario for some types of HOV facilities. For example, extended hours are often the most appropriate approach with exclusive reversible facilities and contraflow lanes open to carpools, vanpools, and buses.

Potential limitations of extended operating hours include confusion on the part of motorists, which makes enforcement more difficult, and the need for additional signing and pavement markings. The use of a facility during non-HOV operations may influence these concerns. If an HOV facility is closed during non-HOV operating hours, which is usually the case with exclusive reversible lanes; these potential limitations may not be major problems. These limitations may be a concern on a concurrent flow HOV lane that is open to general traffic during non-HOV operating periods.

The final operating scenario is to use the HOV lane only during the peak-periods in the morning and afternoon. Peak-period operation is defined more narrowly than the extended hours, usually encompassing the hours from 6:00 a.m. to 9:00 a.m. and 4:00 p.m. to 6:00 p.m., although variations are found in these hours. Some facilities use the HOV restriction only in the peak-direction of travel, while others may operate only in the morning peak-period, peak-direction of travel.

Peak-period operating hours are used primarily with concurrent flow and contraflow HOV lanes. Currently, concurrent flow lanes in Minneapolis, Miami, Fort Lauderdale, Orlando, San Francisco, and San Jose are restricted to HOVs only during the peak-hours. The contraflow lanes on Rt. 495, the Long Island Expressway, and the Gowanus Expressway in New York operate only in the morning peak-period in the peak-direction of travel into Manhattan.

Peak-period only operations present many of the same advantages, limitations, and issues as extended operations. Advantages include providing priority to HOVs at critical times of the day and addressing specific bottleneck problems. Depending upon the use of the facility during non-HOV operating periods, possible limitations include confusion on the part of commuters, more difficult enforcement, safety issues, and increased signing needs.

Factors to Consider in Changing HOV Operating Hours

Factors to consider in assessing possible changes in HOV operating hours are similar to those discussed previously with changes in vehicle-eligibility requirements and vehicle-occupancy levels. Potential factors include the level of congestion in the HOV lane and the general-purpose freeway lanes, the project goals and objectives, the type of HOV facility, and use of the lane during other times of the day. Additional factors address bus operations, system connectivity, enforcement, safety, changes in signing, operating costs, benefits, and perceptions of users, non-users, and policy makers. As noted previously, these factors address both technical elements and public and political acceptance issues.

Assessing Possible Changes in HOV Operating Hours

The factors presented in the previous section can be applied to assess possible changes in operating hours. Changes in five HOV operating hour scenarios are described. These scenarios are lengthening peak-period operations, changing peak-period or extended HOV operations to 24/7 operation, reducing peak-period or extended operation, reducing 24/7 operation to peak-period or extended operating hours, and modifying 24/7 operation to open the HOV lanes to general-purpose traffic in the evenings or on weekends. These scenarios will have different impacts on different user groups. It is important to examine the perceptions of these different groups to potential changes, to assess possible impacts, and to conduct outreach efforts to various user groups and policy makers when changes in operating hours are being considered.

The sketch planning, travel demand models, and simulation techniques used in the initial planning for an HOV facility may be appropriate for use in assessing these scenarios or other possible changes in the HOV operating hours. Data collected through ongoing HOV performance monitoring programs can be used with these models or as input to examining the issues presented in this section. The factors highlighted in the previous section should be examined when possible changes in HOV lane operating hours are being considered.

These factors include both technical issues and the reactions or perceptions of HOV lane users, non-users, and policy makers. The five scenarios will have different impacts on HOV lane users and travelers in the general-purpose freeway lanes. As noted previously, the political and policy ramifications of any change should be key considerations. Since transportation agencies are public agencies, supported by public funds, consideration should be given to public and political support, which is critical for any changes in operating hours.

The first scenario focuses on extending peak-period HOV lane operating hours. Possible changes might include starting the HOV operations earlier in the morning or in the afternoon or maintaining the HOV designation later in the morning or afternoon/evening. These options may be considered in response to increasing levels of congestion in the HOV lane at the start and the end of the current operating hours, plans to expand bus service into these time periods or initiate BRT, and changes in travel and commute patterns due to new developments and employment locations.

Depending on the type of HOV lane and current use during non-HOV operating hours, this scenario has the greatest potential to raise concerns from single-occupant vehicles and traffic in the general-purpose freeway lanes. Experience to date indicates that these user groups are often vocal in their opposition to any expansion of HOV operating hours. Experience further indicates that these groups are often able to obtain support from policy makers for their position. The two recent examples of attempts to extend HOV or HOT operating hours in Minneapolis and Fort Lauderdale highlight the need for outreach efforts to users, non-users, and policy makers to build a consensus for possible extensions in HOV operating hours. There are no recent case study examples of situations where the operating hours on an HOV lane that is open to general-purpose traffic during non-HOV time periods have been extended.

The second scenario focuses on changing peak-period or extended HOV operating hours to 24/7 operation. This option may be considered in response to increasing levels of traffic congestion in a corridor or area over longer periods of the day and evening. Other factors that may influence consideration of changing to 24/7 operating hours include the implementation of a BRT system, the location of new businesses with significant numbers of employees on different work shifts, new recreational or planned special event developments, and the adoption of policies supporting priority treatments for HOVs at all times.

The key issues in assessing a change from peak-period or extended HOV operating hours to 24/7 operation will be primarily the same as those discussed under the previous scenario. If the HOV lane is open to general-purpose traffic during other times, the main issue will most likely be addressing concerns from single-occupant drivers, the public, and policy makers. This situation occurred with the implementation of the MnPASS project on I-394 in Minneapolis. Vocal opposition from travelers in the corridor and the public to the 24/7 designation with the MnPASS project on I-394 resulted in a change back to the previous peak-period, peak-direction operating hours on the concurrent flow HOV lanes.

The third scenario focuses on reducing peak-period or extended HOV operating hours. Possible changes include starting the HOV designation later in the morning or afternoon and ending the HOV operating time earlier in the morning or evening. These options may be considered in response to actual low use levels during these time periods or perceptions of policy makers and the public related to use levels during these time periods. The impact of this scenario on HOV lane users and travelers in the general-purpose freeway lanes will depend primarily on the type of HOV lane, the anticipated use of the lane during the previous HOV operating hours, current vehicle volumes in the HOV lane, and the level of congestion in the general-purpose freeway lanes.

HOV lane users and public transportation services may be negatively impacted by reducing peak-period or extended operating hours. Most peak-period HOV lanes have high utilization levels throughout the operating periods. HOV lanes with extended operating hours are also well used. Further, HOV lane users may view a reduction in current operating hours as a step toward eliminating the HOV designation altogether. Motorists in the general-purpose freeway lanes and the public may view this change positively if they are able to use the HOV lane during the previous HOV-only operating period. This type of change may not have a significant impact on any user group if the HOV lane is closed to all traffic during the previous HOV operating hours. For example, the operating hours on the exclusive reversible HOV lanes in Houston have been modified slightly over the years, including lengthening and then reducing extended operating hours. These minor changes in operating hours at times well before or after the peak-periods on HOV lanes that are closed to all traffic during non-HOV operating periods do not seem to have had a major impact on HOV lane users or non-users.

The fourth scenario focuses on reducing 24/7 HOV operating hours to extended or peak-period operating hours. This change may be considered in response to low use levels during certain time periods or perceptions on the part of the public and policy makers that the HOV lanes are under utilized at these times. This scenario represents a major change in the HOV lane operating philosophy for an area. Rather than providing priority treatment for HOVs at all times, this change would focus primarily on peak-period commute trips. There are no case study examples of changing 24/7 HOV operations to extended or peak-period hours.

The final scenario examines opening HOV lanes to general-purpose freeway traffic in the evenings or on weekends. Interest has periodically been expressed by policy makers and the public in some areas related to opening HOV lanes that operate on a 24/7 basis to general-purpose traffic in the evenings and on weekends. This interest may be the result of perceived or actual lower vehicle volumes in the HOV lanes during these time periods.

Assessments of opening HOV lanes during these time periods have been conducted in Los Angeles in 1999 and the Puget Sound region in 2002. In Los Angeles, the study recommended that no changes be made in the operating hours. In the Puget Sound region, a pilot project was implemented in 2003 opening HOV lanes on the east side of Seattle to general-purpose traffic from 7:00 p.m. to 5:00 a.m. seven days a week.

Case Studies

Changes in Vehicle-Eligibility and Vehicle-Occupancy Requirements on the I-10 West HOV Lane in Houston

The I-10 West HOV lane, located on the west side of Houston, Texas, is 13 miles in length. It is a one-lane, barrier-separated, reversible HOV lane located in the freeway median. There are two major park-and-ride lots located in the corridor with direct access ramps to the HOV lane. The development and operation of the I-10 West HOV lane and the supporting components represent the joint effort of TxDOT and METRO.

The vehicle-eligibility and the vehicle-occupancy requirements on the I-10 West HOV lane have been changed a number of times since the facility opened in 1984. Some of these changes were based on initial low use of the lane due to limited vehicle-eligibility requirements, while others were due to the success of the lane, which resulted in congestion in the lane during the peak-hours.

Only buses and authorized vanpools were eligible to use the I-10 West HOV lane when it was first opened in 1984. The authorization process included insurance requirements, driver training, and vehicle inspection. The vehicle-eligibility requirement and the authorization process reflected the approach used on the I-45 North contraflow demonstration project, which was opened in 1981 as the first HOV facility in Houston.

Approximately 50 vehicles used the lane during the morning peak-hour with the bus and authorized vanpool vehicle-eligibility requirement. Due to this low level of use, the lanes were opened to authorized 4+ carpools after six months of operation. This change added approximately 10 vehicles to the morning peak-hour volume on the lane.

The vehicle-occupancy level was lowered again after six months to authorized carpools with three or more occupants. This change added some 100 vehicles to the morning peak-hour traffic stream. In 1986 the vehicle-occupancy level was lowered to 2+ carpools and the authorization requirement was discontinued. The morning peak-hour volumes increased to approximately 1,200 vehicles after this change.

During this time, morning peak-hour vehicle volumes on the I-10 West HOV lane were regularly reaching or exceeding 1,500. The congestion resulting from these volumes, coupled with the design of the facility, reduced the travel time savings and travel time reliability bus riders, carpoolers, and vanpoolers had come to expect. In response to lower travel speeds in the HOV lane and complaints from bus passengers, the vehicle-occupancy requirement was increased in October 1988 from 2+ to 3+ during the period from 6:45 to 8:15 a.m. The 2+ occupancy requirement was maintained at other operating times.

The morning peak-hour vehicle volume dropped from approximately 1,400 to 510 after the change. This decline represented a 64 percent reduction in vehicle volumes. A corresponding drop of 33 percent in person volume also occurred. Use levels during the morning peak-hour increased to 660 vehicles in March of 1989. Although the vehicle and passenger volumes declined during the morning peak-hour, the AVO increased. The AVO was 3.1 prior to the change, 4.7 in March 1989, and 4.5 in December 1989.

Further modifications have been made in the vehicle-occupancy requirements on the I-10 West HOV lane. In May 1990, the 3+ restricted period was changed slightly to 6:45 - 8:00 a.m. In September 1991, the 3+ requirement was implemented from 5:00 to 6:00 p.m. By 1996, morning peak-hour carpool volumes had increased to approximately 858 vehicles.

In the late 1990s, METRO and TxDOT staff began considering the potential of allowing two-person carpools to use the I-10 West HOV lane during the 3+ restricted period for a fee, reflecting the ongoing interest in maximizing use of the lane to benefit travelers. A demonstration project to test allowing two-person carpools to use the HOV lane for a $2.00 per trip fee during the 3+ occupancy requirement periods – 6:45 a.m. to 8:00 a.m. and 5:00 p.m. to 6:00 p.m. The demonstration, called *QuickRide*, which uses the automatic vehicle identification (AVI) system for electronic toll collection (ETC), was implemented at the end of January 1998. Individuals are required to register for the program and must have an active electronic tag account.

Daily *QuickRide* use has grown slightly over time. In 1998, an average of 103 daily *QuickRide* participants used the I-10 West HOV lanes. By 1999, some 121 participants were using the program daily. Use levels from 2000 through 2005 remained relatively constant, averaging between 120 and 128 vehicles during the 3+ restricted peak-hour. Use levels are higher in the morning on the I-10 West HOV lanes, with some 68 percent of the daily participants traveling in the lane in the morning peak-hour.

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

Changes in Vehicle-Eligibility and Vehicle-Occupancy Requirements on the El Monte Busway in Los Angeles

The El Monte Busway on the San Bernardino Freeway is located in eastern Los Angeles County, stretching from El Monte to downtown Los Angeles. The Busway was opened in 1973 and 1974, making it one of the earliest HOV facilities in the country. A one-mile extension into the downtown area was opened in 1989, providing a link to the Los Angeles Union Railroad Station.

The two-way HOV facility includes two design treatments. From El Monte to I-710, the Busway is located in the center of the I-10 Freeway, separated from the general-purpose lanes by a 10.5-foot painted striped buffer. From I-710 to downtown Los Angeles, the Busway is located adjacent to, but separated from, the I-10 Freeway.

The construction, financing, and operation of the Busway has been guided by a 1971 agreement and a series of amendments between the Southern California Rapid Transit District (SCRTD), now known as the Los Angeles County Metropolitan

Transportation Authority (MTA), and the State of California Department of Public Works, now Caltrans. The facility was opened to buses in January 1973. Three-person carpools and vanpools were allowed to use the Busway in August 1974 in response to an SCRTD bus operators strike. Bus-only operations were resumed in October 1974 when the strike was settled.

The number of buses using the lane and ridership levels increased significantly during the first three years of operation. From 1973 to 1976, the number of buses using the lane in the morning peak-hour, peak-direction of travel increased from 21 to 64, with a corresponding increase in passengers from 766 to 3,044. Daily bus ridership levels increased from 1,000 to 14,500 passengers during the three-year bus-only operations phase from 1973 to 1976. Allowing 3+ carpools on the facility in October 1976 did not cause a noticeable change in bus ridership levels. Overall daily utilization levels increased from approximately 14,420 bus riders, carpoolers, and vanpoolers in October 1976 to 20,440 in April 1978.

Use of the Busway continued to grow during the 1980s and 1990s, with peak-hour volumes averaging between 835 to 1,500 vehicles and 5,800 to 7,100 passengers. Bus ridership and carpooling over the two decades was influenced by a variety of factors including the status of the local economy, the oil crisis and the Arab oil embargo, the cost of gasoline and parking, and changes in employment locations and levels.

In 1999, the California legislature approved Senate Bill (SB) 63 lowering the vehicle-occupancy requirement on the Busway to 2+ persons. Caltrans District 7 was responsible for implementing the 2+ occupancy requirement change directed in SB 63 and for monitoring the effects of the legislation. Caltrans established the SB 63 Implementation Committee, comprised of representatives from appropriate agencies, to help support and coordinate the change.

Caltrans monitored the affects of SB 63 on the operation of the Busway and the freeway. The results of the monitoring effort were summarized in regularly issued fact sheets and presented in an Executive Summary. The Caltrans monitoring effort focused primarily on vehicle volumes, person movement, travel speeds, and occupancy violation rates. A separate traffic safety analysis was also conducted by Caltrans. Foothill Transit monitored the affects of the 2+ demonstration on bus operating speeds, bus travel-times, on-time performance, service overtime, safety incidents, and customer complaints.

Prior to completion of the AB 769 demonstration project, Caltrans representatives met with the Implementation Committee to discuss ongoing operations of the El Monte Busway. Based on input from all stakeholders, an operational report and request was submitted to FHWA for consideration since the 3+ peak/2+ off-peak operation was identified as a significant change from the original operation of the Busway. FHWA approval was granted and the permanent dual 3+/2+ occupancy requirement continues in use today.

Peak-hour travel speeds in the Busway were negatively affected during the 2+ demonstration, declining from freeflow conditions at 65 mph to approximately 20 mph in the morning westbound direction. In the afternoon eastbound direction, travel speeds on the Busway decreased from 65 mph to 27 mph during the first month of the demonstration and then increased to 40 mph for the duration of the test. A significant corresponding increase in travel speeds did not occur in the general-purpose lanes.

The number of vehicles on the Busway in the morning peak-hour increased from 1,100 to 1,600 during the 2+ demonstration, but the number of persons carried declined from 5,900 to 5,200. Thus, more vehicles carrying fewer people were on the Busway. Trends in the afternoon peak-period were different with hourly vehicle volumes increasing from 990 to 1,500 and person volumes increasing from 5,100 to 5,600. Vehicle volumes in the general-purpose freeway lanes increased slightly or remained relatively constant. Thus, lowering the vehicle-occupancy rate on the Busway, and the subsequent increase in 2+ carpools, did not have a corresponding affect of lowering vehicle volumes in the general-purpose freeway lanes.

In the morning peak period, total vehicle volumes increased by 15 percent with the change to the 2+ operating requirement, but total person volumes increased by less than 1 percent. Similar trends were experienced in the afternoon peak-hours, with total vehicle volumes increasing by 9 percent and total person volumes increasing by less than 1 percent.

Bus operating speeds slowed during the 2+ demonstration affecting overall bus travel times and on-time performance. Historically, buses operating on the Busway experienced freeflow speeds, averaging 65 mph prior to the 2+ demonstration. As noted previously, during the 2+ period, travel speeds for all vehicles in the Busway declined to 20 mph in the westbound direction during the morning peak period. In the afternoon peak-period travel speeds in the eastbound direction initially decreased to 27 mph and then stabilized at around 40 mph.

The slower operating speeds resulted in longer bus travel times and reduced on-time performance. Bus travel times from the eastern end of the Busway into downtown Los Angeles were 20 to 30 minutes longer during the morning peak-period. Schedule adherence and on-time performance dropped from an average of 88 percent in the fall of 1999 to 48 percent in May 2000. The consistent 20-minute travel time savings provided to bus passengers over vehicles in the general-purpose lanes was lost during the 2+ demonstration.

The slower bus operating speeds, longer travel times, and reduced on-time performance also caused declines in service productivity. Bus operators finishing their runs late were frequently not able to return for a second trip in the corridor. To fill these voids and to maintain schedules, extra buses and operators had to be dispatched when available. At some points during the demonstration, as many as 10 extra buses and operators were staged in the downtown area to help ensure that trips were not missed and schedules were maintained. Foothill Transit estimated that the personnel and fuel costs associated with providing these extra buses were approximately $1,250 per weekday. Over the course of the demonstration, Foothill Transit allocated close to $150,000 for the extra buses and operators.

The changes in vehicle-occupancy levels significantly affected the violation rates on the Busway. The violation rates declined during the 2+ demonstration, as 2+ person carpools which would previously have been cited became authorized users. Field observations, reports from Foothill Transit operators, and interviews with CHP officers indicated that the number of buffer violations increased significantly during the 2+ demonstration. In most cases, these violations were due to carpools exiting the Busway illegally to avoid the congestion and slow travel speeds in the lane.

Caltrans, Foothill Transit, the MTA, and other agencies received letters, telephone calls, faxes, and E-mails related to the change to the 2+ occupancy level required by SB 63. The overwhelming majority of the correspondence and calls were critical of the change, with individuals complaining about the negative effects it had on their travel. Caltrans and Foothill Transit received the largest number of complaints. Although no total official log was maintained, it appears that at least 1,000 comments were received by the various agencies. Foothill Transit alone received almost 900 complaints from passengers.

Bus passengers were the most vocal group responding to the effects of the 2+ demonstration. Bus Riders noted 20- to 30-minute longer travel times with the 2+ requirement. Individuals in existing 3+ carpools also reported longer travel times and delays. It does not appear that motorists in the general-purpose freeway lanes were vocal in support of the 2+ demonstration. This lack of interest may be logical given the fact that the change to the 2+ requirement did not noticeably improve travel conditions in the freeway lanes.

Articles in the Los Angeles Times and the San Gabriel Tribune described the effects of the 2+ occupancy requirement on the Busway and the change back to a 3+ requirement during weekday peak periods. During the demonstration, media coverage focused on the increased congestion levels in the Busway, the decline in travel speeds, and the increase in trip times

Expansion of the I-15 HOV Lanes in San Diego to Include HOT Vehicles

The two-lane exclusive HOV facility on I-15 was opened in 1988 with a 2+ vehicle-occupancy requirement. The I-15 HOV lane is located on the northeast side of San Diego, California, and is approximately eight miles in length. There is one entrance and one exit. The lanes were open in the southbound direction from 6:00 to 9:00 a.m. and in the northbound direction from 3:00 to 6:30 p.m. and were closed at other times.

In 1996, approximately 1,800 vehicles were using the HOV lanes during the morning peak-hour, and the lanes were operating at a level-of-service C. During the same period, the adjacent four freeway lanes were carrying 12,000 vehicles, operating at a level-of-service F.

Interest in considering pricing on the HOV lanes emerged during the examination of potential transportation control measures in the regional air quality plan. The pricing approach was supported by the mayor of a suburban community in the corridor. This individual was elected to the State Assembly and sponsored the enabling legislation needed for the project.

The I-15 Freeway HOV Pricing project was one of the congesting pricing demonstrations funded as a result of the ISTEA of 1991. The project included two phases to test allowing single-occupant vehicles to use the I-15 HOV lanes for a fee. The objectives of the demonstration included testing value pricing as a method of managing congestion on the freeways lanes, managing demand on the HOV lanes, expanding transit and ridesharing services in the corridor, and enhancing air quality in the region.

The initial demonstration project and the ongoing HOT project represent the joint efforts of the San Diego Council of Governments (SANDAG), the California Department of Transportation (Caltrans), the Metropolitan Transit Development Board (MTDB), and the California Highway Patrol (CHP). SANDAG is responsible for overall project management, Caltrans operates the HOV lanes, MTDB operates bus service in the corridor, and CHP is responsible for enforcement.

The initial demonstration project, *ExpressPass*, began in 1996. During this phase a limited number of monthly permits were sold to motorists on a first-come, first-serve basis. Drivers with permits could use the lanes without meeting vehicle-occupancy requirement, while carpools, vanpools, and buses continued to use the lanes for free. The monthly fee was first set at $50 in December 1996 and 500 permits were sold. In 1997, 700 permits were issued and the fee increased to $70. A permit waiting list of between 200 and 600 individuals existed over the course of this phase.

In April 1989, the FasTrak™ phase was implemented with electronic toll collection replacing the monthly passes. Variable fees for single-occupancy vehicle use of the HOV lanes are collected electronically. The fee depends on the congestion level in the HOV lanes and is recalculated each six minutes to maintain a level-of-service C. Fees typically range from $0.50 to $4.00 according to the time-of-day relative to traffic peaks, although the fee could reach as high as $8.00. Message signs located before the start of the lanes display the updated fee.

During the first month of *ExpressPass* phase, a 12 percent increase in traffic throughput occurred. Most of this increase was the result of new carpools rather than single-occupant vehicles. Before the demonstration, weekday traffic counts included 7,900 HOVs, accounting for 85 percent of the vehicles, and 1,400 single-occupant vehicle violators, accounting for 15 percent. Weekday traffic counts during the initial months of the *ExpressPass* phase included 9,300 HOVs, accounting for 80 percent of the vehicles, 1,025 *ExpressPass* users, accounting for 10 percent, and 200 single-occupant vehicle violators, accounting for 2 percent of the vehicles.

As of March 2005, there were approximately 18,670 active FasTrak™ accounts and some 27,700 transponders in use. In 2004 and 2005, the daily weekday average traffic using the I-15 HOV lanes ranged from a high of 22,341 in March 2004 to a low of 19,401 in February 2005. Over this time period HOVs accounted for approximately 75 percent to 78 percent of the total vehicle volumes. FasTrak™ users accounted for most of the remaining 22 percent to 25 percent, although there were a small percentage of invalid reads of toll tags and FasTrak™ violators. Approximately 80 citations and 14 verbal warnings are issued each month by CHP. Annual revenue generated from FasTrak™ users is approximately $1.2 million.

The revenue has been used to support operations of the system and to expand public transportation services in the corridor. The Inland Breeze bus service provides express trips into downtown San Diego and reverse commute trips to suburban destinations in the corridor.

Expansion of the I-394 HOV Lanes in Minneapolis to Include HOT Vehicles

The I-394 HOV lanes are approximately 11 miles in length. There are two different sections of HOV lanes. A three-mile, two-lane, barrier-separated reversible section in located directly to the west of downtown Minneapolis. To the west of this section are seven miles of concurrent flow HOV lanes. There are two general-purpose lanes in each direction throughout the 11-mile segment of I-394. The reversible section connects to the A, B, C parking garages in downtown Minneapolis, which include an intermodal transfer facility, reduced parking for carpoolers, and links to the downtown skyway system. The lanes are operated by the Minnesota Department of Transportation (Mn/DOT) in coordination with Metro Transit, the Minnesota State Patrol, and local communities.

Initial operation of the HOV lanes varied by segment. The concurrent flow HOV lanes operated only in the peak-hours in the peak-direction of travel. The operating hours for the concurrent flow lanes were 6:00 a.m. to 9:00 a.m. in the eastbound direction and 4:00 p.m. to 7:00 p.m. in the westbound direction, Monday through Friday. The lanes were open to all traffic at other times. The operating hours on the two-lane reversible section were 6:00 a.m. to 10:00 a.m. eastbound and 2:00 p.m. to 7:00 p.m. westbound, Monday through Friday. The reversible lanes were closed at other times, with the exception of some weekends and evenings when the lanes were open to accommodate traffic for sporting and special events at facilities in downtown Minneapolis.

Interest in considering allowing single-occupant vehicles to use the HOV facilities emerged during the late 1990s and early 2000s. In 2003, state legislation was approved allowing a HOT project on the I-395 HOV lanes. A I-394 Express Lane Community Task Force was formed to help oversee the project. The Task Force includes 22 individuals appointed by the Governor, the Lieutenant Governor, and communities in the corridor. The Task Force recommended implementing an HOT project, called MnPASS.

The MnPASS project was implemented in May 2005. Dynamic pricing is used on the project, with tolls based on the level of congestion in the HOV lane. The base toll is $0.25 and the maximum toll is $8.00. The project represents the first use of tolling in the Minneapolis-St. Paul metropolitan area and in Minnesota.

MnPASS represents the first HOT project on concurrent flow HOV lanes. The previous unlimited access to the I-394 concurrent flow HOV lanes was changed to limited access points as part of the project. There are five eastbound and six westbound access points in the concurrent flow lane section. The MnPASS tags are read electronically as vehicles enter the lanes at these locations and the occupancy requirement is visually checked by enforcement personnel.

Increased enforcement has been provided through partnerships with the Minnesota State Patrol, the Metro Transit Police, and the local county police departments. Violating the MnPASS HOV lanes is classified as a petty misdemeanor with $130 fine.

The initial hours of operation were 24/7 on the seven-mile concurrent flow HOV lanes and eastbound from 6:00 a.m. to 1:00 p.m. and westbound from 2:00 p.m. to 5:00 a.m. on the three-mile two-lane reversible section. These operating hours represented a significant change from those used since the I-394 HOV lanes opened in 1992.

Thus, the implementation of the MnPASS program represented a change from a primarily peak-hours, peak-direction HOV operation to a 24/7 HOV/HOT operation in both directions on the concurrent flow lanes. This change had a significant impact on traffic congestion in the morning westbound direction of travel. The response from commuters in the corridor to this situation was very negative. The Minnesota Senate passed a resolution supporting rescinding the off-peak tolls and other policy makers voiced support for a change.

In response to these concerns, Mn/DOT made some initial changes in the operating hours. In August, the operating hours were further reduced to 6:00 a.m. to 10:00 a.m. in the eastbound direction and 2:00 p.m. to 7:00 p.m. in the westbound direction. These hours are the same operational hours used with the concurrent flow HOV lanes from 1992 to 2005.

A total of 4,057 transponders were purchased prior to the opening of the project. Another 1,594 transponders were sold during the first week of the project, and 1,864 transponders were purchased over the next nine weeks. After the first 10 weeks of the project 7,515 transponders had been purchased or accounts opened and 47 accounts had been cancelled, bringing the total active accounts to 7,468. As of December 2005, some 8,700 transponders had been purchased.

The number of daily MnPASS trips on weekdays grew from 916 on the first day of operation to an average of 3,400 by the 10th week. A high of 4,039 MnPASS users were recorded on one day during the 11th week of operation. The maximum toll reached $8.00 on four days during the first 10 weeks of operation. The maximum toll on most days averaged between $3.25 and $4.00, and the weekday average toll was under $1.00 over the initial 10-week period.

During the morning peak-hour, volumes in the HOV lane increased by some 316 vehicles by the third quarter of 2005. MnPASS vehicles accounted for 476 vehicles, or 16 percent, of the total 2,928 vehicles using the HOV lane. HOVs and a few violators accounted for the remaining 84 percent of vehicles using the lane. The number of HOVs declined by approximately 167 vehicles and the AVO declined from 3.41 to 2.88.

Low-Emission and Energy-Efficient Vehicle Use of the HOV Lanes in Northern Virginia

State legislation approved in 1993 established a clean special fuel license plate for special fuel vehicles. The legislation defines clean special fuel as any product or energy source used to propel a highway vehicle, the use of which, compared to conventional gasoline or reformulated gasoline, results in lower emissions of oxides of nitrogen, volatile organic compounds, carbon monoxide or particulates or any combination thereof. The term is defined to include compressed natural gas, liquefied natural gas, liquefied petroleum gas, hydrogen, hythane (a combination of compressed natural gas and hydrogen), and electricity.

State legislation approved in 1994 allows vehicles with clean special fuel license plates to use the HOV lanes in Virginia without meeting the minimum-occupancy requirements. Subsequent legislation in 1996, 1999, 2003, and 2006 extended the sunset date. In 2000, hybrid vehicles became available in the state were allowed to qualify for clean special fuel vehicle license plates.

Only vehicles with clean special fuel license plates are authorized to use the HOV lanes in Virginia without meeting the occupancy requirements. As of October 2004, a total of 10,413 clean special fuel license plates had been issued in the state. In the six years from 1994 and 1999, a total of 78 clean special fuel license plates were issued. In the almost five years from 2000 to October 2004, with hybrids qualifying for the HOV exemption, a total of 10,335 clean special fuel license plates were issued. This increase is directly attributed to hybrid vehicle owners applying for the special clean fuel license plates.

Hybrid vehicles comprise the vast majority of the license plates issued, accounting for almost 95 percent of the total. In comparison, no other type of low-emission or energy-efficient vehicle comprises more than 1.3 percent of the total. Between 1994 and March 2004, the vast majority of the clean special fuel vehicle plates were issued in counties and cities in northern Virginia, are served by the I-95, I-395, I-66, and Dulles Toll Road HOV lanes.

The Washington Metropolitan Council of Governments (WASHCOG) has an ongoing program for monitoring and reporting on the use of HOV facilities in northern Virginia. Vehicle and vehicle-occupancy counts are conducted twice a year, along with other data collection activities. Since the fall of 2003, the number of vehicles with clean special fuel license plates has been included in the counts, with field data collection personnel counting license plates at specific points along the HOV lanes.

The results from the ongoing monitoring program show that owners of vehicles with clean special fuel license plates are using the HOV lanes in northern Virginia. In the fall of 2003, clean special fuel vehicles accounted for between 2 percent and 12 percent of the HOV volumes during the peak-periods on the different HOV facilities in northern Virginia. Counts from six days in October, 2004 indicate that clean special fuel vehicles accounted for between 11 percent and 17 percent of the vehicles in the HOV lanes on I-95 during the 6:00 a.m. to 9:00 a.m. peak-period in the northbound direction. These percentages translate into between some 844 and 1,422 vehicles with clean special fuel license plates using the HOV lanes during the three-hour period and the corresponding total vehicle volumes in the HOV lane ranged from 7,994 to 8,450. Some 6-7 percent, or 552 to 725 vehicles with clean special fuel license plates, were recorded in the HOV lanes at Glebe Road Station on I-395 inside the Beltway during three days in September 2004 during the same 6:00 a.m. to 9:00 a.m. peak period.

Concerns related to the use of HOV lanes by vehicles with the clean special fuel license plates have been voiced by different groups. In 2003 an HOV Enforcement Task Force was established by the Virginia Secretaries of Transportation and Public Safety. The Task Force was formed in response to growing concerns from numerous groups related to enforcement of the HOV lane restrictions in northern Virginia. The HOV Enforcement Task Force is composed of representatives from state, regional, and local transportation and enforcement agencies. The Task Force made a number of recommendations related to managing use of the HOV lanes by hybrid vehicles.

Legislation approved in 2006 extended the deadline for use of HOV lanes in the state by vehicles with clean special fuel license plates until July 1, 2007. The legislation also requires that a new distinctively different design be used for clean special fuel license plates issued after July 1, 2006. The design of the new clean special fuel license plates is to be developed by the Department of Motor Vehicles in consultation with the Department of State Police. The legislation limits use of the HOV lanes in the I-95/I-395 corridor to vehicles registered with and displaying the clean special fuel license plates issued prior to July 1, 2006. Finally, the legislation added a $25 fee for the clean special fuel license plates. For each $25 fee collected in excess of 1,000 registrations, $15 is paid to the State Treasurer and credited to a special non-revenue HOV Enforcement Fund for use by the Virginia State Police for enhanced HOV enforcement.

Opening HOV Lanes on the East Side of Seattle to General-Purpose Traffic in the Evenings

The HOV lanes in the Puget Sound region have traditionally operated on a 24/7 basis. Most of the HOV facilities in the area are concurrent flow HOV lanes located on the inside freeway lane. The HOV lanes have unlimited access, meaning HOVs can enter and exit at any point. Ongoing monitoring efforts indicate that there is both strong public support for the HOV lanes and heavy peak-period use. At the same time, there has been public and policy maker interest in allowing single-occupancy vehicles to use HOV lanes during off-peak periods, when HOV volumes are lower.

In 2002, WSDOT examined options for opening the HOV lanes to general-purpose traffic at different times. This analysis indicated that there was little unused HOV lane capacity during the peak-travel periods, but that excess capacity did exist in evening and early morning hours. The analysis identified some safety concerns with opening the HOV lanes to single-occupancy vehicles at these times and potential impacts on transit reliability. The HOV lanes are important for bus on-time reliability even outside the peak periods, as buses use the lanes during the mid-day to ensure maintaining afternoon schedules. Bus use during the evening and early morning hours is low, however.

In January 2003, the Washington State Transportation Commission agreed to conduct a two-year demonstration project opening the HOV lanes on the eastside of the Seattle metropolitan area to single-occupant vehicles from 7:00 p.m. to 5:00 a.m. seven days a week. Analysis indicated that this change would provide some congestion relief, while not degrading transit reliability. The analysis also indicated that safety should not be degraded significantly as long as specific roadway improvements were made.

The HOV lanes included in the demonstration project are I-405, SR 167, SR 520, and I-90 east of I-405. Prior to opening these HOV lanes to general traffic, WSDOT made a number of safety improvements, including installation of left-hand rumble strips, increased clear zones, and added guardrails. The cost of these improvements was approximately $1.6 million.

An ongoing monitoring and evaluation program was conducted on the HOV lanes as part of the overall HOV performance monitoring program in the region. The one-year evaluation of the new operating hours focused on five major elements. These elements were vehicle volumes in the general-purpose and the HOV lanes, roadway performance as defined by travel speed and frequency of congestion, violation rates, crashes, and public perception. The one-year evaluation indicated that the overall changes in system performance were very small.

Increases in HOV lane vehicle volumes occurred after 7:00 p.m. at most locations. Vehicle volume increases in the HOV lanes between 7:00 p.m. and 8:00 p.m. ranged from 89 to 589 vehicles. The level of the increases varied, however. Some slight increases also occurred just prior to the 5:00 a.m. morning start of the HOV lane restrictions. Corresponding reductions in vehicle volumes in the general-purpose lanes occurred at some locations.

The overall performance of the freeways changed very little as a result of the new operating hours. There was not a noticeable change in the frequency of general-purpose freeway congestion. The average general-purpose lane speeds on the most congested roadways – SR 167 and southbound I-405 – increased slightly by some 1-3 mph. There was also no major change in HOV lane performance. The analysis indicated that on a limited number of occasions and on a limited number of road segments, moderate numbers of general-purpose vehicles were able to avoid some general-purpose lane congestion by moving into the HOV lane. This shift did not appear to have changed the speed with which the congested general-purpose lane returned to normal operation, however.

Violation of HOV requirements were monitored before-and-after the change in operating hours. The analysis indicated that there was a slight increase in the violation level just prior to the 7:00 p.m. start time of the new operating requirements. The increases in violation rates were generally small, with one exception.

The safety concerns examined in the assessment of possible changes in HOV operating hours related primarily to the potential for an increase in the number of vehicles running off the road due to an increase in vehicle volumes in the HOV lanes. A second concern was that the change might impact the operation of planned HOV direct access ramps.

Before-and-after data for run-off-the-road crashes was examined as part of the one-year evaluation. The data was nearly identical and no obvious trouble spots were identified. It appears that the number of King County freeway collisions dropped by approximately 9 percent from 2002 to 2003.

Public opinion was monitored after the change in operation through a survey of freeway users. A total of 5,349 surveys were mailed to motorists and 1,209 completed surveys were returned, accounting for a response rate of 23 percent. The survey included questions on awareness of the change in operating hours, perceptions on changes in freeway conditions, and impressions of the new operating hour policy and HOV lanes in general. The survey results indicated that many motorists were unaware of the changes in HOV operating hours. The responses indicated that motorists perceived some improvements in conditions, however.

CHAPTER THREE – MANAGING HOV LANES

Chapter-at-a Glance

This chapter discusses managing the operation of HOV lanes. It summarizes federal interest in HOV operational changes and highlights the roles and responsibilities of the agencies typically involved in managing HOV lanes. The link to HOV performance monitoring is described, as is the connection to HOV operation and enforcement plans. Potential issues associated with managing the operation of HOV lanes are presented. The general process for assessing possible changes in the operation of an HOV lane is summarized. The following sections are included in this chapter.

- **Federal Interest in HOV Operational Changes**. This section highlights federal interest in changes in HOV lane vehicle-eligibility requirements, vehicle-occupancy levels, and operating hours. Provisions of SAFETEA-LU related to the operation and monitoring of HOV lanes are summarized.
- **Agencies Involved in Managing the Operation of HOV Lanes**. This section summarizes the agencies typically involved in proactively managing HOV lanes. The roles and responsibilities of these agencies, including state departments of transportation, public transportation agencies, and law enforcement agencies are described.
- **Link to HOV Performance Monitoring**. This section highlights the major elements in HOV performance monitoring programs. The steps in developing and conducting performance monitoring programs are summarized and the link to managing the operation of HOV lanes is described. Establishing minimum and maximum use thresholds or guidelines for managing the operation of HOV lanes is discussed.
- **Link to HOV Operation and Enforcement Plans**. This section presents the elements commonly found in an HOV operation and enforcement plan. These elements include the vehicles allowed to use the facility, the vehicle-occupancy requirement, the hours of operation, enforcement techniques and strategies, incident management techniques, and special operating considerations. The link to proactive management of an HOV facility is described.
- **Possible Issues with Managing the Operation of HOV Lanes**. This section highlights potential issues associated with managing the operation of HOV lanes. Issues summarized include high levels of demand that result in congested lanes and underutilized HOV lanes.
- **Assessing Possible Changes in HOV Lane Operation**. This section summarizes the general process for assessing possible changes in the operation of an HOV facility. The steps highlighted include identifying

possible operating issues, identifying and evaluating possible alternatives, reviewing alternatives with stakeholders, selecting and implementing the preferred alternative, and monitoring the impact of the change.

Federal Interest in HOV Operational Changes

Federal funding is typically used to support the design, right-of-way acquisition, construction, and operation of freeway HOV lanes. The FHWA Program Guidance on HOV Operations is intended to help protect the federal investment in these facilities and to promote the efficient use of HOV lanes while maintaining the intent of maximizing the person-movement capacity of these facilities. It also provides guidance on HOV-related provisions included in the Safe, Accountable, Flexible, and Efficient Transportation Equity Act – A Legacy for Users (SAFETEA-LU) and other federal legislation.

> FHWA provides periodic HOV Program Guidance to support the federal investment in freeway HOV facilities and to help promote their effective use, while maintaining the intent of maximizing the person-movement capacity. The guidance supports performance monitoring programs, which provide the information needed to make sound decisions on operating HOV facilities.

The Program Guidance identifies the circumstances under which federal action is required to initiate changes in the operation of an HOV facility, and the federal review process and requirements to be used in these situations. It also includes information on the requirements for monitoring, evaluating, and reporting on the use of HOV lanes by certain exempt vehicles. The Program Guidance and other recent information on federal activities related to HOV facilities are available on the FHWA Internet site at http://www.fhwa.dot.gov/legsregs/ directives/ policy/index.htm.

As noted in the Program Guidance, the source of federal funds used on an HOV project will influence the ability to make changes in the operation of an HOV facility. Some funding categories cannot be used for additional general-purpose roadway capacity. These categories include the Congestion Mitigation and Air Quality (CMAQ) program, the Interstate Maintenance Program, and Mass Transit Capital Investment Grants. Other federal funding sources may have requirements that limit consideration of possible changes in user groups or operating strategies.

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

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

SAFETEA-LU contains a number of provisions related to HOV lanes. These provisions include requirements for monitoring, evaluating, and reporting on the use of HOV lanes by certain exempt vehicles. The basic elements of the SAFETEA-LU association with operating HOV lanes are highlighted next. More information on these provisions and requirements is available in the updated FHWA HOV Program Guidance.

- The state agency responsible for operating an HOV lane has authority to establish vehicle-occupancy requirements. No fewer than two occupants per vehicle may be required with the possible exception of the exempt vehicles described next.
- Motorcycles and bicycles shall be allowed to use HOV lanes unless a state agency certifies to the U.S. Secretary of Transportation that such use would create a safety hazard and the Secretary accepts the certification. The Secretary may accept a certification only after the notice of certification has been published in the Federal Register and an opportunity for public comment has been provided.
- Public transportation vehicles with only the driver may be allowed to use an HOV lane if the state agency establishes requirements for clearly identifying these vehicles and procedures for enforcing their use.
- HOT projects are allowed if the state agency establishes a program that addresses how individuals can enroll and participate, uses automatic toll collection, and establishes policies and procedures to manage demand by varying the toll and enforcing violations. Operating agencies must give priority consideration for use of excess toll revenues to projects developing alternatives to single-occupant vehicle use and improving highway safety.
- The state agency may allow low-emission and energy-efficient vehicles, including inherently low-emission vehicles (ILEVs) and other vehicles defined by the U.S. Environmental Protection Agency (EPA), to use HOV lanes without meeting occupancy requirements until September 30, 2009. The state agency must develop and maintain a program to select allowed vehicles and to enforce their use of HOV lanes.
- A state agency allowing HOT vehicles and/or low-emission and energy-efficient vehicles must establish and maintain a performance monitoring, evaluation, and reporting program.

- The state agency must also establish and maintain an enforcement program to ensure the HOV lane is operated in accordance with federal requirements.
- The state agency is required to limit or discontinue use of the HOV lane by the exempt vehicles if allowing access has degraded the operation of the HOV lane. The operation of an HOV lane is defined as being degraded if vehicles using the facility fail to maintain a minimum average operating speed 90 percent of the time over a consecutive 180-day period during the morning or evening weekday peak-hour periods. The minimum operating speeds are defined as 45 mph when the posted speed limit is 50 mph or greater and not more than 10 mph below a posted speed limit of less than 50 mph.

Agencies Involved in Managing the Operation of HOV Lanes

The agencies typically involved with managing the operation of HOV lanes include state departments of transportation, public transportation agencies, state and local law enforcement agencies, and local jurisdictions. In addition, FHWA and FTA have a role in providing federal oversight in maintaining the effective and efficient operation of HOV lanes. Other agencies and groups, including MPOs, regional rideshare agencies, emergency response agencies, and the judicial system may also be involved. In addition, policy makers and elected officials at the local, state, and federal levels may influence the management of HOV facilities.

> **Involvement of All Appropriate Agencies**
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> A key to the successful management of HOV facilities is to involve staff from all appropriate agencies and groups in the development of an operation and enforcement plan and in the ongoing monitoring of a project. Individuals from these agencies should be involved in managing the operation of an HOV lane and in discussing possible changes in operations.

The typical roles and responsibilities of these agencies are highlighted in Table 3.1 and described in this section. Transportation professionals can use this information as a guide to ensure that consideration is given to including the appropriate agencies in managing the operation of an HOV facility and in any decision to change operations. One approach used in some areas is to continue the multi-agency team formed during the planning phase of a project through the development of an operations plan and managing the ongoing operation of a facility. The exact approach and agencies will vary by project and by area.

State Department of Transportation. The state department of transportation or the state highway department is usually the lead agency for HOV facilities on freeways. These agencies have overall responsibility for HOV lanes, including developing the operation and enforcement plan, managing operation of the facility, performance monitoring, and assessing potential changes in operations. In many areas, state departments of transportation have been responsible for organizing, staffing, and chairing the multi-agency project management team associated with HOV facilities. Representatives from a variety of departments within the agency may participate in a team associated with managing the operation of HOV lanes. These departments might include the planning, design, marketing or public information, construction, legal, operation, traffic management, transportation management center, ITS, and highway assistance departments.

Table 3.1. Agencies Involved in Managing the Operation of HOV Lanes.

Agency or Group	Potential Roles and Responsibility – Operations
State Department of Transportation	Overall project management. Lead in developing operation and enforcement plan. Operate facility and manage operations. Performance monitoring. Assess potential operating changes. Staff multi-agency team or committee.
Public Transportation Agencies	Support role or overall project management on bus-only projects. Participate in multi-agency teams. Assist with operation and enforcement plan, managing operations, performance monitoring, and assessing changes. Bus operations.
State and Local Law Enforcement Agencies	Assist with development of operation and enforcement plan. Responsible for enforcement. Coordinate with judicial personnel. Participate on multi-agency teams.
Cities and Counties	Support role with freeway HOV facilities. May have overall project management with arterial projects. Develop or assist with operation and enforcement plan. Operate arterial HOV lanes. Staff multi-agency team or participating on team.
Rideshare Agency	Assist with development of operation and enforcement plan, performance monitoring, managing operations, and assessing changes. Participate on multi-agency teams.
Metropolitan Planning Organization (MPO)	Assist in facilitating meetings and multi-agency coordination, data collection, and analysis. May have policies relating to HOV facilities.
Federal Agencies – FHWA and FTA	Implement federal legislation. Policies related to managing HOV lanes. Participate on multi-agency teams. Funding support.
Other Groups	Judicial system – state and local courts. EMS, fire, and other emergency personnel. Tow truck operations. Traffic information service providers. State legislatures and policy makers.

Public Transportation Agencies. Public transportation agencies usually have the lead responsibilities for HOV facilities on separate rights-of-way. A transit agency may be a co-sponsor on other HOV lanes or may play a supporting role. If the transit agency has the overall responsibility for a project, they will also have the lead role in developing an operations plan, operating the facility, performance monitoring, and assessing possible changes. On freeway HOV lanes, transit agencies typically play supporting roles. Key responsibilities may focus on the bus operations, rideshare services, and overall project coordination. Ensuring that bus operations are not degraded or compromised by other user groups is often a key concern of transit agencies.

Multi-Agency Teams

Multi-agency teams or committees have been used in many areas to help coordinate planning, designing, funding, implementing, operating, marketing, monitoring, and managing HOV facilities. A subgroup, comprised of the operation and enforcement personnel from various agencies, may be formed to focus on managing the operation of an HOV lane. Multi-agency teams can ensure that all appropriate agencies are involved in managing the operation of HOV projects, considering possible issues and opportunities, and assessing potential changes.

State and Local Law Enforcement Agencies. Involving enforcement personnel throughout all aspects of planning, designing, constructing, implementing, and operating HOV facilities has been identified as an important element of successful projects. Ensuring that the needs of enforcement personnel are considered early in the planning process is important to developing a facility that can be enforced. Enforcement personnel may take a lead role in the development of the enforcement section of a plan. They also typically participate in multi-agency teams and assist with assessing possible changes in operation.

Local Municipalities. City or county departments may have important supporting roles on HOV facilities on freeways and in separate rights-of-way. On projects headed by the state or transit agency, local jurisdictions are likely to play a supporting and coordinating role in the operation of HOV lanes. City and county representatives may participate in multi-agency teams, assist with proactively managing the operation of HOV projects, and assist with assessing possible changes in operation.

Metropolitan Planning Organization (MPO). Representatives from the MPO are usually members of multi-agency groups associated with HOV facilities. The MPO may have policies relating to various aspects associated with managing the operation of HOV lanes. Staff from the MPO may help facilitate meetings, assist with multi-agency coordination, and assess possible changes in operating policies.

Rideshare Agency. In most metropolitan areas, the public transportation agency operates not only the bus service, but also provides ride matching services, vanpool programs, and other ridesharing services. In some areas, however, these activities are the responsibility of a separate agency or organization. In these cases, the rideshare agency typically is included as a member of the multi-agency HOV lane operations team and is involved in assessing possible changes in operations.

Federal Agencies. As noted previously, FHWA and FTA is the two model agencies within the U.S. Department of Transportation with responsibilities associated with HOV facilities, including implementing policies and programs in SAFETEA-LU and other federal legislation relating to HOV lanes. FHWA provides periodic guidance on HOV facilities and is responsible for ensuring that operating agencies conduct monitoring programs associated with allowing certain exempt vehicles to use HOV lanes. Representatives from FHWA and FTA may also participate on multi-agency teams.

Other Groups. Other groups may be members of the operations team. These groups may include representatives from the state and local judicial system responsible for enforcing fines and citations; EMS, fire, and other emergency personnel responsible for responding to incidents and crashes on the facility; and tow-truck operators who may be responsible for removing disabled vehicles. In addition, traffic and transportation information service providers may be included in the operations team. Representatives from these public and private entities may have roles in both obtaining information on the operation of an HOV facility and in disseminating information to the public.

Policy Makers. In addition to the agencies and groups listed previously, policy makers at the national, state, and local levels may influence operating decisions related to HOV facilities. At the federal level, SAFETEA-LU includes provisions relating to HOV lanes and state legislatures may set policies relating to operating requirements, fines and other operating elements.

Link to HOV Performance Monitoring

Managing the operation of HOV lanes requires accurate information about the performance of the lanes, the general-purpose freeway lanes, and other supporting services and facilities. Thus, there is a close link between monitoring and evaluating HOV facilities and proactively managing the operation of HOV lanes. The information provided through HOV monitoring programs is also critical for assessing the impacts of possible changes in vehicle-eligibility requirements, vehicle-occupancy levels, and operating hours.

The *HOV Performance Monitoring, Evaluation, and Reporting Handbook* provides a complete guide to developing and conducting HOV performance monitoring programs. This section summarizes the HOV performance monitoring process. The development of an HOV performance monitoring program should include the major activities that would normally be conducted as part of any evaluation program. Figure 3.1 illustrates the major steps in this process, which are briefly outlined next. To ensure that a comprehensive, well-designed performance monitoring program is pursued, consideration should be given to each of these steps.

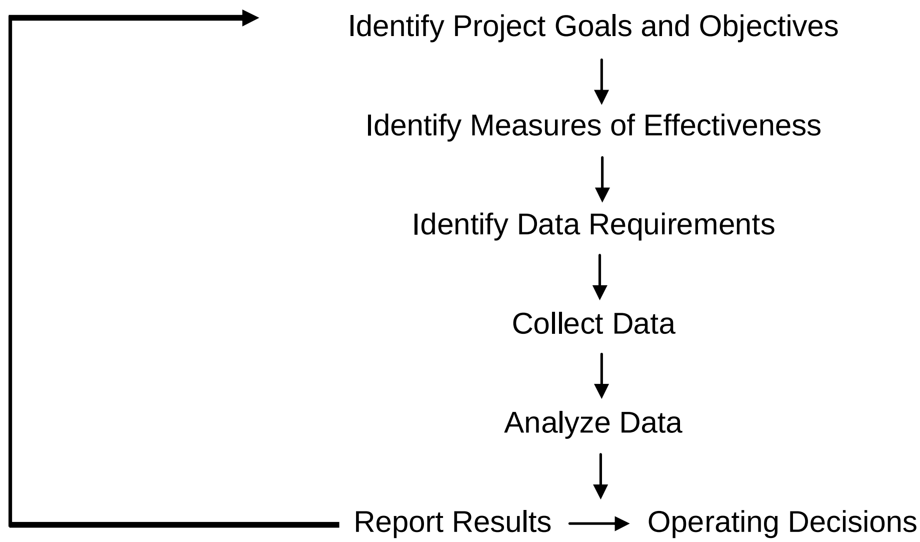

Figure 3.1. Steps in Developing and Conducting an HOV Performance Monitoring Program.

Identification of Project Goals and Objectives. The goals and objectives that an HOV project is intended to accomplish should be clearly defined as the first step in developing a performance monitoring program. These goals and objectives should flow from, and be consistent with, those articulated during the policy development phase and the planning process. This step is critical, as the remainder of the performance monitoring program will be designed to obtain and evaluate information that will be used to determine if these objectives have been met. The development of measurable objectives is not an easy task, but time spent on this effort will help ensure a focused monitoring program. The objectives of an HOV project should be stated clearly and concisely. Each objective should represent a well-defined and measurable statement. A commonly used approach in developing measurable objective statements is to ensure that the statement includes the desired end result, the action that will be taken to achieve this result, and the time frame within which the result will occur.

Identify Measures of Effectiveness. For each objective, the appropriate measure or measures of effectiveness should be identified. The desired threshold level of change that will be used to determine if the facility has met the objective should also be identified. It is important that this activity focus on identifying the measures that most accurately relate to the objectives, and that meaningful threshold levels are established. These measures and thresholds should relate to the key elements in the objective statements.

Identify Data Requirements. This step identifies the data needed for the performance monitoring process. The data needs for each measure of effectiveness should be outlined, and the appropriate methods to obtain and evaluate the information must be identified. Ideally, the same procedures and definitions should be used throughout the performance monitoring program to ensure comparability. Any changes in data collection procedures, such as those associated with implementing advanced technologies, or definitions should be well documented.

Collect Data. In this step, the data identified in the previous step are collected. A variety of data collection techniques are typically associated with HOV performance monitoring programs. Data collection techniques may include observation of vehicle volumes and vehicle-occupancy levels, using information from advanced transportation management systems (ATMS), and reviewing crash data and occupancy or buffer violation citations.

Analyze Data. In this step, the data collected in the previous step are analyzed to provide usable information. The information is then examined to determine if the measures of effectiveness have been met.

Report Results. The results from HOV performance monitoring programs may be used for numerous purposes by different audiences. The results are typically used to determine if the project goals and objectives are being met. Information from performance monitoring programs is also used to make decisions concerning operation of an HOV facility. Methods frequently used to report the results to different audiences and stakeholder groups include technical reports, quarterly reports, PowerPoint presentations, summaries on Internet sites, and newsletters.

Following this general approach will result in the development, implementation, and conduct of a meaningful HOV performance monitoring program. While some elements of this approach may vary in different areas, the basic procedures are appropriate for consideration in monitoring and evaluating all types of HOV facilities. The results from ongoing HOV performance monitoring programs are used to proactively manage the operation of HOV facilities in an area.

In addition, minimum and maximum HOV lane operating thresholds may be established as part of a performance monitoring program, operations plan, or highway performance monitoring program. These thresholds provide guidance for determining if changes in the operation of an HOV lane need to be considered. Tables 3.2 and 3.3 present elements for developing guidelines on minimum and maximum operating thresholds for HOV lanes.

Some state departments of transportation have developed guidelines to help identify when changes in vehicle-eligibility or vehicle-occupancy requirements may be needed. The WSDOT case study highlights one example of these guidelines. In addition, SAFETEA-LU requires that agencies responsible for operating HOV lanes conduct monitoring programs if certain exempt vehicles are allowed to use the lanes. These exempt categories include tolled vehicles and low-emission and energy-efficient vehicles. The operating agency is required to limit or discontinue use of the HOV lane by these vehicles if allowing access has degraded the operation of the HOV lane. The operation of the HOV lane is defined as being degraded if vehicles using the facility fail to maintain a minimum average operating speed 90 percent of the time over a consecutive 180-day period during the morning or evening weekday peak-hour periods. The minimum operating speeds are defined as 45 mph when the posted speed limit is 50 mph or greater and not more than 10 mph below a posted speed limit of 50 mph. Additional information on monitoring requirements is available in the FHWA HOV Program Guidance.

SAFETEA-LU requires that operating agencies limit or discontinue use of an HOV lane by exempt vehicles, including tolled vehicles and low-emission and energy-efficient vehicles, if allowing access has degraded the operation of an HOV lane. Degraded operation is defined as vehicles failing to maintain a peak-hour minimum average operating speed 90 percent of the time over a consecutive 180-day period. The minimum operating speeds are defined as 45 mph when the posted speed limit is 50 mph or greater and not more than 10 mph below a posted speed limit of 50 mph.

Washington State Department of Transportation Guidelines

The guidelines developed by WSDOT provide an example of criteria for determining if changes are needed in vehicle-eligibility and vehicle-occupancy requirements. The WSDOT policies focus on the minimum average speed and speed reliability on an HOV facility. The measures used by WSDOT indicate that HOV lane vehicles should maintain or exceed an average operating speed of at least 45 mph 90 percent of the time over a consecutive six-month period. If this criteria is not met, approaches for addressing the problem will be examined. These approaches may or may not include change vehicle-occupancy or vehicle-eligibility requirements

Table 3.2. Elements for Developing Guidelines on Minimum Operating Thresholds for HOV Lanes.

Possible Elements	Comments/Possible Minimum Thresholds
Goals and Objectives of Project	The goals and objectives of a project may influence the minimum operating thresholds. For example, a project intended to give buses priority around a congested freeway segment could be expected to have a lower threshold than an exclusive HOV lane. Local policies on carpool definitions or other elements may also influence the operating thresholds and should be considered in developing local guidelines.
Type of HOV Facility	The type of HOV facility will probably have the most influence on developing local minimum operating guidelines. The following general levels provide an indication of the national experience and can be used in developing local guidelines. Separate right-of-way, bus only – 200-400 vphpl Separate right-of-way, HOV – 800-1,000 vphpl Freeway, exclusive two-directional – 400-800 vphpl Freeway, exclusive reversible – 400-800 vphpl Freeway, concurrent flow – 400-800 vphpl Freeway, contraflow, bus-only – 200-400 vphpl Freeway, contraflow, HOV – 400-800 vphpl HOV bypass lanes – 100-200 vphpl
Vehicle-Eligibility Requirements	Lower minimum vehicle thresholds can be expected, and are usually accepted, with bus-only facilities than with facilities open to buses, vanpools, and carpools.
Vehicle-Occupancy Requirements	Lower minimum vehicle thresholds can be expected with higher vehicle-occupancy requirements.
Level of Congestion Corridor	The minimum vehicle threshold may be higher in a heavily congested corridor than in one with lower levels of congestion. Non-users in heavily congested areas may be much more vocal about a facility they feel is underutilized than commuters in a corridor where congestion is not at serious levels.
Local Conditions and Perceptions	The perceptions of commuters and the public, as well as any unique local conditions, should be considered in developing minimum operating thresholds. Regional norms are also a factor.

Table 3.3. Elements for Developing Guidelines on Maximum Operating Thresholds for HOV Lanes.

Possible Elements	Comments/Possible Maximum Thresholds
Goals and Objectives of Project	The goals and objectives of a project may influence the maximum operating thresholds. For example, a project intended to give buses priority around a congested freeway segment could be expected to have a lower threshold than an exclusive HOV lane. Local policies on carpool definitions or other elements may also influence the operating thresholds and should be considered in developing local guidelines.
Type of HOV Facility	The type of HOV facility will probably have the most influence on developing local maximum operating guidelines. The following general levels provide an indication of the national experience and can be used in developing local guidelines. Separate right-of-way, bus only – 800-1,000 vphpl Separate right-of-way, HOV – 1,500-1,800 vphpl Freeway, exclusive two-directional – 1,200-1,500 vphpl Freeway, exclusive reversible – 1,500-1,800 vphpl Freeway, concurrent flow – 1,200-1,500 vphpl Freeway, contraflow, bus-only – 600-800 vphpl Freeway, contraflow, HOV – 1,200-1,500 vphpl HOV bypass lanes – 300-500 vphpl
Vehicle-Eligibility Requirements	Lower maximum thresholds can be expected, and are usually accepted, with bus-only facilities than with facilities open to buses, vanpools, and carpools.
Vehicle-Occupancy Requirements	The vehicle-occupancy requirements will influence use of a facility and the potential for congestion. A higher threshold may be needed with a 2+ requirement.
Level of Congestion Corridor	The maximum operating threshold may be higher in a heavily congested corridor than in one with lower levels of congestion.
Design Considerations	An HOV facility with geometric constraints or sections with less than standard designs may have lower maximum operating thresholds than those with standard designs.
Local Conditions and Perceptions	The perceptions of HOV lane users, commuters and the public, as well as any unique local conditions, should be considered in developing maximum operating thresholds.

Link to HOV Operation and Enforcement Plans

This section highlights the elements commonly found in an HOV operation and enforcement plan. These elements relate to the type and design of a project, the vehicles allowed to use the facility, the vehicle-occupancy requirement, the type and orientation of the transit services provided, the hours of operation, enforcement techniques and strategies, and incident management techniques. These elements are discussed briefly in this section. The vehicle requirements, vehicle-occupancy levels, and operating hours are discussed in more detail in the next chapters. Developing and using an HOV operation and enforcement plan, along with a performance monitoring program, forms the basis for proactively managing the operation of an HOV lane.

HOV Operational Alternatives. The type of HOV facilities will influence the operation and enforcement alternatives available for consideration. For example, the operating strategies associated with reversible or contraflow HOV lanes will be different than those used with concurrent flow lanes. The enforcement requirements and techniques will also vary based on the type of HOV facility. A barrier-separated HOV lane provides different enforcement approaches than a concurrent flow HOV lane.

Ingress and Egress. The nature and number of access points will also influence the operation of an HOV facility. Access considerations are closely linked to the type of HOV facility being considered. Some access treatments are more appropriate with certain kinds of HOV lanes, while others may be realistic only with specific types of facilities.

Vehicle-Eligibility and Vehicle-Occupancy Requirements. The types of vehicles allowed to use an HOV facility and the number of people required in a vehicle will influence the operation of a project. Issues to be considered in determining the appropriate vehicle mix and occupancy requirement include safety, demand, project objectives, and special features. Public perceptions related to use levels may also be considered.

Transit Facilities and Services. The nature and orientation of transit services using an HOV facility, as well as the supporting features, will impact operations. For example, a facility with high volumes of buses may require a different operational approach than one oriented toward carpools.

Hours of Operation. HOV facilities may be operated on a 24/7 basis, during major portions of the day, or only during the peak-periods. If a lane is not operated for HOVs on a 24/7 basis, how the facility will be used during non-HOV operating periods must be defined. Options may include allowing general-purpose traffic to use the facility or closing the lane. The type and orientation of the HOV facility will influence the hours of operation.

Enforcement. A major element of the operation plan and ongoing operations should focus on the enforcement strategies to be used on the facility. Elements that should be addressed include the enforcement techniques, design features, violation penalties and fines, and roles and responsibilities of the various law enforcement agencies. The enforcement elements should include communication and coordination with representatives from the state and local judicial systems to ensure that citations will be upheld in court.

Public Information and Voluntary Enforcement. In addition to the legal enforcement conducted by police agencies and state patrols, some areas have voluntary enforcement educational efforts and peer enforcement programs. These ongoing educational programs are needed as people move into an area from places that do not have HOV lanes. Brochures and websites are two examples of ongoing educational approaches. The Seattle area operates a peer enforcement program, called the HERO program, where citizens can voluntarily phone 206-764-HERO and report violators observed in the HOV lanes. The motorists receive an educational brochure in the mail that explains the HOV lane rules and regulations. Only a small percentage of reported violators are repeat offenders, so the educational effort appears to be worthwhile. Information on vehicles reported violating the HOV requirements at the same location and time over a multiple-month period, is forwarded to law enforcement personnel. Concerns about "big brother" are addressed by specifically mentioning that only law enforcement personnel can write a ticket.

Incident Management. The incident management portion of an operation and enforcement plan usually focuses on two major components. The first outlines the procedures and techniques that will be used to respond to incidents and crashes on the HOV facility. The second element addresses whether or not the HOV lane will be used to help manage incidents and crashes on the general-purpose freeway lanes, and if so, the procedures and techniques that will be used on these instances. Coordination with TMC, EMS, and other emergency personnel is a key element of incident management.

Possible Issues with Managing the Operation of HOV Facilities

This section highlights possible issues that may be encountered in managing the operation of HOV facilities. Possible approaches for addressing these concerns are also identified. More detailed information on possible changes in vehicle-eligibility requirements, vehicle-occupancy levels, and operating hours is presented in Chapters Four, Five, and Six.

Demand Exceeding Capacity at 2+ Occupancy Requirement. An HOV facility with a 2+ vehicle-occupancy requirement may be at or reaching capacity. In this situation, recurring congestion in the HOV lane causes a reduction in travel speeds, travel time savings, and trip time reliability that HOV lane uses have come to expect. Possible approaches to address this situation include increasing the occupancy requirement to 3+, varying occupancy requirements by time-of-day, and tolling two-person vehicles while allowing 3+ vehicles to travel for free.

Not Enough Vehicles at 3+ Occupancy Requirement. An HOV lane may be underutilized at a 3+ vehicle-occupancy level. Lowering a 3+ vehicle-occupancy requirement to 2+ may be considered in response to underutilization of an HOV facility at the 3+ level. Another approach would be to allow exempt tolled or low-emission and energy-efficient vehicles with 2 persons or with only the driver, while maintaining the 3+ HOV requirement.

Exempt Vehicle Demand Exceeding Capacity. Use of an HOV lane by exempt vehicles, including HOT vehicles and low-emission and energy-efficient vehicles, may cause the facility to become congested. As required by SAFETEA-LU, operating agencies must limit or restrict use of these exempt vehicles if their use degrades the operation of an HOV lane. Possible approaches for addressing this issue include variable pricing to reduce use during peak times, instituting a vehicle-occupancy requirement for these vehicles, and allocating use by other methods.

Bottleneck Caused Before Start or the End of HOV-Period. In some cases non-HOVs may enter the HOV lane just before the start of the HOV restricted time period and thus be in the HOV lane during the restricted period. In other cases, non-HOVs may wait on the shoulder or other location for the HOV restricted period to end so they can enter the lane. Both of these situations may cause vehicles not meeting the occupancy requirements to be in an HOV lane during the HOV-only operating period and may cause the facility to become congested. Additional enforcement and education programs may be used to address these problems. Extending operating hours may also be considered.

Use of Lanes by Unauthorized Vehicles. Issues may be encountered with the use of HOV lanes by unauthorized vehicles. These vehicles may include lower-occupant vehicles, non-qualifying hybrid vehicles, and law enforcement personnel in their own vehicles or in unmarked enforcement vehicles while not on duty. Enforcement of vehicle-occupancy requirements and other policies are critical to the successful operation of HOV facilities. Visible and effective enforcement promotes fairness and maintains the integrity of the HOV facility to help gain acceptance of the project among users and non-users. Strategies to address these issues include adding extra enforcement personnel, increasing the level of fines or adding other penalties, targeted compliance outreach efforts, and public information and outreach programs.

Special Event Needs. The location of a new special event venue may provide the opportunity to consider extending the hours of operation for an HOV facility or opening it to general-purpose traffic to assist with managing traffic for the event.

Adjustments Needed To Operating Hours. The hours of operation may be adjusted over the life of an HOV project. HOV facilities may be operated on a 24/7 basis, during major portions of a day, or only during the peak-periods. During non-HOV use times a lane may be open to general-purpose traffic, closed to all traffic, used as a shoulder, or used for some other purpose.

Access Controls. Consideration may also be given to the ingress and egress provided along an existing HOV lane to increase use or to address congestion issues. Approaches that may be examined include adding access points, removing access points, and metering carpools at access points.

Process for Assessing Possible Changes in HOV Lane Operation

The process for assessing possible HOV operating strategies should be similar to the one used to plan a project and should emerge from an established monitoring program. Information on vehicle and passenger volumes, travel speeds, travel-time savings, violation rates, and crashes should form the basis of an ongoing monitoring and evaluation program. This information can be used to identify possible problems and potential changes in the operation of an HOV facility.

Figure 3.2 shows the key elements in the process for assessing, implementing, and monitoring possible changes in HOV operations. These key elements are highlighted below. The exact steps may vary depending on the local situation. The multi-agency operation team typically plays an important role in identifying possible issues, analyzing alternatives, and implementing and monitoring changes.

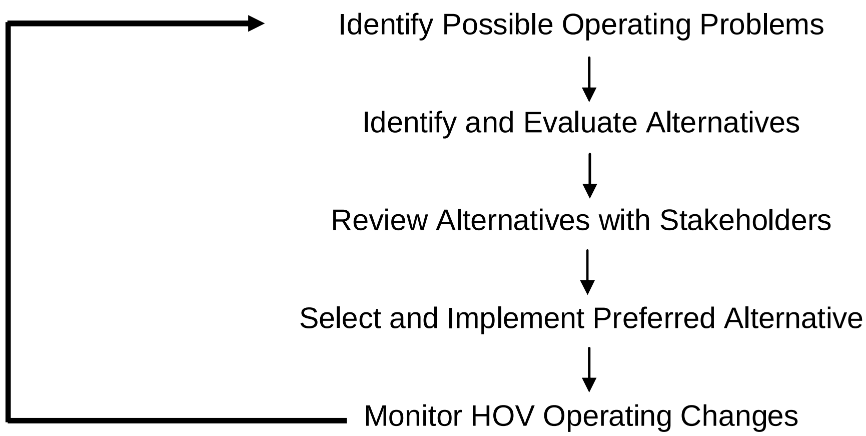

Figure 3.2. Process for Assessing, Implementing, and Monitoring Changes in HOV Operations.

Identify Possible Operating Problems. Information from the ongoing monitoring program should be used to identify potential operating problems, such as facilities reaching capacity or high violation rates. A good database on vehicle and passenger volumes, travel speeds, travel time savings, violation rates, and accidents should alert agency personnel to possible problems. Regular visual monitoring of a facility, such as personnel driving the corridor or surveillance through Advance Transportation Management Systems (ATMS) can also help identity potential problems.

Identify and Evaluate Alternatives. Possible approaches to addressing the issues are identified and evaluated in this step. As an example, possible alternatives that may be considered when an HOV lane is reaching capacity include increasing the vehicle-occupancy requirement, pricing strategies, sticker programs, restricting some user groups, eliminating access points, and metering some user groups. The identified options can be evaluated using available data and various planning models and methods. Methods to assess the potential impacts of possible changes in vehicle-eligibility criteria, vehicle-occupancy levels, and operating hours are described in the following chapters.

Review Alternatives with Stakeholders. The results of the evaluation are discussed with key stakeholder groups in this step. In addition to members of the multi-agency team, other stakeholders usually include agency management personnel, policy makers, and commuters in the corridor. The groups and individuals involved should be matched to the nature of the problems being examined and the solutions being considered.

Select and Implement Preferred Alternative. In this step the preferred alternative is selected and implemented. Input from technical staff, policy makers, and commuters may be used in identifying the preferred alternative. A plan for implementing the operating change should be developed and followed. Key elements of a successful implementation effort include public information and outreach activities, necessary changes in signing, and other possible modifications. Ensuring that HOV user groups and commuters are informed of the change and that adequate enforcement is provided represent two key elements associated with implementing HOV operational changes.

Monitor HOV Operating Changes. The monitoring program should continue to track the affects of the changes made in the operation of an HOV facility. The information collected through the ongoing monitoring efforts should be used to evaluate the change and to provide a feedback loop to continue to identify possible operating problems and to ensure the efficient operation of the HOV facility.

CHAPTER FOUR – ASSESSING VEHICLE-ELIGIBILITY REQUIREMENTS

Chapter-at-a Glance

This chapter reviews the types of vehicles usually considered for HOV facility use. The advantages of allowing different vehicles are highlighted along with possible limitations associated with various approaches. Factors to consider in changing vehicle-eligibility requirements are discussed. Assessing the impacts of potential changes in vehicle-eligibility requirements are presented. The chapter includes the following sections.

- **Vehicle-Eligibility Requirements**. This section highlights vehicles typically allowed to use HOV lanes, exempt vehicles that may be considered, and vehicles not usually provided access. Potential advantages and limitations with different vehicle-eligibility requirements are summarized.
- **Factors to Consider in Changing Vehicle-Eligibility Requirements**. This section summarizes factors that may need to be examined when changes in vehicle-eligibility requirements are being considered.
- **Assessing Possible Changes in Vehicle-Eligibility Requirements**. This section describes assessing possible changes in vehicle-eligibility requirements, including allowing HOT vehicles and low-emission and energy-efficient vehicles.

Vehicle-Eligibility Requirements

Vehicle-eligibility requirements identify the types of vehicles allowed to use an HOV lane. Determining vehicle-eligibility is important, as it influences other decisions relating to the operation of an HOV facility. Table 4.1 highlights the types of vehicles that may be allowed to use an HOV lane or may be considered for HOV facility use. As Table 4.1 shows potential vehicles may be classified as those meeting occupancy requirements, vehicles exempt from occupancy requirements, and vehicles not usually allowed regardless of occupancy levels.

The general characteristics of these vehicles are described next. The advantages and limitations associated with allowing each type of vehicle to use an HOV facility are presented in Table 4.2 and summarized in this section. The FHWA HOV Program Guidance provides additional information on the provisions in SAFETEA-LU related to exempt vehicle requirements.

Table 4.1. Potential Vehicles Allowed to Use an HOV Lane.

Vehicles Meeting Occupancy Requirements	• Buses carrying passengers. • Vans, vanpools, and shuttle (airport, taxi, etc.) meeting eligibility requirements. • Carpools in automobiles and light trucks meeting eligibility requirements.
Vehicles Not Meeting Occupancy Requirements	• Designated public transportation vehicles with only the driver (deadheading). • Motorcycles. • Marked law enforcement and emergency vehicles. • Allocation process vehicles (stickered, etc.). • Value pricing and tolled vehicles (HOT projects). • Low-emission and energy-efficient vehicles. • Bicycles.
Vehicles Not Usually Allowed	• Commercial vehicles and semi-trucks.

Vehicles Meeting Occupancy Requirements

HOV facilities are designed and operated to provide travel time savings and trip time reliability to buses, vanpools, and carpools to encourage individuals to use these modes over driving alone. Rather than creating disincentives to discourage drivers who travel alone, HOV lanes provide incentives and benefits to encourage commuters to change from driving alone to riding a bus, joining a vanpool, or carpooling. The characteristics of these three types of HOVs are described in this section.

Buses. Buses are usually given first consideration in the use of an HOV facility. High volumes of buses offer the greatest potential benefit for increasing the people carrying capacity of a facility, as well as energy savings and air pollution benefits. Buses may be the only vehicles allowed to use a facility or buses may be one of many eligible users. Examples of the former include the busways in Ottawa, Pittsburgh, Miami, Boston, and Minneapolis-St. Paul; the contraflow HOV lane on Route 495 approaching the Lincoln Tunnel in New York City; and the bus-only shoulder freeway lanes on Highway 99 in Vancouver and freeway sections in the Minneapolis-St. Paul area. Bus Rapid Transit (BRT) systems are being planned, implemented, and operated in other areas. Although buses provide the greatest person carrying capacity, corridors in many metropolitan areas in North America do not have high enough current or projected transit vehicle volumes to warrant limiting the use of a facility to buses only. Thus, most HOV lanes allow other vehicles meeting the vehicle-occupancy requirement along with buses.

Table 4.2. Vehicle-Eligibility Considerations.

Vehicle Type	Advantages	Limitations
Vehicles Meeting Occupancy Requirement		
Buses	• Highest person-moving capacity. • Greatest potential for increasing corridor throughput.	• May be difficult to establish or expand bus service depending on orientation of HOV lane. • The lane will look unused unless there are high numbers of buses.
Vanpools and shuttles meeting occupancy	• High person-moving capacity.	• The lane will look unused unless there are high numbers of vanpools.
Carpools using automobiles and light trucks	• Adds users at no public cost. • Adds to person-moving efficiency. • Helps avoid having lane look empty. • Expands potential user groups. • Maximizes available capacity.	• Too many carpools may cause congestion in an HOV lane. • May be safety concerns with some facilities. • Potential equity issue when HOV requirement exceeds the capacity of small automobiles (e.g. 2-seater sports cars).
Exempt Vehicles Not Meeting Occupancy Requirement		
Designated public transportation vehicles with only driver	• Enhances bus operation efficiencies.	• Potential public perception problems if only operator is on board vehicle.
Marked law enforcement and emergency vehicles	• Travel time savings and enhanced reliability to emergency vehicles.	• Potential public perception problems if only operator in on board vehicle. • May lead to abuse by off-duty personnel or commuting in personal vehicle.
Motorcycles	• Adds vehicles to lanes. • Maximizes available capacity.	• Potential safety concerns. • Potential public perception problem.
Allocation process vehicles (stickers, etc.)	• Maximizes available capacity. • Manages demand. • Expands eligible user group. • Addresses actual or perceived low use.	• Enforcement more difficult. • Time and cost to administer program. • Possible confusion among users. • May add too many vehicles to the facility resulting in congestion.

Table 4.2. Vehicle-Eligibility Considerations - Cont.		
Vehicle Type	Advantages	Limitations
Value pricing and tolled vehicle	• Maximizes available capacity. • Manages demand. • Expands eligible user group. • Addresses actual or perceived low use. • Generate new revenues.	• Enforcement may be more difficult. • Time and cost to administer program/equipment. • Possible confusion among users. • May add too many vehicles to the facility, causing congestion. • Potential public and policy maker concerns related to equity, double taxation, and use of revenues.
Low-emission and energy-efficient vehicles	• May encourage purchase and use of low-emission and energy-efficient vehicles. • Maximizes available capacity.	• Potential public perception problems. • Enforcement may be more difficult. • May cause congestion on the facility if too many vehicles are allowed. • May be confusion among buyers, automobile dealers, and policy makers about which vehicles qualify.
Bicycles	• Provides connections on arterial HOV lanes.	• Safety concerns. • Bicycles not allowed on Interstate system.
Vehicles Not Usually Allowed		
Commercial vehicles and semi-trucks	• Exclusive use of HOV lanes during off-peak-hours by trucks may help reduce truck traffic in freeway lanes. • May enhance good movement and economic development.	• Potential safety concerns if trucks mixed with HOVs. • Safety concerns during transition period. • Access points may not serve commercial origins and destinations. • Geometric restrictions may not accommodate trucks. • Does not provide incentive to use transit or rideshare. • Does not enhance people moving capability.

Vans and Vanpools. The next vehicles typically considered for HOV lane use are vanpools. Although vans have operating characteristics similar to automobiles, vanpools have higher vehicle-occupancy levels than carpools. As a result, vanpools may be given preference over carpools in some situations. Vanpools are currently authorized to use all of the non-bus only HOV facilities in North America. Some metropolitan areas have active company-based and area-wide vanpool programs that help support the formation and ongoing operation of vanpools.

Carpools Using Automobiles, SUVs, and Light Trucks. Carpools comprise the majority of vehicles on most HOV lanes. Carpools add to use levels at no additional public cost and can enhance the person carrying capacity of a facility. A potential disadvantage of allowing carpools in an HOV lane is that congestion may be created by too many vehicles, which may negatively impact the travel time savings and travel time reliability of buses and vanpools. As discussed in Chapter Five, different carpool occupancy requirements may be used to influence demand.

Exempt Vehicles Not Meeting Occupancy Requirements

In an attempt to maximize the use of HOV facilities and to meet other goals, operating agencies in some areas have expanded HOV lane use to include HOT vehicles, low-emission and energy-efficient vehicles, and other exempt vehicles not meeting occupancy requirements. The characteristics of possible exempt vehicles, and advantages and limitations with HOV lane use are summarized in this section. The provisions in SAFETEA-LU associated HOV lane use by some types of exempt vehicles are highlighted.

Designated Public Transportation Vehicles with Only Driver. Buses with only the operator on board are typically operating in non-revenue service, which is referred to as deadheading. Deadheading usually occurs in the morning and evening as buses are going to and from the garage to the start or the end of a route. Deadheading also occurs with express services, as buses travel back out to start another trip. Operating efficiencies may be realized by allowing deadheading buses to use the HOV lanes. For example, allowing deadheading buses to use an HOV facility may reduce transit operating costs or increase revenue service at no additional operating cost. Buses with only an operator in an HOV lane may create public perception problems, however. Public transportation buses deadheading or in non-revenue service have historically been allowed to use most HOV lanes due to the benefits noted above. Deadheading buses have not been addressed in federal legislation until SAFETEA-LU. The section in SAFETEA-LU on HOV facilities specifically permits the agency responsible for operating HOV lanes to allow designated public transportation vehicles to use an HOV lane without meeting the occupancy requirements. The agency must establish requirements for clearly identifying these vehicles and must establish procedures for enforcing the restrictions on use of the facility by these vehicles.

Marked Law Enforcement and Emergency Vehicles. Marked law enforcement and emergency vehicles are typically allowed to use HOV facilities, even when not on an emergency trip. In most cases, marked law enforcement emergency vehicles do not make extensive use of HOV lanes due to access limitations, hours of operation, public perception, and other factors. Use of the HOV lanes in northern Virginia by law enforcement and emergency personnel traveling in unmarked vehicles without meeting the occupancy requirements has been identified as a problem.

Motorcycles. Federal policies related to motorcycle use of HOV lanes without meeting occupancy requirements have varied over the past 20 years. The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 authorized motorcycle use of HOV facilities, regardless of the number of riders. Previous federal regulations provided some flexibility for states and other operating agencies in determining motorcycle use of HOV lanes based on safety concerns. SAFETEA-LU requires state operating agencies to allow motorcycles to use HOV lanes unless such use creates a safety hazard. A state agency must certify to the U.S. Secretary of Transportation that motorcycle use of an HOV lane or HOV lanes would create a safety hazard and the Secretary must accept the certification. The Secretary may accept a certification only after the notice of certification has been published in the Federal Register and an opportunity for public comment has been provided.

Allocation Process Vehicles. One possible approach to managing demand on an HOV facility is through the use of an allocation or sticker program to identify and allow vehicles not meeting the occupancy requirement to use the lane on a regular or semi-regular basis. The basic concept of this approach is to allow vehicles with a valid sticker, ETC tag, or other marking to use an HOV facility. This approach was used for a time on the Southeast Expressway contraflow HOV lane in Boston. A 3+ vehicle-occupancy requirement was in use on this facility, but two-person carpools with a valid sticker were allowed to access the lane. The stickers were distributed by the Massachusetts Highway Department (MassHighways), which operates the HOV lane. To ensure that the HOV lane did not become too congested, the stickers were color coded to help regulate use. Vehicles with license plates ending in an odd number had blue stickers and were allowed in the lane on odd numbered days. Vehicles with license plates ending in even numbers had red stickers and were able to access the lane on even numbered days. Potential advantages of this approach include maximizing available capacity in the HOV lane, managing demand, expanding the eligible user groups, and addressing actual or perceived perceptions of low use. Potential disadvantages include more difficult enforcement, adding extra administrative functions and costs to manage the program, confusing users, and adding too many vehicles to the lane.

Value Pricing and Tolled Vehicles. Another possible approach is to allow lower or single-occupant vehicles to use an HOV facility for a fee. This technique, which may be referred to as priority pricing, value pricing, or high-occupancy toll (HOT) lanes, is currently in use on the I-15 HOV facility in San

Diego, the I-10 West and U.S. 290 HOV lanes in Houston, and the I-394 HOV lanes in Minneapolis. It is being considered and implemented in other areas. Potential advantages of this technique include maximizing available capacity, managing demand, expanding the eligible user groups, addressing real or perceived low use levels, and generating new revenues. This approach may also provide opportunities for new public/private partnerships or other innovative financing and project development methods. Possible disadvantages include making enforcement more difficult, adding costs to administer the program, adding costs associated with automated toll collection, confusing users, and adding too many vehicles to the lane. This approach may also raise concerns from the public and policy makers relating to equity, double taxation, and use of revenues.

The section in SAFETEA-LU on HOV facilities includes provisions relating to HOT vehicles. It permits state operating agencies to allow HOT vehicle use of HOV lanes without meeting occupancy requirements if the agency establishes a program for motorists to enroll and participate in the toll program; develops, manages, and maintains a system to automatically collect tolls; and establishes policies and procedures to manage demand by varying tolls and to enforce violations on use of the lanes. The Act also allows for tolling low-emission and energy-efficient vehicle use of HOV lanes. As noted in Chapter Three, the operating agency must have a monitoring program and must limit or discontinue use by tolled vehicles if the HOV lanes become degraded based on the definitions contained in SAFETEA-LU. The Act also requires that agencies give priority consideration to using any excess toll revenues for projects developing alternatives to single-occupancy vehicle travel and projects for improving highway safety.

Low-Emission and Energy-Efficient Vehicles. The Clean Air Act Amendments of 1990 and the Transportation Equity Act for the 21st Century (TEA-21) allowed states to exempt Inherently Low-Emission Vehicles (ILEVs) from HOV occupancy requirements. SAFETEA-LU continues to allow states to provide ILEVs access to HOV lanes without meeting occupancy requirements until September 30, 2009. States must establish procedures for enforcing restrictions on use and vehicles must be certified and labeled according to federal requirements. SAFETEA-LU also expands the exempt vehicle classification to include other low-emission and energy-efficient vehicles, including some types of hybrids as defined by EPA. These vehicles must be certified by EPA and marked according to EPA guidance. States must establish a program for selecting vehicles and for enforcing regulations related to their use. These vehicles may be allowed before September 30, 2009 if they pay a toll. The SAFETEA-LU language states that this toll could be “no toll” or a toll lower than the fee charged for other exempt vehicles. A total of 10 states have had approved legislation allowing ILEVs to use HOV lanes based on the provisions of TEA-21. Four states – Arizona, California, Colorado, and Georgia – approved subsequent legislation allowing hybrids to use HOV facilities without meeting occupancy requirements if authorized in federal legislation or federal agency action. Virginia was the only state allowing hybrids to use the HOV lanes, even though it was counter to the TEA-21 provisions.

Bicycles. Bicycles have not been allowed to use HOV lanes on freeways and in separate rights-of-way. Non-motorized vehicles, including bicycles, are prohibited from using the Interstate system. Bicycles may use arterial HOV lanes in some areas. SAFETEA-LU includes bicycles in the same HOV lane exception category as motorcycles. The language in SAFETEA-LU provides that state agencies shall allow motorcycles and bicycles to use HOV facilities unless an agency certifies to the U.S. Secretary of Transportation that such use would create a safety hazard and the Secretary accepts the certification. As noted in the previous section on motorcycles, the Secretary must publish the notice of certification in the Federal Register and must provide an opportunity for public comment before accepting a certification.

Vehicles Not Usually Allowed

Commercial Vehicles. Commercial vehicles or semi-trucks are not allowed to use any HOV facility in North America, regardless of the number of passengers. This restriction has been applied for safety reasons and because allowing trucks would not encourage ridesharing or reduce VMT. Potential concerns with opening HOV facilities to commercial vehicles during peak and off-peak periods include lack of compatibility with policies and objectives to increase ridesharing and vehicle occupancy levels, lack of access points to meet the origins and destinations of trucks, design limitations which may not accommodate truck movements, and conflicts between commercial vehicles and HOVs.

Factors to Consider in Changing Vehicle-Eligibility Requirements

A number of factors may need to be considered in assessing possible changes in vehicle-eligibility requirements for an HOV facility. The exact factors and issues will vary by metropolitan area and by the type of change in the vehicle-eligibility requirements being considered. Factors discussed in this section include HOV project goals and objectives, facility type and length, design treatments, congestions levels in the HOV lane and the general-purpose freeway lanes, bus operations, system connectivity, and supporting services and facilities. Other important factors to consider include safety, enforcement, and perceptions of HOV lane users, non-users, and policy makers. Additional factors associated with considering HOT vehicles include target markets, pricing alternatives, the cost of the tolling infrastructure and operating strategies, use of revenues generated from the project, identifying qualifying vehicles, potential equity concerns, and methods to restrict use. Equity issues may also need to be considered with allowing low-emission and energy-efficient vehicles along with techniques to identify qualifying vehicles, and methods to restrict use. The elements discussed in this section can be used to help guide consideration of changes in vehicle-eligibility requirements on HOV facilities.

Project Goals and Objectives. The goals and objectives of a specific HOV project or an HOV system should be used in considering possible changes to vehicle-eligibility requirements. For example, the goals and objectives for a bus-only facility on a separate right-of-way and a concurrent flow freeway HOV lane serving primarily carpools, may be different. Expanding user groups to include HOT vehicles and low-emission and energy-efficient vehicles may be considered for a number of reasons. Determining the specific goals and objectives of allowing these types of vehicles is a critical first step. Possible objectives for a HOT project include improving HOV lane utilization or maximizing available capacity by allowing lower-occupancy vehicles, restoring freeflow to HOV lanes by charging lower-occupancy vehicles, generating additional revenues, introducing another travel option, and supporting other secondary impacts such as air quality. Possible objectives for allowing low-emission and energy-efficient vehicles include encouraging the purchase of these types of vehicles, maximizing available capacity, and enhancing air quality and energy independence.

Type and Length of HOV Lane. The type of HOV facility may influence consideration of changes in vehicle-eligibility requirements. Options for busways and contraflow HOV lanes may be more limited than exclusive and concurrent flow HOV lanes. The length of an HOV lane will also influence consideration of alternative vehicle-eligibility requirements. A short HOV lane is probably not a logical candidate for a HOT project, as the travel time savings realized are not significant enough to attract paying users and warrant the public investment in the HOT infrastructure. Similarly, allowing low-emission and energy-efficient vehicles to use a short HOV lane would not provide enough travel time savings to encourage an individual to invest in a low-emission and energy-efficient vehicle.

Design Treatments or Operating Limitations. Consideration of changes in vehicle-eligibility requirements may be influenced by design or operating constraints associated with a specific HOV facility. HOV lanes with design limitations may not be able to accommodate the higher vehicle volumes that would result from allowing additional user groups.

Congestion Levels in the HOV Lane and General-Purpose Freeway Lanes. The level of congestion in the HOV lane, the general-purpose freeway lanes, and in the travel corridor will influence consideration of changes in vehicle-eligibility requirements on an HOV lane. Information from an HOV performance monitoring program can be used to identify potential issues or concerns with current vehicle-eligibility requirements. An HOV lane operating at or near capacity would typically not be considered for additional vehicle types, unless tolled lower-occupant vehicles are being considered as a method to help manage demand. Allowing other HOVs or exempt vehicles may be considered for an HOV lane with available capacity.

Bus Operations. Examining the impact on public transportation operators and bus riders from expanding the vehicle-eligibility requirements on an HOV lane is important if buses currently represent a significant user group. Bus operators and bus riders may experience slower travel speeds and degraded service if an HOV lane becomes congested from allowing other user groups.

System Connectivity. If there is more than one HOV facility in operation or in the planning stage in a metropolitan area, changes in vehicle-eligibility requirements on one facility may influence the operation of other HOV lanes. Consideration of uniform vehicle-eligibility requirements may be appropriate. Maintaining the same requirements on multiple facilities can improve public understanding and simplify enforcement. Uniform vehicle-eligibility requirements may not be appropriate if there are different types of HOV facilities in an area or if significantly different travel and mode share characteristics exist in various corridors. Both approaches are currently in use in urban areas throughout the country. A few metropolitan areas use different vehicle-eligibility requirements on different HOV facilities, while other areas use the same regulations on all HOV lanes.

Supporting Facilities and Services. The type and levels of support facilities and services may influence consideration of changes in vehicle-eligibility requirements. For example, the availability of rideshare programs may be an important supporting components if carpools and vanpools are not currently allowed to use an HOV lane, but are being considered.

Safety. Possible safety impacts should be considered in assessing potential changes in vehicle-eligibility criteria. Ensuring that the HOV lane can be operated safely with the new vehicles is important. Safety concerns will typically relate to the type of HOV lane and the design treatments discussed previously. Improvements may need to be made in an HOV lane to accommodate the higher vehicle volumes anticipated from allowing additional user groups.

Enforcement. Enforcement needs should be considered in examining possible changes in vehicle-eligibility requirements. It is important that new vehicle-eligibility requirements can be enforced, especially if use by HOT and low-emission and energy-efficient vehicles not meeting the occupancy requirements are being considered. As noted previously, SAFETEA-LU requires operating agencies to develop and maintain enforcement programs if either HOT or low-emission and energy-efficient vehicles are allowed to use an HOV lane.

Perceptions of HOV Lane Users. The perceptions of HOV lane users to changing vehicle-eligibility requirements are an important factor to consider in assessing possible changes. The perceptions of current HOV lane users are especially important if additional vehicle types are being considered on a well utilized facility. Current HOV lane users may not favor allowing HOT or low-emission and energy-efficient vehicles not meeting the occupancy requirements if the lane becomes too congested as a result. As noted in the northern Virginia case study, there has been vocal opposition from carpoolers and bus riders to allowing hybrid vehicles to use the HOV lanes without meeting the occupancy requirements. There may also be mixed reactions to the concept of HOT vehicles or pricing, since the facility has already been paid for through tax dollars.

Perceptions of Non-Users. The perceptions of motorists in the general-purpose freeway lanes related to possible changes in vehicle-eligibility requirements are also important. Travelers in the general-purpose freeway lanes may view allowing other HOVs, such as carpools and vanpools, to use a bus-only lane positively if it eases congestion in the freeway lanes. Motorists may have mixed reactions to allowing HOT and low-emission and energy-efficient vehicles to use an HOV lane without meeting the occupancy requirements. Motorists and the public may favor allowing these vehicles if they are willing to pay to use the lane or if they own an eligible low-emission and energy-efficient vehicle. Motorists and the public may not favor allowing these types of vehicles if they will not be able to use the lane.

Perceptions of Policy Makers. The perceptions of policy makers are also very important in considering changes in vehicle-eligibility requirements. Policy makers may be influenced by the reactions of their constituents, information provided by operating agencies and other groups, and their own perspective on HOV lanes, HOT projects, and low-emission and energy-efficient vehicles. Ensuring that policy makers understand the reasons why specific changes in vehicle-eligibility requirements are being considered is important.

Target Markets. The potential market or markets being considered in changing vehicle-eligibility requirements should be considered, especially when expanding HOV lanes to include HOT vehicles or low-emission and energy-efficient vehicles are being considered. Possible target markets for HOT project include drivers of lower-occupant vehicles and single-occupant vehicles. For example, the I-15 FasTrack™ project in San Diego and the I-394 MnPASS project in Minneapolis, allow single-occupant vehicles to use the HOV lanes for a fee, while the QuickRide project on the I-10 West and US 290 HOV lanes in Houston allows two-person carpools to pay for use of the lane during the period currently restricted to 3+ carpools. The Route 91 Express lanes in Orange County, California use a different approach. As a for-profit toll facility, all vehicles are expected to pay a fee, although the pricing goal is adjusted to favor the formation of 3+ HOVs.

Impact on Current Users. Existing vehicle volumes on the HOV lane will influence consideration of changes in vehicle-eligibility criteria. The impact on existing or projected HOV lane users from allowing other user groups will need to be considered. Ideally, there should be no impact on current HOV users. The impact on the general-purpose lanes should also be considered. Negative impacts might result from changes in vehicle-eligibility criteria, including allowing HOT and low-emission and energy-efficient vehicles, however. For example, increased congestion in the HOV lane might occur if tolls are set too low or if too many stickers are distributed, resulting in too many lower or single-occupant vehicles using the facility. This situation could result in slower travel speeds, reduced travel time savings, and lower levels of travel time reliability. Current HOV volumes may decline if existing bus riders, carpoolers, and vanpoolers decide to change to driving alone for a fee or purchasing eligible low-emission and energy-efficient vehicles. On the other hand, if revenues generated from the project are used to enhance bus service in the corridor, to reduce bus fares, or to make other improvements benefiting HOVs, bus ridership, and carpool and vanpool use may increase.

Pricing Alternatives. The amount the target market may be willing to pay to use an HOV lane should also be considered with HOT projects. Factors to consider include the estimated demand at various pricing levels and the quality of service. In addition to the traditional cost-to-demand relationship, other factors to consider include the bus fares in the corridor and the cost of other transit alternatives.

Cost of Tolling Infrastructure and Strategies. The cost of the tolling infrastructure and the ongoing operation of an HOT project are important factors to consider. The cost of these elements will depend on the approach and the operating strategy used for an HOT project. The two general types of approaches are a manual or static operating strategy and the use of real-time pricing based on congestion. The use of ETC allows for real-time pricing. As noted previously, SAFETEA-LU requires that HOT projects on HOV lanes use ETC. The cost of the two approaches varies considerably. As highlighted in the I-15 HOT project case study, monthly permits displayed on the windshield were initially used on the project. This approach represented a very low cost method. The cost for ETC infrastructure and ongoing operations is much more significant.

Level and Use of Revenues. The anticipated level of revenues generated from a HOT project and the use of the revenues should also be considered. The funds generated by a pricing project and the cost to operate and administer the program should be carefully examined, along with how any excess revenues will be spent. Findings from studies around the country indicate that public and policy maker reaction to a possible HOT project is influenced by how the revenues are anticipated to be used. Public support appears to be higher if the revenues are used for transit and transportation improvements in the corridor, than if they are used for other purposes. If the HOT lane is part of a toll or managed lane project, the funding and revenue agreements among the toll operator and any participating public agency will need to be determined. The tolls may be used to help fund the project.

Identifying Eligible Vehicles. A potential issue with allowing HOT vehicles and low-emission and energy-efficient vehicle use of an HOV lane is being able to identify eligible or qualifying vehicles. This identification is important for both enforcement and public perception. SAFETEA-LU requires that operating agencies develop a method to identify low-emission and energy-efficient vehicles, as well as developing a program to identify qualifying vehicles and enforce their use.

Potential Equity Concerns. Equity issues or concerns that only high income individuals will be able to afford to use HOT projects may be an issue. Experience with existing projects indicates that all income levels use value-priced lanes. Equity concerns may also arise with consideration of low-emission and energy-efficient vehicles, as lower income individuals may not be able to afford eligible hybrid vehicles.

Methods to Restrict Use. SAFETEA-LU requires that operating agencies allowing exempt vehicles—including HOT and low-emission and energy-efficient vehicles—establish programs to monitor the use of an HOV lane by these vehicles. The Act also requires agencies to establish, manage, and support enforcement programs to ensure the HOV lane is operated in accordance with the federal requirements. Further, agencies must limit or discontinue use of the HOV lane by these vehicles if their use degrades the operation of the facility, as defined in the Act. The measures that will be taken to limit or discontinue use should be considered in any assessment of allowing these vehicles to use an HOV lane.

Assessing Possible Changes in Vehicle-Eligibility Requirements

This section describes how the factors presented in the previous section can be applied to assess possible changes in vehicle-eligibility requirements. Since the majority of HOV lanes are open to buses, vanpools, carpools, and motorcycles, this section focuses primarily on assessing the potential impacts of allowing priced or HOT vehicles and low-emission and energy-efficient vehicles. The first scenario briefly examines adding vanpools and/or carpools to a freeway HOV lane initially open to buses only. The second scenario addresses allowing priced or HOT vehicles to use an HOV lane without meeting vehicle-occupancy requirements. The third scenario examines allowing low-emission and energy-efficient vehicles to use an HOV lane without meeting occupancy requirements. Table 4.3 highlights the importance of the factors presented in the previous section in assessing these three scenarios. Case study examples are provided highlighting current experiences with these potential user groups. More detailed information on the case studies is provided in Chapter Seven.

Adding Other HOVs

This scenario focuses on allowing vanpools and carpools to use a bus-only freeway HOV lane or adding carpools to an HOV lane open to buses and vanpools. All of these user groups qualify as HOVs. This scenario may be considered if there is available capacity on an HOV lane that does not yet allow all types of HOVs. The I-10 West HOV lane case study provides an example of the experience on an early HOV lane that was initially opened only to buses and authorized vanpools. Since most freeway HOV lanes are open to buses, vanpools, and carpools, the key elements to consider with this scenario are highlighted. Assessing changes in carpool occupancy requirements are described in the next chapter.

Project Goals and Objectives. Allowing other HOVs, such as vanpools and carpools, would meet HOV project goals and objectives in most areas. This scenario would support goals and policies related to increasing person throughput, enhancing mobility, proactively managing the operation of an HOV lane, and addressing air quality concerns.

Type and Length of HOV Lane. Allowing vanpools and/or carpools would be appropriate with exclusive and concurrent flow freeway HOV lanes. As noted below, design issues and capacity and safety concerns, may limit consideration to allow carpools to use some contraflow HOV lanes.

Table 4.3. Assessing Changes in Vehicle-Eligibility Requirements.

Elements to Consider	Adding Other HOVs	Adding HOT Vehicles	Adding Low-Emission and Energy-Efficient Vehicles
Project Goals/ Objectives	ü	ü	ü
Type of HOV Lane	ü	ü	ü
Design Limitations	ü	ü	ü
Congestion Levels	ü	ü	ü
Bus Operations	ü	ü	ü
System Connectivity	l	l	l
Support Facilities	ü	ü	¡
Safety	ü	l	l
Enforcement	ü	ü	ü
Perceptions of Users	ü	ü	ü
Perceptions of Non-Users	ü	ü	ü
Perceptions of Policy Makers	ü	ü	ü
Target Markets	l	ü	ü
Impact on Current Users	l	ü	ü
Pricing Alternatives	¡	ü	ü
Tolling Infrastructure	¡	ü	ü
Level/Use of Revenues	¡	ü	ü
Identifying Eligible Vehicles	¡	ü	ü
Equity Concerns	¡	ü	ü
Methods to Restrict Use	¡	ü	ü

ü – Critical Factors
l – Important Factors
¡ – Neutral Factors

Design Treatments or Operation Limitations. Design and operating constraints may limit consideration of allowing vanpools and carpools to use an HOV lane. Allowing carpools to use an HOV lane typically increases vehicle volume significantly. The design and operating characteristics of an HOV lane must be able to accommodate these higher volumes, or improvements may be needed before these user groups are allowed to access an HOV lane.

Congestion Levels in the HOV Lane and the General-Purpose Freeway Lanes. Allowing vanpools and carpools would typically be considered if there is available capacity in an HOV lane. Congestion levels in the general-purpose freeway lanes will provide an indication of the benefits to existing and new vanpools and carpools from use of the HOV lane.

Bus Operations. The potential impact on bus speeds, travel times, on-time performance, and operating costs should be examined if allowing vanpools and/or carpools to use an HOV lane is being considered. It is important that providing vanpools and/or carpools with access to an HOV lane does not degrade bus operations.

System Connectivity. Providing vanpools and/or carpools with access to an HOV lane may help with system or regional connectivity if other HOV lanes in the area allow these user groups.

Support Facilities and Services. Consideration should be given to support facilities and services needed with allowing vanpools and/or carpools to use an HOV lane. Park-and-pool lots, vanpool programs, rideshare matching services, and guaranteed ride home programs provide a few examples of the types of support facilities and services that may be needed with these user groups.

Safety. Possible safety concerns related to allowing vanpools and/or carpools to use an HOV lane should be examined. As noted previously, an HOV lane may have design or operating limitations that raise safety issues with use by vanpools and/or carpools. Ensuring that an HOV lane can be operated safely with these user groups is critical. Improvements may be needed to address potential safety issues.

Enforcement. Extra enforcement will typically be needed with the addition of vanpools and/or carpools to an HOV lane, as vehicle-occupancy levels must be monitored. Ensuring that adequate enforcement can be provided is an important element to consider in assessing adding vanpools and/or carpools to an HOV lane.

Perceptions of HOV Lane Users. Current bus riders may be neutral to allowing vanpools and carpools to use an HOV lane if there is available capacity in the lane. Bus riders may become concerned, however, if allowing these user groups results in congestion in the HOV lane.

Perceptions of Non-Users. If the general-purpose freeway lanes are congested, motorists using these lanes would typically favor allowing vanpools and/or carpools to use an HOV lane. Existing vanpoolers and carpoolers who would qualify to use the HOV lane would support the change, as would individuals willing to change modes to use the lanes.

Perceptions of Policy Makers. Policy makers would typically support allowing vanpools and/or carpools to use an HOV lane that has available capacity. As noted previously, most freeway HOV lanes are open to buses, vanpools, and carpools.

Case Study – Expanding HOV User Groups on the I-10 West HOV Lane in Houston

The I-10 West HOV lane, located on the west side of Houston, Texas, is 13 miles in length. It is a one-lane, barrier-separated, reversible HOV lane located in the freeway median. Only buses and authorized vanpools were eligible to use the I-10 West HOV lane when it was first opened in 1984, reflecting the approach used on the I-45 North contraflow demonstration project. Approximately 50 vehicles used the lane during the morning peak-hour with the bus and authorized vanpool vehicle-eligibility requirement. Due to this low level of use, the lanes were opened to authorized 4+ carpools after six months of operation. This change added approximately 10 vehicles to the morning peak-hour volume on the lane. The vehicle-occupancy level was lowered again after six months to 3+ authorized carpools, which added approximately 100 vehicles to the morning peak-hour traffic stream. In 1986 the vehicle-occupancy level was lowered to 2+ carpools and the authorization requirement was discontinued. The morning peak-hour volumes increased to approximately 1,200 vehicles after this change. Morning peak-hour vehicle volumes began to regularly reach or exceed 1,500 over the next few years. The congestion resulting from these volumes, coupled with the design of the facility, reduced the travel time savings and travel time reliability bus riders, carpoolers, and vanpoolers had come to expect. As described in Chapter Five and the detailed case study in Chapter Seven, in response to lower travel speeds in the HOV lane and complaints from bus passengers, the vehicle-occupancy requirement was increased in 1988 from 2+ to 3+ during the period from 6:45 to 8:15 a.m.

Priced or HOT Vehicles

This scenario focuses on allowing lower or single-occupant vehicles to use an HOV lane for a fee. Allowing HOT vehicles to use an HOV lane may be considered for a number of reasons. These reasons may include using available capacity and managing congestion in an HOV lane with a 2+ vehicle-occupancy requirement. In this case, two-person carpools may continue to be able to use the HOV lane for a fee, while the vehicle-occupancy level for non-paying HOVs is increased to 3+. In other cases, HOT project may be implemented to increase use on an HOV lane with available capacity, to generate revenues for transit and transportation improvements, and to provide additional travel options.

As noted previously, SAFETEA-LU includes specific provisions addressing HOV vehicle use of HOV lanes. These requirements are noted in this section related to some of the factors highlighted in Table 4.3. Case study examples of HOT project in Houston, San Diego, and Minneapolis are highlighted in this section and described in more detail in Chapter Seven.

Project Goals and Objectives. The goals and objectives of an HOV project or HOV system should be considered in any assessment of expanding an HOV lane to include HOT vehicles. HOT vehicles may address objectives relating to maximizing use of an HOV lane and providing another travel option. Other objectives may address restoring freeflow conditions in a congested HOV lane by pricing lower-occupant vehicles. Examples of objectives from some HOT Project are noted in the case study below.

Case Study – Objectives of HOT Projects

Objectives of the MnPASS HOT project on the I-394 HOV lanes in Minneapolis include increasing the person and vehicle-carrying capabilities of the HOV lanes, maintaining freeflow speeds for transit and carpools, and using the revenues generated from the project for highway and transit improvements in the corridor. Other project objectives include deploying ETC and using ITS technologies to facilitate enforcement. The objectives of the initial HOT demonstration project on the I-15 HOV lanes in San Diego included testing value pricing as a method of managing congestion on the freeway lanes, managing demand on the HOV lanes, expanding transit and rideshare services in the corridor, and enhancing air quality in the region.

Type and Length of HOV Lane. The type and length of an HOV lane may influence consideration of allowing HOT vehicles. The first HOT projects in San Diego and Houston were on exclusive HOV lanes with limited access points. The single entry and exit on I-15 in San Diego and limited direct access points on the I-10 West and US 290 HOV lanes in Houston allow both electronic toll collection for HOT vehicles and visual enforcement of vehicle-occupancy requirements. The MnPASS project on I-394 involves both barrier-separated, reversible HOV lanes and concurrent flow HOV lanes. The operation of the concurrent flow HOV lanes were changed significantly from unlimited assess to five eastbound and six westbound access points with the implementation of MnPASS. The HOT projects in operation are on HOV lanes that vary in length from eight miles to 13 miles. A short HOV lane may not be a logical candidate for a HOT project due to the cost of the toll collection infrastructure and the need for significant travel time savings to attract paying users.

Design Treatments or Operation Limitations. Potential design or operating concerns that may limit the use of an HOV lane by HOT vehicles should be examined in assessing this scenario. Potential design issues may relate to the tolling infrastructure and operation needs. Improvements or changes in design may be needed to accommodate HOT vehicles. For example, as part of the I-394 MnPASS project, access treatments on the concurrent flow section were changed from unlimited ingress and egress to five eastbound and six westbound access points.

Congestion Levels in the HOV Lane and the General-Purpose Freeway Lanes. The level of congestion in an HOV lane should be considered in assessing possible HOT projects. An HOV lane using a 2+ occupancy requirement that has available capacity may be considered for tolling single-occupant vehicle use. An HOV lane that is congested at a 2+ vehicle-occupancy level may be considered for increasing the vehicle-occupancy level to 3+ and tolling two-person carpools. Finally, similar to HOT projects on the I-10 West and US 290 HOV lanes in Houston, tolling two-person carpools on an HOV lane with a 3+ vehicle-occupancy requirement for all or part of a day may be considered. The level of congestion in the general-purpose freeway lanes should also be examined. Single or lower-occupant vehicle drivers will typically only be willing to pay a toll to use an HOV lane if general-purpose freeway lanes are congested and the HOV lane provides travel time savings and improved trip time reliability.

Bus Operations. The impact that expanding an HOV lane to include HOT vehicles has on bus operations and bus riders should be examined. It is important that the inclusion of HOT vehicles not degrade the travel time savings and trip time reliability of an HOV lane. It is also important that the tolls not be set below the level of bus fares or current riders may change to driving alone and paying the toll.

System Connectivity. Expanding an HOV lane to include HOT vehicles may impact the operation of other HOV lanes in a corridor or area. System connectivity concerns should be included in assessing the potential impacts of adding HOT vehicles to an HOV lane. Examples exist of the HOT project being the only HOV lane in an area and regions with HOT vehicles allowed on some HOV lanes, but not on others. The HOT project on I-15 in San Diego represents the only HOV lane in the area. There are other HOV lanes in both Houston and Minneapolis that do not allow lower-occupancy or single-occupant vehicles to use the HOV lanes for a fee, however.

Support Facilities and Services. The potential impact of allowing HOT vehicles on existing support facilities and services should be examined, as well as assessing the additional services that may be needed to support a HOT project. In addition to the toll infrastructure and enforcement functions described later in this section, other necessary support functions for HOT projects may include marketing and outreach programs, ETC sales and service centers, and the toll collection processing and record keeping functions.

Safety. Possible safety concerns should be examined in assessing the expansion of an HOV lane to include HOT vehicles. If carpools are currently allowed to use an HOV lane, there should not be major safety concerns with a

HOT component. Possible safety issues may relate to the design and operation of the access points and accommodating ETC and visual enforcement activities.

Enforcement. As noted previously, SAFETEA-LU requires operating agencies to develop and maintain enforcement programs if HOT vehicles are allowed to use an HOV lane. Enforcement of both the toll collection and the vehicle-occupancy requirements will be needed with HOT projects.

Perceptions of HOV Lane Users. Current HOV lane users may not favor allowing HOT vehicles if the lane becomes congested as a result. Experience to date indicates that current HOV lane users have not raised major concerns on the operations of HOT projects.

Perceptions of Non-Users. Motorists in the general-purpose freeway lanes may have mixed reactions to allowing HOT vehicles to use an HOV lane without meeting the occupancy requirements. Motorists and the public may favor HOT projects if they are willing to pay to use the lane. Motorists and the public may not favor HOT projects if they will not be able to use the lane themselves.

Perceptions of Policy Makers. The perceptions of policy makers are very important in considering HOT projects. Policy makers may be influenced by the reactions of their constituents, information provided by operating agencies and other groups, and their own perspective on HOV lanes and HOT projects. The I-15 HOT project in San Diego illustrates the important role policy makers can play as project champions for a HOT project. The I-394 MnPASS project also points out the importance of policy maker support in advancing a HOT project and the role policy makers may play in operating decisions if commuters raise concerns about specific elements, such as the hours of operation.

Target Markets. The potential users of a HOT project should be examined in assessing the potential impact of allowing HOT vehicles to use an HOV lane. The Houston QuickRide project focuses on two-person carpools during the 3+ restricted time period. The FasTrack™ project on I-15 in San Diego and the I-394 MnPASS project in Minneapolis focus on single-occupant vehicles. A detailed analysis of the target market, including estimates of use levels at different pricing levels, are typically conducted by consulting firms or other groups as part of an HOT project. The travel time savings and trip time reliability provided by the HOV lane, along with the toll level, will influence use. As noted in the case studies in this section, which are discussed in more detail in Chapter Seven, HOT vehicles on the I-15 HOV lane in San Diego account for approximately 22 percent to 25 percent of the daily vehicles using the lane. These percentages equate to approximately 5,000 daily HOT trips. On I-394 in Minneapolis, MnPASS vehicles account for some 476 vehicles or 16 percent of the total 2,928 vehicles using the HOV lane during the morning peak hour. On I-10 West and US 290 in Houston, two-person QuickRide carpools account for between 120 and 150 daily trips.

Impact on Current Users. Existing vehicle volumes on the HOV lane will influence consideration of HOT projects. If HOT toll are set too low, negative impacts may arise if too many lower or single-occupant vehicles are allowed to use the facility. This situation could result in slower travel speeds, reduced travel time savings, and lower levels of travel time reliability. Current HOV volumes may decline if existing bus riders, carpoolers, and vanpoolers decide to change to driving alone for a fee. On the other hand, if revenues generated from the project are used to enhance bus service in the corridor, to reduce bus fares, or to make other improvements benefiting HOVs, bus ridership, and carpool and vanpool use may increase.

Pricing Alternatives. The amount the target market may be willing to pay to use an HOV lane should be considered. Factors to consider include the estimated demand at various pricing levels and the quality of service. In addition to the traditional cost-to-demand relationship, other factors to consider include the bus fares in the corridor and the cost of other transit alternatives. An ongoing process to review and adjust toll rates should also be developed. A toll schedule that may have been sufficient one month may be outdated the following month. A process must be identified for not only setting the initial toll schedule and adjusting the toll schedule, but also how often toll charges will change. If toll rates are established by dynamic pricing, as used on I-15 in San Diego and I-394 in Minneapolis, the process of changing toll rates must be defined in a manner compatible with automated systems and algorithms.

Cost of Tolling Infrastructure and Strategies. The cost of the infrastructure and the ongoing operation of an HOT project are important factors to consider. The cost of these elements will depend on the approach and the operating strategy used for a HOT project. The two general types of approaches are a manual or static operating strategy and the use of ETC and real-time pricing based on congestion. As noted previously, SAFETEA-LU requires that HOT projects on HOV lanes use ETC. The cost of the two approaches varies considerably. As highlighted in the I-15 HOT project case study, a low cost approach using monthly permits was initially used on the project. The cost for ETC infrastructure and ongoing operations is much more significant.

Level and Use of Revenues. The anticipated level of revenues generated from a HOT project and the use of the revenues should also be considered. Studies conducted around the country indicate that public and policy maker reaction to a possible HOT project is influenced by how the revenues are anticipated to be used. Public support appears to be higher if the revenues are used for transit and transportation improvements in the corridor, than if they are used for other purposes. If the HOT lane is part of a toll or managed lane project, the funding and revenue agreements among the toll operator and any participating public agency will need to be determined. The tolls may be used to help fund the project.

Identifying Eligible Vehicles. Identifying eligible HOT vehicles through the use of ETC or visual monitoring of monthly permits is important to maintain the integrity of a project and the revenue stream. This identification is important for enforcement, public perception, and revenue generation. SAFETEA-LU requires that operating agencies develop a program to address how motorists can enroll and participate in a toll program, to use ETC, to manage demand on the lane, and to enforce violations.

Potential Equity Concerns. Equity issues or concerns that only high income individuals will be able to afford to use HOT projects may be an issue. Experience with existing projects indicates that all income levels use value-priced lanes.

Methods to Restrict Use. SAFETEA-LU requires that operating agencies that allow HOT vehicles establish a program to monitor the use of an HOV lane by these vehicles. The Act also requires agencies to establish, manage, and support enforcement programs to ensure the HOV lane is operated in accordance with the federal requirements. Further, agencies must limit or discontinue use of the HOV lane by these HOT vehicles if their use degrades the operation of the facility, as defined in the Act. The measures that will be taken to limit or discontinue use should be considered in any assessment of allowing these vehicles to use an HOV lane. Increasing tolls to lower HOT vehicle use levels are typically considered with these types of projects.

Case Study –The *QuickRide* HOT Project on the I-10 West and US 290 HOV Lanes in Houston

The I-10 West HOV lane in Houston was opened in 1984 to buses and authorized vanpools. The vehicle-eligibility and vehicle-occupancy requirements were modified over the first few years to maximize use. In response to congestion in the HOV lane at a 2+ HOV vehicle-occupancy level, the occupancy requirement was increased to 3+ during the peak hours in 1988.

In the late 1990s, METRO and TxDOT staff began considering the potential of allowing two-person carpools to use the I-10 West HOV lane during the 3+ restricted period for a fee, reflecting the ongoing interest in maximizing use of the lane to benefit travelers. This approach was viewed as a way to increase use of the HOV lane without allowing it to become overly congested as it was in 1988 when the vehicle-occupancy requirement was raised to 3+.

Based on the results of a feasibility study, the decision was made to implement a demonstration project to test allowing two-person carpools to use the HOV lane for a $2.00 per trip fee during the 3+ occupancy requirement periods – 6:45 a.m. to 8:00 a.m. and 5:00 p.m. to 6:00 p.m. The *QuickRide* HOT project, which uses the automatic vehicle identification (AVI) system for electronic toll collection (ETC), was implemented in 1998. Individuals are required to register for the program and must have an active electronic tag account. By June 1998, 468 *QuickRide* electronic tags had been issued. In 2000, the demonstration was expanded to include the US 290 HOV lanes, only in the morning peak hour. As of April 2003, there were 1,476 active *QuickRide* accounts.

Daily *QuickRide* use has grown slightly over time. In 1998, an average of 103 daily *QuickRide* participants used the I-10 West HOV lanes. Use levels from 2000 through 2005 remained relatively constant, averaging between 120 and 150 vehicles. Use levels are higher in the morning on the I-10 West HOV lanes, with some 68 percent of the daily participants traveling in the lane in the morning peak hour.

Analysis of initial use levels indicated that each enrolled tag generated an average of one tolled trip every four days, producing an average of 115 to 120 total two-person carpool trips during the 1-1/4 morning hours plus the one evening hour. Approximately 6 percent of enrolled tags produced five or more trips per week.

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

Case Study – ExpressPass and FasTrak™ HOT Projects on the I-15 HOV Lanes in San Diego

The eight-mile, two-lane exclusive HOV facility on I-15 was opened in 1988 with a 2+ vehicle-occupancy requirement. There is one entrance and one exit. The lanes were open in the southbound direction from 6:00 to 9:00 a.m. and in the northbound direction from 3:00 to 6:30 p.m. and were closed at other times.

Interest in considering pricing on the HOV lanes emerged during the examination of potential transportation control measures in the regional air quality plan. The initial demonstration project and the ongoing HOT project represent the joint efforts of SANDAG, Caltrans, MTDB, and CHP. SANDAG is responsible for overall project management, Caltrans operates the HOV lanes, MTDB operates bus service in the corridor, and CHP is responsible for enforcement.

The initial demonstration project, ExpressPass, began in 1996. During this phase a limited number of monthly permits were sold to motorists on a first-come, first-serve basis. Drivers with permits could use the lanes without meeting vehicle-occupancy requirement, while carpools, vanpools, and buses continued to use the lanes for free. The monthly fee was first set at $50 in December 1996 and 500 permits were sold. In 1997, 700 permits were issued and the fee increased to $70.

In April 1989, the FasTrak™ phase was implemented with ETC replacing the monthly passes. Variable fees for single-occupancy vehicle use of the HOV lanes are collected electronically. The fee depends on the congestion level in the HOV lanes and is recalculated each six minutes to maintain a level-of-service C. Fees typically range from $0.50 to $4.00, although the fee could reach as high as $8.00. Message signs located before the start of the lanes display the updated fee.

During the first month of ExpressPass phase, a 12 percent increase in traffic throughput occurred. Most of this increase was the result of new carpools rather than single-occupant vehicles. As of March 2005, there were approximately 18,670 active FasTrak™ accounts and some 27,700 transponders in use. In 2004 and 2005, the daily weekday average traffic using the I-15 HOV lanes ranged from a high of 22,341 in March 2004 to a low of 19,401 in February 2005. Over this time period, HOVs accounted for approximately 75 percent to 78 percent of the total vehicle volumes. FasTrak™ users accounted for most of the remaining 22 percent to 25 percent, although there were a small percentage of invalid reads of toll tags and FasTrak™ violators.

Annual revenue generated from FasTrak™ users is approximately $1.2 million. The revenue has been used to support operations of the system and to expand public transportation services in the corridor. The Inland Breeze bus service provides express trips into downtown San Diego and reverse commute trips to suburban destinations in the corridor.

Case Study – I-394 MnPASS HOT Project in Minneapolis

The I-394 HOV lanes are approximately 11 miles in length. There are two different sections of HOV lanes. A three-mile, two-lane, barrier-separated reversible section in located directly to the west of downtown Minneapolis. To the west of this section are seven miles of concurrent flow HOV lanes. The lanes are operated by the Minnesota Department of Transportation (Mn/DOT) in coordination with Metro Transit, the Minnesota State Patrol, and local communities.

Interest in considering allowing single-occupant vehicles to use the HOV facilities emerged during the late 1990s and early 2000s. In 2003, state legislation was approved allowing a HOT project on the I-394 HOV lanes. The MnPASS project was implemented in May 2005. Dynamic pricing is used on the project, with tolls based on the level of congestion in the HOV lane. The base toll is $0.25 and the maximum toll is $8.00. The project represents the first use of tolling in the Minneapolis-St. Paul metropolitan area and in Minnesota.

MnPASS also represents the first HOT project on concurrent flow HOV lanes. The previous unlimited access to the I-394 concurrent flow HOV lanes was changed to five eastbound and six westbound access points. The MnPASS tags are read electronically as vehicles enter the lanes at these locations and the occupancy requirement is visually checked by enforcement personnel.

The initial hours of MnPASS operation were 24/7 on the seven-mile concurrent flow HOV lanes and eastbound from 6:00 a.m. to 1:00 p.m. and westbound from 2:00 p.m. to 5:00 a.m. on the three-mile two-lane reversible section. These operating hours represented a significant change from those used since the I-394 HOV lanes opened. After negative response from commuters in the corridor and policy makers, Mn/DOT returned the MnPASS hours on the concurrent flow section to those used with the HOV lanes from 1992 to 2005.

A total of 4,057 transponders were purchased prior to the opening of the project. As of December 2005, some 8,700 transponders had been purchased. The number of daily MnPASS trips on weekdays grew from 916 on the first day of operation to an average of 3,400 by the 10th week, with a one-day high of 4,039 MnPASS trips. The maximum toll reached $8.00 on four days during the first 10 weeks of operation. The maximum toll on most days averaged between $3.25 and $4.00, and the weekday average toll was under $1.00 over the initial 10-week period.

During the morning peak-hour, volumes in the HOV lane increased by some 316 vehicles by the third quarter of 2005. MnPASS vehicles accounted for 476 vehicles, or 16 percent, of the total 2,928 vehicles using the HOV lane. HOVs and a few violators accounted for the remaining 84 percent of vehicles using the lane. The number of HOVs declined by approximately 167 vehicles and the AVO declined from 3.41 to 2.88.

Texas High-Occupancy/Toll Strategic Analysis Tool

A research project sponsored by the Texas Department of Transportation (TxDOT) and conducted by the Texas Transportation Institute (TTI) developed a High-Occupancy/Toll STrategic Analysis Tool (HOT START). HOT START provides a tool to aid in the assessment of expanding existing HOV lanes to include HOT vehicles. The program was developed using the Visual Basic.NET® platform.

HOT START includes three general categories of factors to consider in assessing expanding an HOV lane to include a HOT component. These general categories are facility factors, performance factors, and institutional factors. Elements within the facility category include the cross-section, the toll collection method, lane separation treatment, the access locations and design, and the ability to enforce the HOT payment. Other elements in the facility category include facility traffic control, pricing strategy, incident management, and maintenance.

The six performance factors are HOV lane utilization, travel time, benefits, willingness to pay tolls, safety, and environment. Institutional factors include public acceptance, political acceptance, environmental justice, and use of the project revenue. Interagency cooperation, media relations and public information, and education are other institutional factors.

HOT START allows a user to weigh each factor or to use default weights, which were set based on the experience to date with HOV projects. The user assigns a numeric rating to each factor for a given project. The HOT START results provide an indication of the potential success of a HOT project and an indicator of any critical factors.

Low-Emission and Energy-Efficient Vehicles

This scenario focuses on allowing low-emission or energy-efficient vehicles to use an HOV lane. As noted previously, The Clean Air Act Amendments of 1990 and the TEA-21 allowed states to exempt ILEVs from HOV occupancy requirements. SAFETEA-LU continues to allow states to provide ILEVs access to HOV lanes without meeting occupancy requirements until September 30, 2009. SAFETEA-LU also expands the exempt vehicle classification to include other low-emission and energy-efficient vehicles, including some types of hybrids as defined by EPA. These vehicles must be certified by EPA and marked according to EPA guidance. States must establish a program for identifying vehicles and for enforcing regulations related to their use. These vehicles may be allowed before September 30, 2009 if they pay a toll. The SAFETEA-LU language states that this toll could be “no toll” or a toll lower than the fee charged for other exempt vehicles.

A total of 10 states have had approved legislation allowing ILEVs to use HOV lanes based on the provisions of TEA-21. Four states—Arizona, California, Colorado, and Georgia—approved subsequent legislation allowing hybrids to use HOV facilities without meeting occupancy requirements if authorized in federal legislation or federal agency action. Virginia was the only state allowing hybrids to use the HOV lanes, even though it was counter to the TEA-21 provisions.

Allowing low-emission and energy-efficient vehicles to use an HOV lane may be considered if an HOV lane is underutilized. Based on the experience to-date, however, it appears that the interest in allowing low-emission and energy-efficient is coming from state legislators and other policy makers, rather than from individuals at operating agencies.

Project Goals and Objectives. The goals and objectives of a specific HOV project or an HOV system should be used in considering allowing low-emission and energy-efficient vehicles to use an HOV lane. Possible objectives for allowing low-emission and energy-efficient vehicles include encouraging the purchase of these types of vehicles, maximizing available capacity, and enhancing air quality and energy independence.

Type and Length of HOV Lane. The type and length of an HOV facility may influence consideration of allowing low-emission and energy-efficient vehicles to use the lane. Allowing low-emission and energy-efficient vehicles to use a short HOV lane would probably not provide enough travel time savings to encourage an individual to invest in a low-emission and energy-efficient vehicle.

Design Treatments or Operating Limitations. Consideration of providing HOV lane access to low-emission and energy-efficient vehicles may be influenced by design or operating constraints associated with a specific HOV facility. HOV lanes with design limitations may not be able to accommodate the higher vehicle volumes that would result from allowing these types of vehicles.

Congestion Levels in the HOV Lane and General-Purpose Freeway Lanes. The level of congestion in the HOV lane, the general-purpose freeway lanes, and in the travel corridor will influence consideration of allowing low-emission and energy-efficient vehicles to use an HOV lane. Information from an HOV performance monitoring program can be used to identify potential issues or concerns with current vehicle-eligibility requirements. An HOV lane operating at or near capacity would typically not be considered for allowing access by low-emission and energy-efficient vehicles.

Bus Operations. Examining the impact that allowing low-emission and energy-efficient vehicles has on public transportation operators and bus riders is important if buses represent a significant user group. Bus operators and bus riders may experience slower travel speeds and degraded service if an HOV lanes becomes congested from allowing low-emission and energy-efficient vehicles to use an HOV lane.

System Connectivity. If there is more than one HOV facility in operation or in the planning stage in a metropolitan area, allowing energy-efficient and energy-efficient vehicles on one facility may influence the operation of other HOV lanes. The state legislation approved to-date relating to low-emission and energy-efficient vehicle use of HOV lanes covers all HOV facilities in the respective states. The one exception to this approach is the legislation approved in 2006 in Virginia, which requires a new design for clean special fuel license plates issued after July 1, 2006 and limits use of the HOV lanes in the I-95/I-395 corridor to vehicles registered with and displaying the clean special fuel license plates issued prior to July 1, 2006.

Safety. Possible safety impacts should be considered in assessing the potential use of an HOV lane by low-emission and energy-efficient vehicles. Safety concerns will typically relate to the type of HOV lane and the design treatments discussed previously. Improvements may need to be made in an HOV lane to accommodate the higher vehicle volumes anticipated from allowing these vehicles.

Enforcement. Enforcement needs should be considered in examining allowing low-emission and energy-efficient vehicles to use an HOV lane. It is more difficult for law enforcement personnel to check for special license plates or stickers and for the number of occupants in a vehicle. As noted previously, SAFETEA-LU requires operating agencies to develop and maintain enforcement programs if low-emission and energy-efficient vehicles are allowed to use an HOV lane. The cost of these programs should be considered in assessing possible use by low-emission and energy-efficient vehicles.

Perceptions of HOV Lane Users. Current HOV lane users may not favor allowing low-emission and energy-efficient vehicles not meeting the occupancy requirements to use the lane if the lane becomes congested as a result. As noted in the northern Virginia case study, there has been vocal opposition from carpoolers and bus riders to allowing hybrid vehicles to use the HOV lanes without meeting the occupancy requirements.

Perceptions of Non-Users. Motorists in the general-purpose freeway lanes may have mixed reactions to allowing low-emission and energy-efficient vehicles to use an HOV lane without meeting the occupancy requirements. Motorists and the public may favor allowing these vehicles if they own an eligible low-emission and energy-efficient vehicle. Motorists and the public may not favor allowing these types of vehicles if they do not own an eligible vehicle or cannot afford one.

Perceptions of Policy Makers. Policy makers may be influenced by the reactions of their constituents, information provided by operations agencies and other groups, and their own perspective on HOV and low-emission and energy-efficient vehicles. As noted previously, the interest in allowing low-emission and energy-efficient vehicle use of HOV lanes in many states has come primarily from policy makers rather than staff at operating agencies.

Target Markets. The potential market or markets being considered with expanding HOV lanes to include low-emission and energy-efficient vehicles should be examined. The limited experience in Virginia and California seems to indicate that the ability to use the HOV lanes in those states is an important factor in the decision to purchase a hybrid vehicle.

Impact on Current Users. As noted in the northern Virginia case study, allowing hybrid vehicles to use HOV lanes in the area has resulted in increased vehicle volumes and congestion on some HOV lanes. HOV lane users have been vocal in raising concerns about hybrid use of the HOV lanes.

Identifying Eligible Vehicles. A potential issue with allowing low-emission and energy-efficient vehicle use of an HOV lane is being able to identify eligible or qualifying vehicles. This identification is important for both enforcement and public perception. SAFETEA-LU requires that operating agencies develop a method to identify low-emission and energy-efficient vehicles, as well as developing a program to identify qualifying vehicles and enforce their use. Most states either use special license plates or stickers to identify low-emission and energy-efficient vehicles.

Potential Equity Concerns. Equity issues or concerns that only high income individuals will be able to afford to purchase hybrid or low-emission and energy-efficient vehicles may be a concern.

Methods to Restrict Use. SAFETEA-LU requires that operating agencies that allow low-emission and energy-efficient vehicles establish programs to monitor the use of an HOV lane by these vehicles. The Act also requires agencies to establish, manage, and support enforcement programs to ensure the HOV lane is operated in accordance with the federal requirements. Further, agencies must limit or discontinue use of the HOV lane by these vehicles if their use degrades the operation of the facility, as defined in the Act. The measures that will be taken to limit or discontinue use should be considered in any assessment of allowing these vehicles to use an HOV lane. As noted previously, the Virginia Legislature has taken action to limit use of the I-95/I-395 HOV lanes to only vehicles with clean special fuel license plates issued prior to July 1, 2006 as one method to address congestion in the HOV lanes in northern Virginia.

Case Study – Low-Emission and Energy-Efficient Vehicle and HOV Lanes in California

The use of HOV lanes by low-emission and energy-efficient vehicles is addressed in two pieces of legislation. The first, approved in 1999, allows SULEVs to use HOV lanes without meeting minimum-occupancy requirements. The second, approved in September 2004, extends the HOV exemption to hybrid and other alternative fuel vehicles meeting the state's Partial Zero Emission Vehicle (AT PZEV) standard and have a 45 mph or greater fuel economy highway rating, based on federal action allowing use by these types of vehicles, however.

Assembly Bill (AB) 71 was approved in 1999 and became effective on January 1, 2000. AB 71 allows low-emission vehicles to use the HOV facilities in the state without meeting the minimum-occupancy requirements. The purpose of the bill was to encourage the early deployment of cleaner vehicles by allowing access to the HOV facilities. Only vehicles meeting the state's SULEV standards and the federal ILEV standards were allowed to access the HOV facilities without meeting the occupancy requirements.

Approximately 5,371 vehicles registered for the SULEV decal between July, 2000 and May, 2004. The majority of these vehicles are located in counties in the large urban areas of the state, with over half in Los Angeles County. For the most part, these counties are also those with HOV lanes in the state.

Legislation approved in September 2004 expands the definition of exempt vehicles to include hybrid and alternative fuel vehicles meeting the specific standards. The legislation requires CARB to publish and maintain a list of vehicles, including hybrids that meet the defined criteria. It also prohibits the DMV from issuing more than 75,000 clean air vehicle decals to hybrid vehicles. Further, it requires the DMV to stop issuing decals to hybrids if Caltrans makes a specific determination after 50,000 decals have been issued. The legislation outlines the elements Caltrans must address in the assessment.

If Caltrans determines that a significant breakdown of the HOV lanes has occurred throughout the state, it shall notify the DMV, which will discontinue issuing decals to hybrids and related vehicles. The finding must also demonstrate that other means of alleviating the congestion are not feasible. Other possible methods noted include reducing the use of the HOV lane by non-eligible vehicles, increasing occupancy requirements, or adding capacity.

As of early 2006, some 50,000 decals had been issued. No major studies have been conducted on the use of HOV lanes by SULEVs or hybrids in the state. The ongoing monitoring of the HOV lanes by Caltrans has not captured the number of these types of vehicles using the HOV lanes.

Case Study – Low-Emission and Energy-Efficient Vehicle Use of the HOV Lanes in Northern Virginia

State legislation approved in 1994 allows vehicles with clean special fuel license plates to use the HOV lanes in Virginia without meeting the minimum-occupancy requirements. Subsequent legislation in 1996, 1999, 2003, and 2006 extended the sunset date.

In 2000, hybrid vehicles became available in the state and were included as eligible for clean special fuel license plates. As of October 2004, a total of 10,413 clean special fuel license plates had been issued in the state. In the six years from 1994 and 1999, a total of 78 clean special fuel license plates were issued. In the almost five years from 2000 to October 2004, with hybrids qualifying for the HOV exemption, a total of 10,335 clean special fuel license plates were issued. This increase is directly attributed to hybrid vehicle owners applying for the special clean fuel license plates. Hybrid vehicles comprise the vast majority of the license plates issued, accounting for almost 95 percent of the total. In comparison, no other type of low-emission or energy-efficient vehicle comprises more than 1.3 percent of the total.

The vast majority of the clean special fuel vehicle plates were issued in counties and cities in northern Virginia, which are served by the I-95, I-395, I-66, and Dulles Toll Road HOV lanes. Since the fall of 2003, the number of vehicles with clean special fuel license plates has been included in the regular vehicle and vehicle-occupancy counts conducted on the HOV lanes in the area, with field data collection personnel counting license plates at specific points along the HOV lanes.

The results from the ongoing monitoring program show that owners of vehicles with clean special fuel license plates are using the HOV lanes in northern Virginia. In the fall of 2003, clean special fuel vehicles accounted for between 2 percent and 12 percent of the HOV volumes during the peak-periods on the different HOV facilities in northern Virginia. Counts from six days in October 2004 indicate that clean special fuel vehicles accounted for between 11 percent and 17 percent of the vehicles in the HOV lanes on I-95 during the 6:00 a.m. to 9:00 a.m. peak period in the northbound direction. These percentages translate into between some 844 and 1,422 vehicles with clean special fuel license plates using the HOV lanes during the three-hour period and the corresponding total vehicle volumes in the HOV lane ranged from 7,994 to 8,450.

CHAPTER FIVE – ASSESSING VEHICLE-OCCUPANCY REQUIREMENTS

Chapter-at-a-Glance

This chapter provides an overview of possible HOV lane vehicle-occupancy requirements. Potential advantages and limitations with different occupancy requirements are presented. Factors to consider in changing vehicle-occupancy requirements are discussed. Assessing potential changes in vehicle-occupancy requirements are described.

- **Possible Vehicle-Occupancy Requirements**. This section summarizes the different vehicle-occupancy levels that may be considered for use on an HOV lane. The advantages and limitations of different vehicle-occupancy levels, including using vehicle-occupancy requirements, are described.
- **Factors to Consider in Changing Vehicle-Occupancy Requirements**. This section summarizes factors that may be appropriate to consider when changes in vehicle-occupancy requirements are being considered.
- **Assessing Possible Changes in Vehicle-Occupancy Requirements**. This section discusses assessing possible changes in vehicle-occupancy requirements.

Possible Vehicle-Occupancy Requirements

If carpools are allowed to use an HOV facility, the vehicle-occupancy requirement must be established. The planning process for an HOV lane typically includes an analysis of the demand for a facility at different vehicle-occupancy levels and the impact these requirements will have on traffic flow. The goal is to set the occupancy requirement at a level that will encourage the use of carpooling, vanpooling, and taking the bus, but will not create a level of demand that makes the lane congested.

During the late 1970s and early 1980s, FHWA used a 3+ definition for carpools on HOV projects funded through federal programs. As a result, HOV projects opened during that time period, including the Shirley Highway HOV lanes in northern Virginia and the El Monte busway on the San Bernardino Freeway in Los Angeles, used a 3+ vehicle-occupancy requirement. The 3+ requirement has been in effect over the life of the Shirley Highway HOV lanes. The 3+ requirement was in use on the El Monte busway from 1974 to 2000 when the state legislature approved legislation lowering the occupancy requirement to 2+. Due to the congestion, slower travel times, and reduced trip time reliability experienced by HOV lane users with this change, legislation was approved increasing the occupancy requirement back to 3+ during the morning and afternoon peak-periods. SAFETEA-LU defines the occupancy requirement for use of

HOV lanes as no fewer than two occupants per vehicle, with the exceptions noted in Chapter Four on exempt vehicles.

Changes in vehicle-occupancy levels may be needed over the life of an HOV facility. For example, some HOV lanes using a 2+ requirement have experienced congestion resulting in reductions in trip time reliability and slower travel times. This situation happened on both the I-10 West and U.S. 290 HOV lanes in Houston. To address this problem, the vehicle-occupancy requirements were increased to 3+ during the morning and afternoon peak-hours. Increasing vehicle-occupancy levels is not an easy change to make. Public and political pressure may limit the ability of operating agencies to consider increasing occupancy levels.

Currently, the majority of operating HOV facilities use a 2+ vehicle-occupancy requirement. A 3+ occupancy requirement is in use on a few facilities. Three projects – the El Monte Busway on the San Bernardino Freeway in Los Angeles and the I-10 West and U.S. 290 HOV lanes in Houston – use a 3+ occupancy requirement during the morning and afternoon peak-hours and a 2+ requirement at other times. Although no HOV facility currently requires four or more (4+) occupants, this level has been used in the past. The characteristics, advantages, and disadvantages of the various vehicle-occupancy requirements are briefly described in this section and highlighted in Table 5.1.

Two or More (2+) Persons per Vehicle. Two or more persons (2+) per vehicle represent the lowest level of carpooling. SAFETEA-LU uses a two-person occupancy definition for use of an HOV lane. Forming a two person carpool is much easier than forming a three- or four-person carpool. Many two person carpools are comprised of family members, co-workers, or friends. While infants and children qualify as the second person, a pregnant woman does not qualify as two. The vast majority of HOV lanes open to carpoolers use a 2+ occupancy requirement. If an HOV lane becomes too congested at the 2+ occupancy level, increasing the requirement to 3+ may be considered. As noted previously, public and political perceptions are critical to consider in assessing the potential for increasing vehicle occupancy levels.

Three or More (3+) Persons per Vehicle. The next level for defining a carpool is to require three or more persons (3+) per vehicle. Vehicle volumes at the 3+ level are usually lower than at a 2+ requirement, as it is more difficult for individuals to form three-person carpools, so some potential carpoolers may not be able to use a facility at a 3+ requirement.

Four or More (4+) Persons per Vehicle. A four or more (4+) persons per vehicle requirement was used during the initial stages of the Shirley Highway HOV lanes in northern Virginia and the I-10 West HOV lane in Houston. No HOV lane in North America currently uses this occupancy level. It is difficult for most individuals to not only form carpools with four or more persons, but also to sustain four-person carpools over time. Many metropolitan areas probably may not have enough demand at the 4+ level to make this a viable option, especially during the early stages of a project.

Table 5.1. Vehicle-Occupancy Requirement Criterion.

Vehicle-Occupant Level	Advantages	Disadvantages
Two or more (2+) persons per vehicle	Easiest level of carpools to form. Often significant numbers of existing 2+ carpools in a corridor.	May be too many 2+ carpools resulting in congestion in an HOV lane. May not provide incentive to carpool if high number of existing 2+ carpools or help reduce vehicle trips.
Three or more (3+) persons per vehicle	Can address congestion problems at the 2+ level. Higher person-moving capacity.	Harder for individuals to form 3+ carpools. May not have enough 3+ carpools to make lane look used, causing the empty lane syndrome. If existing carpools cannot find an additional passenger, they may travel in the general-purpose lanes; adding to the congestion in these lanes.
Four or more (4+) persons per vehicle	Can address congestion problems at the 3+ level. Higher person-moving capacity.	Hard for individuals to form four-person carpools. Harder to operate on a regular basis due to individual travel needs and schedules. May not have enough 4+ carpools to make lane look used, causing the empty lane syndrome. If existing carpools cannot find an additional passenger, they may travel in the general-purpose lanes; adding to the congestion in these lanes.
Variable requirements by time of day (3+ peak-hours, 2+ other operating hours)	Can address congestion problems during peak-periods. More acceptable to users and policy makers than 3+ at all times.	May be confusing for users, especially during transition periods. May make enforcement more difficult, especially during transition periods.

Variable Vehicle-Occupancy Requirements by Time-of-Day. Another approach is to change the HOV occupancy requirement by time-of-day. This technique represents one approach to managing demand on an HOV lane. This approach is used on the El Monte Busway in Los Angeles and the I-10 West and U.S. 290 HOV lanes in Houston. This approach may initially be confusing to users and to enforcement personnel. The experience with the three current projects indicates that regular users understand the requirements, although additional enforcement is still typically needed during the transition periods.

Factors to Consider in Changing Vehicle-Occupancy Requirements

Many of the factors to be considered in assessing possible changes in vehicle-occupancy levels are similar to those described previously with changes in vehicle-eligibility requirements. There are differences, however, as changes in occupancy levels focus on carpool use of HOV facilities. Since carpools are already included in the vehicle-eligibility requirements, the factors associated with the type and length of an HOV lane, design limitations, and safety, are not typically considered in assessing possible changes in vehicle-occupancy requirements, unless a higher occupancy level was used as a way of limiting vehicle volumes due to design or safety concerns. As highlighted below, potential factors to consider in changing vehicle-occupancy requirements include the project goals and objectives, the level of congestion in the HOV lane and the general-purpose freeway lanes, the number of two-person and three-person carpools, bus operations, system or regional connectivity, enforcement, and the perceptions of users, non-users, and policy makers.

Project Goals and Objectives. The goals and objectives related to HOV facilities should help guide consideration of changes in vehicle-occupancy requirements. The goals, objectives, and measures of effectiveness can be used to help identify when changes in vehicle-occupancy levels may be appropriate to consider.

Congestion Levels in the HOV Lane and General-Purpose Freeway Lanes. The level of traffic congestion in the HOV lane is obviously the key factor in considering changes in vehicle-occupancy requirements. An HOV lane operating at a 2+ level that exceeds a locally established maximum threshold may be a candidate to consider for increasing the occupancy requirements. On the other hand, an HOV lane with a 3+ vehicle-occupancy requirement with vehicle volumes not meeting a local minimum threshold may be considered for lowering the vehicle-occupancy requirement to 2+. The levels of congestion in the general-purpose freeway lanes and in the travel corridor should also be considered in possible changes in vehicle-occupancy levels. Increasing vehicle-occupancy requirements may result in some two-person carpools moving to the general-purpose freeway lanes. Lowering occupancy requirements from 3+ to 2+ may result in existing two-person carpools moving from the general-purpose freeway lanes to the HOV lane.

Current Two-Person and Three-Person Carpool Volumes. The number of current two-person and three-person carpools in both the HOV lane and the general-purpose freeway lanes should be examined in assessing possible increases or decreases in vehicle-occupancy requirements. This information provides a base for estimating the possible impact of various changes. Current 3+ carpools will form the basic user group if an increase in the occupancy level is being considered. On the other hand, current two-person carpools in the general-purpose lanes are likely to move to an HOV lane if the occupancy requirement is lowered from 3+ to 2+.

Bus Operations. The impact of changing vehicle-occupancy levels on bus operations should be examined. As noted in the Houston and Los Angeles case studies, the negative impacts on bus operators and bus riders from congestion in the HOV lanes with a 2+ occupancy requirement resulted in changes to the 3+/2+ variable occupancy requirements. Bus riders in both areas were vocal in their support for increasing occupancy levels to address congestion occurring at the 2+ level.

System or Regional Connectivity. If there are multiple HOV lanes in an area, changes in vehicle-occupancy requirements on one HOV facility may impact the operation of other HOV lanes. Consideration should be given to coordinating the vehicle-occupancy requirements on the various HOV facilities. Uniform vehicle-occupancy requirements are more easily understood by travelers and enforcement personnel. Similar vehicle-occupancy requirements may not be possible or desirable, however, depending on the type of HOV facilities in an area and the location of the lanes.

Enforcement. Enforcement needs should be considered in examining possible changes in vehicle-occupancy levels, especially if increasing the vehicle-occupancy requirement or using variable occupancy levels are being considered. The transition periods with variable occupancy requirements may require additional enforcement.

Perceptions of HOV Lane Users. The perception of HOV lane users to increasing or decreasing vehicle-occupancy levels is a key factor to consider in assessing possible changes. The perceptions of current HOV lane users are especially important when increasing vehicle-occupancy requirements are being evaluated. Since it is more difficult to form three-person carpools, current two-person carpoolers may voice concerns about increasing vehicle-occupancy levels. Ensuring that current carpoolers understand the need for the change, and providing them with support to form three-person carpools is important. As noted in the El Monte Busway case study, 3+ carpoolers on a well used HOV lane may react negatively to lowering occupancy requirements when the lane becomes congested as a result of the change.

Perceptions of Non-Users. The perceptions of motorists in the general-purpose freeway lanes related to possible changes in HOV lane vehicle-occupancy requirements are also important. Increasing the vehicle-occupancy requirement may add more two-person carpools to the general-purpose freeway lanes, while decreasing vehicle-occupancy requirements may allow existing carpools to move from the general-purpose freeway lanes to the HOV lane.

Perceptions of Policy Makers. The perceptions of policy makers are also very important, especially when consideration is being given to raising vehicle-occupancy levels. Current HOV lane users, and motorists in the general-purpose freeway lanes, may voice opposition to increasing vehicle-occupancy requirements. Current HOV lane users may also voice concerns about lower vehicle-occupancy levels. Ensuring that policy makers understand the reason why changes are being considered and implemented is important.

Assessing Vehicle-Occupancy Levels

As discussed previously, the goal of an HOV facility is to provide travel time savings and travel time reliability to buses, vanpools, and carpools. The vehicle-occupancy requirement should be maintained at a level that will encourage use of the facility and the formation of new carpools, but that will not create a demand level that would make the lane congested. An ongoing HOV performance monitoring program provides the information needed to proactively manage the operation of an HOV lane and to assess possible changes in vehicle-occupancy requirements. The sketch planning and travel forecasting models used in the initial planning process for an HOV project may also be appropriate for use in assessing possible changes in occupancy requirements.

This section describes how the factors presented in the previous section can be applied to assess possible changes in vehicle-occupancy requirements. Three scenarios are presented for changes in vehicle-occupancy requirements. These scenarios are increasing vehicle-occupancy levels from 2+ to 3+, decreasing occupancy requirements from 3+ to 2+, and implementing variable time-of-day occupancy requirements (3+ peak-hours/2+ off-peak). As highlighted in this section, these scenarios will have different impacts on different user groups. Table 5.2 provides an indication of the importance of the various factors in assessing the potential impacts of each scenario. Table 5.3 provides an example of a checklist for use in assessing possible changes in vehicle-occupancy requirements.

Table 5.2. Assessing Changes in HOV Vehicle-Occupancy Requirements.

Elements to Consider	**Increase 2+ to 3+**	**Decrease 3+ to 2+**	**Variable Occupancy (3+ peak/2+ off-peak)**
Project Goals/ Objectives	ü	ü	ü
Congestion Levels in HOV Lane and General-Purpose Freeway Lanes	ü	ü	ü
Current Number of Two-person and Three-person Carpools	ü	ü	ü
Bus Operations	ü	ü	ü
System Connectivity	l	l	l
Enforcement	ü	ü	ü
Perceptions of HOV Lane Users	ü	ü	ü
Perceptions of General-Purpose Freeway Lane Users	l	ü	l
Perceptions of Policy Makers	ü	ü	ü

ü – Critical Factors
l – Important Factors
¡ – Neutral Factors

Table 5.3. Checklist for Assessing Changes in HOV Occupancy Requirements.

Possible Elements to Consider	Performance Measure	Current Data	Impact
Project Goals and Objectives			
Congestion Levels in HOV Lane and General-Purpose Lanes			
Current Number of Two-person and Three-person Carpools			
Bus Operations			
System Connectivity			
Enforcement			
Perceptions of HOV Lane Users			
Perceptions of General-Purpose Freeway Lane Users			
Perceptions of Policy Makers			

ü – Critical Factors
l – Important Factors
¡ – Neutral Factors

Increasing Vehicle-Occupancy Levels from 2+ to 3+

This scenario focuses on increasing the vehicle-occupancy requirements on an HOV lane from 2+ to 3+ during all operating hours. This option may be considered when an HOV lane with a 2+ requirement becomes congested on a recurring basis, resulting in HOV lane users losing the travel time savings and the trip time reliability they have come to expect. As discussed previously, the exact measures that trigger considerations of increasing vehicle-occupancy levels may vary by area. The measures, which may focus on vehicle volumes, LOS, slower travel speeds, longer travel times, and loss of trip time reliability, should be included in an HOV performance monitoring program.

The key issues to be examined in assessing an increase in vehicle-occupancy levels are the level of congestion in the HOV lane and the general-purpose freeway lanes, the number of two-person and 3+ carpools, the number of buses and the level of bus service operated on the lane, and the perceptions of HOV lane users and policy makers. Other important factors include enforcement, regional connectivity, HOV goals and policies, and the perceptions of motorists in the general-purpose freeway lanes. There are no case study examples of increasing the vehicle-occupancy level on an HOV lane from 2+ to 3+ during all operating periods. It appears that concerns over possible negative reactions from HOV lane users and policy makers have limited consideration of increasing occupancy levels in some areas.

Project Goals and Objectives. The goals and objectives identified for a specific HOV project or for HOV lanes in an area should be used to help guide an assessment of increasing vehicle-occupancy levels. This change would be supportive of goals and objectives related to providing travel time savings and trip time reliability to HOV lane users, enhancing bus operations, and proactively managing the operation of the HOV lane.

Congestion Levels in HOV and General-Purpose Freeway Lanes. As noted previously, increasing vehicle-occupancy levels would typically only be considered if vehicle volumes in the HOV lane are causing the lane to become congested on a regular basis, negating the travel time savings and trip time reliability users have come to expect. The exact vehicle volumes or techniques to measure when an HOV lane becomes too congested may vary by area. The measure of effectiveness related to a maximum vehicle volume, LOS, travel speed, travel time saving, or trip time reliability should be established in the HOV performance monitoring program. In some cases, other techniques may be considered prior to increasing vehicle-occupancy levels. For example, when the I-10 West HOV lane in Houston became congested at the 2+ level, postcards were initially distributed to carpoolers during the peak-hours asking them to shift their travel times slightly to help reduce congestion levels. This request did not result in enough of a change to reduce congestion levels, and the carpool requirement was increased to 3+ during the morning peak-hour.

Current Number of Two-Person and 3+ Carpools. The number of two-person and three-person carpools currently using the HOV lane should be examined in assessing a possible increase in the vehicle-occupancy requirement on an HOV lane. The number of 3+ carpools will provide an indication of the base level of users at the higher occupancy level. If there are few 3+ carpools currently using the HOV lane, an increase may result in very low volumes in the HOV lanes and negative reactions from 2+ carpoolers and policymakers. The number of two-person carpools provides an indication of the number of vehicles that may shift to the general-purpose freeway lanes if they cannot find a third person for their existing carpool.

Bus Operations. The impact of increasing the vehicle-occupancy requirement on bus operations and bus riders should be considered. Bus operators and bus riders would benefit from increasing the vehicle occupancy level if an HOV lane is congested at the 2+ level. As noted in the Houston and Los Angeles case studies, bus operators and bus riders were negatively impacted by congestion at the 2+ level and were vocal in supporting a 3+ occupancy requirement.

System Connectivity. The impact that increasing vehicle-occupancy requirements on one HOV lane may have on other HOV lanes in an area or corridor should be considered. While maintaining the same occupancy requirement on all HOV lanes in an area may be desirable, experience in northern Virginia, Houston, and Los Angeles indicates that commuters and travelers adjust to different occupancy requirements on different HOV lanes in an area.

Enforcement. Additional enforcement may be needed when vehicle-occupancy levels are increased from 2+ to 3+. Extra enforcement will typically be needed immediately after the change as well as on an ongoing basis. The ability to provide additional enforcement should be considered in assessing an increase in the vehicle-occupancy requirement.

Perceptions of HOV Lane Users. The perceptions of current HOV lane users—carpoolers, vanpoolers, and bus riders—to increasing vehicle-occupancy levels from 2+ to 3+ is an important element to consider. If an HOV lane is congested at the 2+ level, vanpoolers and bus riders would benefit from the increase in occupancy level, and thus, could be expected to support the change. On the other hand, two-person carpools that would no longer be able to use the lane could be expected to strongly oppose an increase to 3+.

Perceptions of General-Purpose Freeway Lane Users. Motorists in the general-purpose freeway lanes may not have strong opinions about increasing the vehicle-occupancy level from 2+ to 3+. This group may react negatively if the change results in significant numbers of two-person carpools moving to the general-purpose freeway lanes, however, further degrading conditions in these lanes.

Perceptions of Policy Makers. The perceptions of policy makers may reflect those of their constituents. If HOV lane users and non-users voice opposition to increasing vehicle-occupancy levels, policy makers may also not be supportive of such a change. The I-66 case study provides an example of the direction provided by the Virginia Legislature on elements VDOT must include in any consideration of increasing the vehicle-occupancy requirements on I-66 inside the Capitol Beltway in northern Virginia. The El Monte Busway case study provides an example of the California Legislature initially approving legislation lowering the vehicle-occupancy requirement from 3+ to 2+, but increasing it to 3+ during the morning and afternoon peak-hours in response to the congestion in the HOV lane and the vocal response to the 2+ change from bus riders and 3+ carpoolers.

Virginia Legislation—Possible Increase in Vehicle-Occupancy Requirements.

Legislation in Virginia provides direction to VDOT in considering increasing vehicle-occupancy levels from 2+ to 3+ on I-66. The legislation requires that the following conditions shall be met before the HOV 2+ designation on I-66 outside the Capital Beltway can be changed to HOV 3+ or any more restrictive designation:

1. The Department shall publish a notice of its intent to change the existing designation and also immediately provide similar notice of its intent to all members of the General Assembly representing districts that touch or are directly impacted by traffic on Interstate Route 66.

2. The Department shall hold public hearings in the corridor to receive comments from the public.

3. The Department shall make a finding of the need for a change in such designation, based on public hearings and its internal data and present this finding to the Commonwealth Transportation Board for approval.

4. The Commonwealth Transportation Board shall make written findings and a decision based upon the following criteria:

a. Is changing the HOV 2+ designation to HOV 3+ in the public interest?

b. Is there quantitative and qualitative evidence that supports the argument that HOV 3+ will facilitate the flow of traffic on I-66?

c. Is changing the HOV 2+ designation beneficial to comply with the federal Clean Air Act Amendments of 1990?

Decreasing Vehicle-Occupancy Levels from 3+ to 2+

This scenario focuses on lowering the occupancy level on an HOV lane from 3+ to 2+ during all operating hours. This option may be considered in response to low volumes of HOVs at the 3+ level. This situation was experienced on the I-10 West HOV lane in Houston in the mid-1980s, when a 4+ authorized carpool designation was initially used. The requirement was changed to 3+ authorized carpools and then to 2+ carpools with no authorization requirement. Lowering the occupancy level may also be considered based on the perception that an HOV lane is underutilized. The El Monte Busway case study and the I-66 HOV lane in northern Virginia case study provide examples of this situation. The El Monte Busway case study describes what happened when the California Legislature passed a bill in 1999 lowering the occupancy requirement from 3+ to 2+. The I-66 case study highlights Congressional direction to lower the occupancy level from 3+ to 2+.

Project Goals and Objectives. The goals and objectives identified for a specific HOV project or for HOV lanes in an area should be used to help guide an assessment of lowering vehicle-occupancy levels. Depending on vehicle volumes in the lane, this change may be supportive of goals and objectives related to maximizing throughput in a congested travel corridor.

Congestion Levels in HOV and General-Purpose Freeway Lanes. As noted previously, lowering vehicle-occupancy levels would typically only be considered if vehicle volumes in the HOV lane are below the minimum threshold or if policy makers direct a change. The exact vehicle volumes or techniques to measure if an HOV lane is not meeting desired use levels may vary by area. As noted in the I-10 West case study, only about 53 registered 3+ carpools used the HOV lane during the morning peak-hour in 1985. When the occupancy level was lowered to 2+ and the authorization requirement was removed, carpool levels increased to 1,195 immediately.

Current Number of Two-Person and 3+ Carpools. The number of 2-person carpools currently using the general-purpose freeway lanes should be examined in assessing a possible decrease in the vehicle-occupancy requirement on an HOV lane. The number of two-person carpools in the general-purpose freeway lanes will provide an indication of how many vehicles may immediately move to the HOV lane.

Bus Operations. The impact of lowering the vehicle-occupancy requirement on bus operations and bus riders should be considered. Bus operators and bus riders may be negatively impacted from decreasing the vehicle occupancy level if an HOV lane becomes congested at the 2+ level. This situation occurred on the El Monte Busway when the California Legislature lowered the occupancy requirement from 3+ to 2+. Bus riders were vocal in criticizing the change to the 2+ level and in supporting a return to the 3+ occupancy requirement.

System Connectivity. The impact that decreasing vehicle-occupancy requirements on one HOV lane may have on other HOV lanes in an area or corridor should be considered. While maintaining the same occupancy requirement on all HOV lanes in an area may be desirable, experience in northern Virginia, Houston, and Los Angeles indicates that commuters and travelers adjust to different occupancy requirements on different HOV lanes in an area.

Enforcement. Lowering vehicle-occupancy requirements from 3+ to 2+ may make enforcement easier, as two-person carpools who were previously violators would become eligible users.

Perceptions of HOV Lane Users. The perceptions of current HOV lane users—vanpoolers, and bus riders—to lowering vehicle-occupancy levels from 3+ to 2+

is an important element to consider. If an HOV lane is uncongested at the 3+ level, all user groups may be neutral on the change. If an HOV lane is well used at a 3+ level, vanpoolers, carpoolers, and bus riders would probably not favor the change, as it will result in increased congestion in the lane and decreased travel time savings and trip time reliability. As noted in the El Monte Case Study, 3+ carpoolers and bus riders were vocal in their opposition to the legislatively directed lowering of the vehicle-occupancy requirement. On the other hand, two-person carpools who would be able to use the lane could be expected to strongly favor a decrease to 2+.

Perceptions of General-Purpose Freeway Lane Users. Motorists in the general-purpose freeway lanes may not have strong opinions about lowering the vehicle-occupancy level from 3+ to 2+, even though they may benefit slightly from two-person carpools moving to the HOV lane. The El Monte Busway case study indicates that there was no significant improvement in traffic conditions in the general-purpose freeway lanes from lowering the occupancy requirement to 2+.

Perceptions of Policy Makers. The perceptions of policy makers may reflect those of their constituents. If HOV lane users and non-users voice opposition to lowering vehicle-occupancy levels, policy makers may also not be supportive of such a change. If HOV lane users and non-users favor or are neutral about decreasing the occupancy requirements, policy makers may support a change. Policy makers also may have their own perceptions related to use of an HOV lane, which may or may not reflect actual experience. Providing updates on the use of HOV lanes as part of an ongoing HOV performance monitoring program is a good way to keep policy makers informed about the benefits of these projects.

Lowering the Vehicle-Occupancy Requirement on I-66, Northern Virginia

I-66 was open from I-495 (Capital Beltway) into the District of Columbia in December 1982. The freeway is restricted to HOVs only from 6:30 a.m. to 9:00 a.m. in the eastbound direction and from 3:30 to 6:30 p.m. in the westbound direction. A 4+ vehicle-occupancy requirement was used on the facility until a congressional mandate changed it to 3+ in 1986.

In 1994, Congress authorized the Commonwealth of Virginia to conduct a one-year demonstration using a 2+ occupancy requirement for the section of I-66 inside the Beltway. A 2+ requirement is in use on the concurrent flow HOV lanes on I-66 beyond the Beltway. VDOT, in conjunction with other agencies and an advisory committee, evaluated this test.

Information on changes in vehicle volumes, passenger volumes, average vehicle occupancy (AVO), and transit ridership before-and-after the change was examined by VDOT. Total vehicle volume increased by 62 percent in the morning peak-hour and by 51 percent in the morning peak period. Total vehicle person movement rose by 50 percent in the peak-hour and 35 percent in the peak-period. Total HOV volumes increased by 178 percent in the peak-hour and 133 percent in the peak period, largely based on the reduction in 2+ violations.

The reclassification of 2+ carpools from violators to HOVs was also a major factor in the reduction in violation rates, but a decline in single-occupancy vehicle violations also occurred. After the change to 2+, the number of single-occupant vehicles decreased by 51 and 22 percent for the peak-hour and the peak period, respectively. The all-vehicle AVO declined from 2.49 to 2.30 in the peak-hour and 2.38 to 2.13 in the peak period, but was more than counterbalanced in total facility carrying capacity by the increase in overall vehicle flow.

Case Study – Lowering the Vehicle-Occupancy Requirement on the El Monte Busway in Los Angeles

In 1999, legislation was approved that lowered the vehicle-occupancy requirement on the El Monte busway on the San Bernardino (I-10) Freeway in Los Angeles from 3+ to 2+ full-time. The California Department of Transportation (Caltrans) was directed to implement this change on January 1, 2000 and to monitor and evaluate the effects of the 2+ requirement on the operation of the busway and the freeway. Based on the operational effects that resulted from this change, emergency legislation was approved increasing the vehicle-occupancy requirement back to 3+ during the morning and afternoon peak-periods effective July 24, 2000.

Lowering the vehicle-occupancy requirement from 3+ to 2+ full time had a detrimental effect on the busway. At the same time, significant improvements were not realized in the general-purpose freeway lanes. Morning peak-period travel speeds in the busway were reduced from 65 mph to 20 mph, while travel speeds in the general-purpose lanes decreased from 25 mph to 23 mph for most of the demonstration. Hourly busway vehicle volumes during the morning peak-period increased from 1,100 to 1,600 with the 2+ designation, but the number of persons carried declined from 5,900 to 5,200. The freeway lane vehicle volumes and passengers per lane per hour remained relatively similar. Peak-period travel times on the busway increased by 20 to 30 minutes. Bus schedule adherence and on-time performance declined significantly and passengers reported delays.

Variable-Occupancy Requirements (3+ Peak/2+ Off-Peak)

This scenario focuses on the use of variable vehicle-occupancy requirements by time-of-day. The example presented uses a 3+ occupancy requirement during the morning and afternoon peak-hours and a 2+ requirement during the other operating periods. This option may be considered in response to congestion occurring in the HOV lane during the peak-hours, but not at other times. As noted in the case studies, variable occupancy requirements are currently in use on the I-10 West and the US 290 HOV lanes in Houston and the El Monte Busway in Los Angeles. The use of a variable-occupancy requirement may be more acceptable to both HOV lane users and policy makers than increasing from a 2+ to a 3+ occupancy level during all operating hours. As noted in this section, however, variable occupancy requirements may require higher enforcement levels, especially during the transition periods.

Project Goals and Objectives. The goals and objectives identified for a specific HOV project or for HOV lanes in an area should be used to help guide an assessment of implementing variable vehicle-occupancy requirements. This change may be supportive of goals and objectives related to providing travel time savings and trip time reliability to HOV lane users, enhancing bus operations, and proactively managing operation of the HOV lane.

Congestion Levels in HOV and General-Purpose Freeway Lanes. As noted previously, variable vehicle-occupancy requirements would typically only be considered if vehicle volumes in the HOV lane during the morning and afternoon peak-hours are causing the lane to become congested on a regular basis, negating the travel time savings and trip time reliability users have come to expect. The exact vehicle volumes or techniques to measure when an HOV lane becomes too congested may vary by area. The measure of effectiveness related to a maximum vehicle volume, LOS, travel speed, travel time saving, or trip time reliability should be established in the HOV performance monitoring program. As noted previously, other techniques may be considered prior to increasing vehicle-occupancy levels. When the I-10 West HOV lane in Houston became congested at the 2+ level, postcards were initially distributed to carpoolers during the peak-hours asking them to shift their travel times slightly to help reduce congestion levels. This request did not result in enough of a change to reduce congestion levels, and the carpool requirement was increased to 3+ during the morning peak-hour.

Current Number of 2-Person and 3+ Carpools. The number of two-person and three-person carpools currently using the HOV lane should be examined in assessing a possible increase in the vehicle-occupancy requirement during the peak-hours on an HOV lane. The number of 3+ carpools will provide an indication of the base level of users at the higher occupancy level during the peak-hours. If there are few 3+ carpools currently using the HOV lane, an increase may result in very low volumes in the HOV lanes and negative reactions from 2+ carpoolers and policymakers. The number of two-person carpools provides an indication of the number of vehicles that may shift to the general-purpose freeway lanes if they cannot find a third person for their existing carpool or may shift their travel times to before or after the start of the 3+ period.

Bus Operations. The impact of increasing the vehicle-occupancy requirement during the peak-hours on bus operations and bus riders should be considered. Bus operators and bus riders would benefit from increasing the vehicle-occupancy level if an HOV lane during the peak-hours is congested at the 2+ level. As noted in the Houston and Los Angeles case studies, bus operators and bus riders were negatively impacted by congestion at the 2+ level and were vocal in supporting a 3+ occupancy requirement.

System Connectivity. The impact that using a variable vehicle-occupancy requirements on one HOV lane may have on other HOV lanes in an area or corridor should be considered. While maintaining the same occupancy requirement on all HOV lanes in an area may be desirable, experience in Houston and Los Angeles indicates that commuters and travelers adjust to variable occupancy requirements on some, but not all, HOV lanes in the area.

Enforcement. Additional enforcement will typically be needed with use of variable vehicle-occupancy requirements. Extra enforcement will typically be needed immediately after the change as well as on an ongoing basis, especially during the transition periods from 2+ to 3+ and 3+ to 2+. The ability to provide additional enforcement should be considered in assessing an increase in the vehicle-occupancy requirement.

Perceptions of HOV Lane Users. The perceptions of current HOV lane users—carpoolers, vanpoolers, and bus riders—to increasing vehicle-occupancy levels from 2+ to 3+ during the peak-hours is an important element to consider. If an HOV lane is congested at the 2+ level, vanpoolers and bus riders would benefit from the increase in occupancy level, and thus, could be expected to support the change. On the other hand, two-person carpools that would no longer be able to use the lane could be expected to strongly oppose an increase to 3+. Two-person carpoolers may show more support for of variable-occupancy requirements than a change to a higher occupancy level at all times.

Perceptions of General-Purpose Freeway Lane Users. Motorists in the general-purpose freeway lanes may not have strong opinions about increasing the vehicle-occupancy level from 2+ to 3+ during the peak-hours. This group may react negatively if the change results in significant numbers of two-person carpools moving to the general-purpose freeway lanes, further degrading conditions in these lanes.

Perceptions of Policy Makers. The perceptions of policy makers may reflect those of their constituents. If HOV lane users and non-users voice opposition to increasing vehicle-occupancy levels during the peak-hours, policy makers may also not be supportive of such a change. If HOV lane users are supportive of the change, policy makers may also be in favor of variable-occupancy requirements. Policy makers may also view this option as a compromise that still provides two-person carpoolers access to an HOV lane.

Case Study – Lowering the Vehicle-Occupancy Requirement and Use of Variable-Occupancy Requirements on the I-10 West and US 290 HOV Lanes in Houston

The I-10 West HOV lane opened in1984 to buses and authorized vanpools. Approximately 50 vehicles used the lane during the morning peak-hour with the bus and authorized vanpool vehicle-eligibility requirement. Due to this low level of use, the lanes were opened to authorized 4+ carpools after six months of operation. This change added approximately 10 vehicles to the morning peak-hour volume on the lane.

The vehicle-occupancy level was lowered again after six months to authorized carpools with three or more occupants. This change added some 100 vehicles to the morning peak-hour traffic stream. In April 1986 the vehicle-occupancy level was lowered to 2+ carpools and the authorization requirement was discontinued. The morning peak-hour volumes increased to approximately 1,200 vehicles after this change.

Carpool volumes in the HOV lane, as well as vehicle volumes in the general-purpose freeway lanes, increased over the next year, partly due to the economic recovery occurring in the Houston area. During this time, morning peak-hour vehicle volumes on the I-10 West HOV lane were regularly reaching or exceeding 1,500. The congestion resulting from these volumes, coupled with the design of the facility, reduced the travel time savings and travel time reliability that bus riders, carpoolers, and vanpoolers had come to expect. In response to lower travel speeds in the HOV lane and complaints from bus passengers, the vehicle-occupancy requirement was increased in October 1988 from 2+ to 3+ during the period from 6:45 to 8:15 a.m. The 2+ occupancy requirement was maintained at other operating times. In 1991, the occupancy requirement was increased to 3+ from 5:00 p.m. to 6:00 p.m. In response to similar congestion problems on the US 290 HOV lane, the occupancy requirement was increased to 3+ from 6:45 a.m. to 8:00 a.m.

CHAPTER SIX – ASSESSING HOV OPERATING HOURS

Chapter-at-a Glance

This chapter examines HOV operating hours. Typical HOV operating hour scenarios are described first. Factors to consider in changing HOV operating hours are presented. Assessing possible changes in HOV operating hour scenarios are discussed. The chapter contains the following sections:

- **Alternative HOV Operating Hour Scenarios**. This section highlights the operating hour scenarios associated with different types of HOV lanes. The use of 24-hour, extended morning and afternoon operating hours, and peak-period only operation is described. Opening HOV lanes for special events and other activities is also highlighted
- **Factors to Consider in Changing HOV Operating Hours**. This section summarizes factors that may be appropriate to consider when changes in HOV operating hours are being examined.
- **Assessing Possible Changes in HOV Operating Hours**. This section discusses assessing possible changes in HOV operating hours. Five operating hour scenario changes are presented.

Alternative HOV Operating Hour Scenarios

The characteristics of the three general operating hour scenarios for HOV facilities – 24 hour, extended hours, and peak-only – are described in this section, along with the use of HOV lanes during special events. Examples of HOV projects using different operating hours are noted and the advantages, limitations, and issues associated with the scenarios are highlighted. Table 6.1 summarizes the key features of each HOV operating hour scenario.

24-Hour Operation. This approach maintains the HOV designation and operation of a facility on a 24-hour basis, seven days a week (24/7). In these cases, the HOV lane is open during all operating periods. Continuous 24/7 operation tends to be found with busways in separate rights-of-way and with freeway concurrent flow and exclusive two-way facilities. As could be expected, this approach is not used with contraflow or exclusive reversible HOV facilities. Examples of HOV facilities operating on a 24/7 basis include the bus-only facilities in Pittsburgh and Ottawa; the exclusive two-directional HOV lanes on I-84 in Hartford and the El Monte Busway in Los Angeles; and most of the concurrent flow HOV lanes in Southern California and many of the concurrent flow HOV lanes in the Puget Sound region.

Table 6.1. HOV Operating Hours Scenarios.

HOV Operating Hour Scenario	Key Features	Typical Types of HOV Lanes
24 Hour/7 Days a Week (24/7)	HOV lane in operation at all times (24/7).	Busways Exclusive Two-Directional HOV Lanes Concurrent Flow HOV Lanes
Extended Hours	Extended hours, but not all day. Typical operating hours are in the range of 6:00 a.m. to 11:00 a.m. and 3:00 p.m. to 7:00 p.m.	Exclusive-Reversible HOV Lanes
Peak-Period Only	Typical operating hours in the range of 6:00 a.m. to 9:00 a.m. and 4:00 p.m. to 6:00 p.m. May be in the peak-direction of travel only and in some cases only the morning peak-period, peak-direction.	Concurrent Flow HOV Lanes Contraflow HOV Lanes
Special Event or Other Activity Use	HOV lane open extra hours to assist with traffic management during a special event or other planned activity.	Exclusive-Reversible HOV Lanes

The 24/7 operating scenario is based on the premise or policy that HOVs should be provided with priority treatment at all times. Since congestion or incidents may occur at any time, the 24/7 designation provides HOVs with travel time savings and trip time reliability throughout the day and night. This operating scenario also allows travelers to use the HOV facility during non-commute hours. For example, recreational trips often include more than one person in a vehicle. The 24/7 operating scenario allows individuals making recreational or other non-work trips to use the HOV lanes, which may promote wider acceptance of the facility. Off-peak use by some of these travelers may help encourage them to change to carpooling, vanpooling, or taking the bus to be able to use the HOV lanes for work trips during the peak-periods.

The 24/7 designation may also help to minimize potential motorist confusion on whether or not the HOV designation is in effect. Since the vehicle-occupancy requirement is always in effect, motorists know they should not use the lane unless they have the correct number of passengers. As a result, the continuous HOV designation makes enforcement easier, as there is no question on the operating requirements. Twenty-four hour operation may simplify signing and lane markings.

Limitations and issues associated with 24/7 operation of an HOV facility include possible negative public perception if the facility is not well used during off-peak-hours, the need for ongoing enforcement, and potential safety concerns.

Extended Operating Hours. Extended operating hours encompass a major portion, but not all, of the day. In most cases, HOV lanes using extended hours are open for major portions of the morning and afternoon into the early evening. Although the exact hours of operation vary by facility, this scenario often encompasses the time periods from 6:00 a.m. to 11:00 a.m. and 3:00 p.m. to 7:00 p.m. These times correspond to the major commuting periods, when traffic congestion is heaviest.

Extended operating hours are typically used with exclusive reversible HOV lanes and contraflow lanes. Examples of specific facilities using this operating approach include the exclusive reversible HOV lanes in Houston, San Diego, Denver, Minneapolis, and northern Virginia, and the contraflow lanes in Dallas and Boston.

Extended operating hours provide HOVs with travel time savings and travel time reliability during the periods when the general-purpose freeway lanes are most likely to be congested. This approach may also represent the most logical or the only realistic scenario for some types of HOV facilities. For example, extended hours are often the most appropriate approach with exclusive reversible facilities and contraflow lanes open to carpools, vanpools, and buses.

Potential limitations of extended operating hours include confusion on the part of motorists, which makes enforcement more difficult, and the need for additional signing and pavement markings. The use of a facility during non-HOV operations may influence these concerns. If an HOV facility is closed during non-HOV operating hours, which is usually the case with exclusive reversible lanes; these potential limitations may not be major problems. These limitations may be a concern on a concurrent flow HOV lane that is open to general traffic during non-HOV operating periods.

Peak-Period Only Operation. The final operating scenario is to use the HOV lane only during the peak-periods in the morning and afternoon. Peak-period operation is defined more narrowly than the extended hours, usually encompassing the hours from 6:00 a.m. to 9:00 a.m. and 4:00 p.m. to 6:00 p.m., although variations are found in these hours. Some facilities use the HOV restriction only in the peak-direction of travel, while others may operate only in the morning peak-period, peak-direction of travel.

Peak-period operating hours are used primarily with concurrent flow and contraflow HOV lanes. Currently, concurrent flow lanes in Minneapolis, Miami, Fort Lauderdale, Orlando, San Francisco, and San Jose are restricted to HOVs only during the peak-hours. The contraflow lanes on Rt. 495, the Long Island Expressway, and the Gowanus Expressway in New York operate only in the morning peak-period in the peak-direction of travel into Manhattan.

Peak-period only operations present many of the same advantages, limitations, and issues as extended operations. Advantages include providing priority to HOVs at critical times of the day and addressing specific bottleneck problems. Depending upon the use of the facility during non-HOV operating periods, possible limitations include confusion on the part of commuters, more difficult enforcement, safety issues, and increased signing needs.

Extended Operating Hours for Special Events and Other Activities. A few HOV facilities throughout the country are open on a periodic basis outside the normal operating hours for special events and other activities. These may include sporting events and special activities. The I-394 HOV lanes in Minneapolis are open in the evening and on weekends for professional baseball, football, and basketball games and University of Minnesota football games at facilities in downtown Minneapolis. Vehicles using the HOV lanes must meet the 2+ vehicle-occupancy requirement. The I-279 HOV lane in Pittsburgh is open extended hours in the outbound direction after baseball and football games at stadiums in the downtown area. All traffic is eligible to use the facility to exit the stadiums.

Opening these and other HOV facilities for special events can provide a number of benefits. First, the HOV lanes can help manage traffic during major events and can improve the traffic flow into and out of the sports stadium or other facility. Second, opening an HOV lane for special events provides opportunities for travelers to use the facility who might not be able to use the lanes during their regular commute. Using an HOV lane during a special event can be a good way to introduce the facility to non-users and to build public acceptance and support.

Opening an HOV lane for special events is not without possible concerns, however. Since many travelers may be first time users, care should be taken to provide advance information on access points, vehicle-occupancy requirements, and other operating instructions. Additional or special signs and enforcement may also be needed to ensure safe operation of an HOV facility during special events.

HOV restrictions may also be lifted in the case of crashes, emergencies, and weather conditions that affect the operation of the overall system. In these cases, the HOV lanes may be used to help with emergency evacuations or to move traffic past a major crash.

Factors to Consider in Changing HOV Operating Hours

Factors to consider in assessing possible changes in HOV operating hours are similar to those discussed previously with changes in vehicle-eligibility requirements and vehicle-occupancy levels. Potential factors include the level of congestion in the HOV lane and the general-purpose freeway lanes, the project goals and objectives, the type of HOV facility, and use of the lane during other times of the day. Additional factors address bus operations, system connectivity, enforcement, safety, changes in signing, operating costs, benefits, and perceptions of users, non-users, and policy makers.

Each of these factors is described briefly in this section. As noted previously, these factors address both technical elements and public and political acceptance issues.

Congestion Levels in the HOV Lane and General-Purpose Freeway Lanes. The level of traffic congestion in the HOV lane, the general-purpose freeway lanes, and in the travel corridor will influence consideration of changes in the hours of operation for an HOV facility. Information from HOV performance monitoring programs can be used to identify potential issues or concerns with current operating hours. It is important to examine possible issues to obtain an understanding of the potential causes and possible approaches to address the identified problems. As discussed in the next section, it is especially critical to have a clear understanding of the issues if extending HOV operating hours into time periods single-occupant vehicles are currently allowed is being considered.

Project Goals and Objectives. The goals and objectives related to HOV facilities should help guide consideration of changes in HOV operating hours. HOV project objectives and measures of effectiveness are key elements of HOV performance monitoring programs. For example, areas such as Seattle and Southern California have policies relating to providing HOVs with priority treatment during all times of the day and night. As a result, most HOV lanes in these areas operate on a 24/7 basis.

Type of HOV Lane. Although no one specific operating scenario necessarily equates to a certain type of HOV lane, the orientation and design of an HOV lane will influence consideration of changes in operating hours. For example, projects providing HOVs with priority treatment around a specific bottleneck typically operate only during the congested time periods when the bottleneck exists. Contraflow HOV lanes operate only during periods of peak congestion, and require time to set up and remove the special lane separation devices. Reversible exclusive lanes also require time to open, close, reverse the direction of traffic flow, reopen, and close the facility. Concurrent flow HOV lanes typically provide the greatest flexibility in considering changes in HOV operating hours. As noted next and in the scenarios, however, if general-purpose vehicles are allowed to use a concurrent flow HOV lane during non-HOV times, these users may react negatively to extending HOV operating times.

Use of Lane During other Time Periods. As noted previously, a key factor in considering possible changes in HOV operating hours relates to use of the lane during the time period being considered for the change. This factor determines the groups impacted by a possible change. Extending hours on an HOV lane that is open to general-purpose freeway traffic at other times will impact single-occupant vehicle drivers. Extending operating hours on an HOV lane that is closed to all traffic during the time period considered would not negatively impact any user group. Reducing HOV operating hours may negatively impact HOV lane users and bus operators, but may be viewed positively by other groups.

Bus Operations. Examining the impact of a possible change in operating hours on public transportation operators is important if buses represent a significant user group. Bus operations may realize benefits from extending operating hours or may realize cost increases and lower service levels if reduced operating hours are being considered.

System Connectivity. If there are multiple HOV lanes in an area, considering changes in operating hours on one HOV facility may impact the operation of other HOV lanes. Consideration may be given to coordinating the operating hours of the various HOV facilities. Uniform operating hours are more easily understood by travelers and enforcement personnel. Similar operating hours may not be possible or desirable, however, depending on the type of HOV facilities in an area and the location of the lanes.

Enforcement. Enforcement needs should be considered in examining possible changes in HOV operating hours. It is important that vehicle-eligibility and occupancy requirements can be enforced when extensions to the HOV operating periods are being considered. The costs associated with enforcement personnel covering longer operating hours will need to be considered.

Safety. Safety should be considered in assessing possible changes in HOV lane operating hours. Ensuring that the HOV lane can be operated safely during the revised hours is important. For example, with reversible HOV lanes, the potential for vehicles to enter a lane in the wrong direction of travel may be examined when longer operating hours are being considered.

Changes in Signing. Altering HOV operating hours typically requires changes in signing and marking to reflect the new operating hours. While these costs are usually a one-time only expenditure, they may be significant depending on the number and the length of HOV lanes being considered for the change.

Operating Costs. Changes in HOV operating hours may impact operating costs. The extent of this impact will depend on the type of HOV lane, the change being considered, and the nature of the operations. The costs associated with operating contraflow and exclusive reversible HOV lanes are higher than those associated with concurrent flow HOV lanes.

Benefits. The benefits associated with potential changes in HOV operating hours represent another factor to consider. Typical benefits include travel time savings to HOVs, increased person throughput, helping to manage congestion and mobility in the corridor, and enhancing bus transit operations. A benefit-cost ratio is a more detailed analysis technique that may be used to help assess changes in HOV operating hours. The benefit-cost ratio is defined as the present value of all benefits divided by the present value of all costs. A benefit-cost ratio of greater than 1.0 is considered cost-effective. Inputs needed to calculate a benefit-cost ratio include the capital and operating cost of an HOV project and the value (in dollars) of the benefits. As a conservative estimate, only the travel time savings accrued to users of an HOV lane is often applied to calculate a benefit-cost ratio for an HOV project.

Perceptions of HOV Lane Users. The perception of HOV lane users related to possible changes in operating hours should also be considered. If a reduction in

HOV operating hours is being considered, HOV lane users may be negatively impacted.

Perceptions of General-Purpose Freeway Lane Users. The perceptions of travelers in the general-purpose freeway lanes are important to consider. As noted in case studies in the next section, the perceptions of this group and the public are especially important when consideration is being given to extending HOV lane operating hours on a facility open to general-purpose traffic during non-HOV hours. Single-occupant drivers who currently use the HOV lane during non-HOV hours may react negatively to extending HOV operating hours.

Perceptions of Policy Makers. The perceptions of policy makers are also important to consider in assessing possible changes in HOV operating hours. As noted in the case studies in the next section, policy makers have influenced recent consideration of changes in HOV operating hours in some areas.

Assessing Possible Changes in HOV Operating Hours

This section describes how the factors presented in the previous section can be applied to assess possible changes in operating hours. Changes in five HOV operating hour scenarios are described. These scenarios are lengthening peak-period operations, changing peak-period or extended HOV operations to 24/7 operation, reducing peak-period or extended operation, reducing 24/7 operation to peak-period or extended operating hours, and modifying 24/7 operation to open the HOV lanes to general-purpose traffic in the evenings or on weekends. As highlighted in this section, these scenarios will have different impacts on different user groups. It is important to examine the perceptions of these different groups to potential changes, to assess possible impacts, and to conduct outreach efforts to various user groups and policy makers when changes in operating hours are being considered.

The sketch planning, travel demand models, and simulation techniques used in the initial planning for an HOV facility may be appropriate for use in assessing these scenarios or other possible changes in the HOV operating hours. Data collected through ongoing HOV performance monitoring programs can be used with these models or as input to examining the issues presented in this section. The factors highlighted in the previous section should be examined when possible changes in HOV lane operating hours are being considered.

These factors include both technical issues and the reactions or perceptions of HOV lane users, non-users, and policy makers. The five scenarios will have different impacts on HOV lane users and travelers in the general-purpose freeway lanes. As noted previously, the political and policy ramifications of any change should be key considerations. Since transportation agencies are public agencies, supported by public funds, consideration should be given to public and political support, which is critical for any changes in operating hours.

The five possible scenarios are based on issues that might be identified through an ongoing HOV performance monitoring program. For each scenario, the possible issues are highlighted and the elements to consider in assessing possible changes in operating hours are described. Case studies are presented for those scenarios where examples exist. Table 6.2 presents the 14 factors described in the previous section which can be used to examine possible changes in HOV operating hours. The potential importance of these factors for each of the five scenarios is highlighted. The factors that may be especially important to consider based on the possible impacts to different users and non-user groups are highlighted, as well as those that may be neutral.

Table 6.2. Assessing Changes in HOV Operating Hours.

Elements to Consider	Extend Peak Period Operations	Peak Period/ Extended Change to 24/7	Reduce Peak Period Operations	Reduce 24/7 to Peak Period/ Extended	Open 24/7 Evenings/ Weekends
Congestion Levels	ü	ü	ü	l	l
Project Goals/ Objectives	ü	ü	ü	ü	ü
Type of HOV Lane	ü	ü	ü	¡	¡
Lane Use/Other Times	ü	ü	l	l	l
Bus Operations	ü	¡	ü	l	¡
System Connectivity	l	l	l	l	l
Enforcement	ü	ü	l	l	l
Safety	ü	ü	ü	ü	ü
Changes in Signing	¡	¡	¡	¡	¡
Operating Costs	ü	ü	¡	¡	¡
Benefits	ü	ü	ü	ü	ü
Perceptions of Users	ü	ü	ü	ü	ü
Perceptions of Non-Users	ü	ü	l	l	l
Perceptions of Policy Makers	ü	ü	ü	ü	ü

ü – Critical Factors
l – Important Factors
¡ – Neutral Factors

Table 6.3 provides an example of a checklist for use in assessing possible changes in HOV lane operating hours. The performance measures for the different elements can be listed and compared with current data to help identify potential impacts.

Table 6.3. Checklist for Assessing Changes in HOV Operating Hours.

Possible Elements to Consider	**Performance Measure**	**Current Data**	**Impact**
Congestion Levels in the HOV and General-Purpose Freeway Lanes			
Project Goals and Objectives			
Type of HOV Lane			
Use of Lane During Other Time Periods			
Bus Operations			
System Connectivity			
Enforcement			
Safety			
Changes in Signing			
Operating Costs			
Benefits			
Perceptions of HOV Lane User			
Perceptions of General-Purpose Freeway Lane Users			
Perceptions of Policy Makers			

Lengthening Peak-Period HOV Operations

This scenario focuses on extending peak-period HOV lane operating hours. Possible changes might include starting the HOV operations earlier in the morning or in the afternoon or maintaining the HOV designation later in the morning or afternoon/evening. These options may be considered in response to increasing levels of congestion in the HOV lane at the start and the end of the current operating hours, plans to expand bus service into these time periods or initiate BRT, and changes in travel and commute patterns due to new developments and employment locations.

As described in this section, depending on the type of HOV lane and current use during non-HOV operating hours, this scenario has the greatest potential to raise concerns from single-occupant vehicles and traffic in the general-purpose freeway lanes. Experience to date indicates that these user groups are often vocal in their opposition to any expansion of HOV operating hours. Experience further indicates that these groups are often able to obtain support from policy makers for their position. The two recent examples of attempts to extend HOV or HOT operating hours in Minneapolis and Fort Lauderdale highlight the need for outreach efforts to users, non-users, and policy makers to build a consensus for possible extensions in HOV operating hours. There are no recent case study examples of situations where the operating hours on an HOV lane that is open to general-purpose traffic during non-HOV time periods have been extended.

Congestion Levels in the HOV and General-Purpose Freeway Lanes. The vehicle volumes in the HOV lane and the general-purpose freeway lanes should be examined during the time periods being considered for extending the HOV operating hours. As noted above, extending peak-period HOV operating hours would typically only be considered in situations where congestion is occurring in the HOV lane throughout the current operating periods or to meet other goals, such as regional connectivity. A key element to consider is if extending the HOV operating hours will help reduce congestion in the HOV lane. If current HOV lane users do not shift their travel times slightly, extending the operating hours may not address the congestion issues being experienced with the operation of the lane. An increase in the vehicle-occupancy level may be the appropriate change to consider in this case.

Project Goals and Objectives. The goals and objectives identified for a specific HOV project or for HOV facilities in an area should be used to help guide assessing lengthening current operating hours. This change would be supportive of goals and objectives related to managing congestion in major travel corridors, providing incentives to HOV use during congested time periods, enhancing mobility options, and supporting air quality and environmental improvement efforts.

Type of HOV Lane. The type of HOV lane will influence consideration of extending peak-period operating hours. Currently, peak-period operations are used primarily with concurrent flow and contraflow HOV lanes. A few exclusive reversible HOV lanes also operate only during the peak-period. The impact of extending operating hours on these types of HOV facilities will depend partly on the use of the lanes during non-HOV operating times, which is described next.

Use of Lane during Other Time Periods. Currently, some concurrent flow and most contraflow HOV lanes operate only during the peak-periods. Extending the operating hours on a contraflow HOV lane would impact travelers in the off-peak direction of travel. If the directional split on a facility allows for a contraflow HOV lane to begin with, extending the operating period should not negatively impact traffic in the off-peak direction general-purpose freeway lanes as traffic should be lighter outside the peak-periods. HOV lane users should benefit from extending operating hours, especially if traffic congestion is becoming worse in the peak direction of travel during time periods being considered. Extending operating hours on concurrent flow HOV lanes or exclusive reversible HOV lanes that are open to general-purpose traffic at other times may bring a strong negative reaction from this group. The Minneapolis and Fort Lauderdale case studies highlight recent experience with significant negative reactions to implemented or planned extensions to HOV and HOT lane operating hours.

Bus Operations. The impact of extending peak-period HOV lane operating hours on bus operations will depend on the level of service provided or planned during the time periods being considered. Benefits may be realized if there are significant numbers of buses currently operating in the general-purpose freeway lanes during the time periods being considered or if service expansions are planned. Potential benefits to transit agencies may include improved on-time performance, higher operating speeds, service efficiencies, and cost savings. Transit users may benefit from new or expanded services and enhanced mobility.

System Connectivity. Extending peak-period operating hours on an HOV lane may be considered to match the operating hours on another facility and to provide regional connectivity.

Enforcement. Enforcing longer peak-period operating hours may be a challenge on concurrent flow HOV lanes that were previously open to general-purpose traffic during the extended time periods. Extra enforcement will probably be needed when the new hours are initiated and periodically to maintain compliance. Due to the limited access, enforcement on contraflow HOV lanes and exclusive reversible HOV lanes may be easier, but enforcement personnel will still be needed for longer periods of time.

Safety. Potential safety concerns should be examined when extending peak-period HOV operating hours are being considered. Safety concerns will typically be facility-specific and will relate partly to the type, design, and operation of the HOV lane. One example of a possible safety issue with extending peak-period HOV operating hours on concurrent flow HOV lanes that are currently open to all traffic during the non-HOV restricted time periods focuses on the potential for conflicts with general-purpose traffic during the new transition periods.

Changes in Signing. Changes in signs and pavement markings will be needed with any modification in operating hours, including extending peak-period operations. The costs associated new signs and pavement markings should be considered in the assessment of possible changes in operating hours, but generally represent a one-time cost. The extent of needed changes and possible costs will depend on the number of HOV lanes under consideration, as well as the length of these lanes and the types of signs in use.

Operating Costs. The impact on operating costs from extending peak-period hours will depend on the type of HOV lane and the need for operating and enforcement personnel to be deployed over a longer time period. Lengthening the operation of exclusive reversible HOV lanes and contraflow HOV lanes will typically require longer hours for the personnel responsible for opening, closing, and monitoring use of the lanes. Enforcement officers will be needed for longer time periods, as will tow truck operators or other support personnel provided when exclusive reversible or contraflow HOV lanes are in operation. The operating costs associated with extending hours on concurrent flow HOV lanes will typically be lower. The costs associated with additional enforcement would usually be the major increase in operating costs from extending peak-period HOV hours on concurrent flow lanes.

Benefits. The potential benefits from extending peak-period operating hours on an HOV lane will relate to the travel time savings realized by users during the new operating time periods. The dollar value of the savings in travel time accrued by these users can be calculated and a benefit-cost ratio can be estimated. Other possible benefits from extending peak-period HOV operating hours include encouraging additional travelers to change to HOV modes, increasing the AVO and facility throughput, improving bus operations, and enhancing mobility.

Perceptions of HOV Lane Users. In general, the existing HOV lane users – including carpoolers, vanpoolers, and bus riders – should be supportive of extending peak-period operating hours. Further, carpoolers, vanpoolers, and bus riders currently traveling in the general-purpose freeway lanes during the time period being considered for extended hours should favor the change.

Perceptions of General-Purpose Lane Users. Experience to date indicates that travelers in the general-purpose freeway lanes and single-occupant drivers currently using HOV lanes during non-HOV time periods do not favor extending peak-period operating hours on HOV lanes. As noted in the Fort Lauderdale and the Minneapolis case studies, single-occupant vehicle drivers and the public may react negatively to extending peak-period operating hours on an HOV lane that is currently open to general-purpose traffic at other times. These groups may be very vocal and may influence policy makers. Outreach activities to these groups appear to be critical when extending peak-period HOV operating hours are being considered.

Perceptions of Policy Makers. As noted above, policy makers may not be supportive of extending peak-period operating hours on HOV lanes that are currently open to general-purpose traffic during the time periods being considered. The experience in Fort Lauderdale and Minneapolis indicates that even when outreach activities are undertaken with policy makers and other stakeholders, these groups may still oppose any change and may initiate legislation or other actions to ensure that the change does not occur.

Extending Peak-Period Operating Hours – I-95 HOV Lanes, Fort Lauderdale

In the summer of 2005, the Florida Department of Transportation (FDOT) postponed plans to extend the operating hours on the I-95 HOV lanes in the Fort Lauderdale-Miami area due to concerns raised by the public and some policy makers. Extending the operating hours was one of the recommendations in the I-95 HOV Systems Plan, Phase II – System-wide Operations Study. The operating hours on the I-95 HOV lanes currently vary by location. The operating hours in the section from the southern terminus at SR 112 to the Miami-Dade/Broward County line are weekdays from 7:00 a.m. to 9:00 a.m. southbound-only and 4:00 p.m. to 6:00 p.m. northbound-only. The section from the Miami-Dade/Broward County line to the northern terminus at Linton Boulevard operates weekdays in both directions of travel from 7:00 a.m. to 9:00 a.m. and from 4:00 p.m. to 6:00 p.m. Three options were examined as part of the operation study. These options were maintaining the existing operating hours, extending the current hours to include more of the morning and afternoon peak-periods, and 24-hour operation. Data examined in the study included traffic volumes, travel time runs, and traffic growth rates. The long-range transportation plans for the three counties were also reviewed. Based on the assessment, the recommendation was made to extend the HOV operating hours to 24-hour operations in both directions of travel south of the Golden Glades interchange and to 6:00 a.m. to 10:00 a.m. and 3:00 p.m. to 7:00 p.m. in both directions of travel north of the interchange. A public and policy maker outreach effort was undertaken by FDOT and it appeared there was support for the change. However, travelers in the corridor and some policy makers reacted negatively as signs began to be changed along I-95 and other public information was distributed. As a result, FDOT postponed implementing the extended hours to enable further outreach efforts.

Changing Peak-Period or Extended Hours to 24/7 Operations

This scenario focuses on changing peak-period or extended HOV operating hours to 24/7 operation. This option may be considered in response to increasing levels of traffic congestion in a corridor or area over longer periods of the day and evening. Other factors that may influence consideration of changing to 24/7 operating hours include the implementation of a BRT system, the location of new businesses with significant numbers of employees on different work shifts, new recreational or planned special event developments, and the adoption of policies supporting priority treatments for HOVs at all times.

The key issues in assessing a change from peak-period or extended HOV operating hours to 24/7 operation will be primarily the same as those discussed under the previous scenario. If the HOV lane is open to general-purpose traffic during other times, the main issue will most likely be addressing concerns from single-occupant drivers, the public, and policy makers. The Minneapolis case study provides an example of how vocal opposition to the 24/7 designation with the MnPASS project on I-394 resulted in a change back to the previous peak-period, peak-direction operating hours on the concurrent flow HOV lanes.

Congestion Levels in HOV and General-Purpose Freeway Lanes. The vehicle volumes in the HOV lanes and the general-purpose lanes should be analyzed during the mid-day, evening, early morning, and weekend time periods being considered for 24/7 operation. Vehicle volumes on all facilities may be lower during these time periods. The vehicle volumes during these time periods can be compared to the measures of effectiveness and the minimum and maximum vehicle volumes identified in the HOV performance monitoring program or other highway performance criteria.

Experience from some areas, including Los Angeles, indicates that the HOV lanes are well utilized during the mid-day and on weekends. For example, 24-hour volumes on the El Monte Busway analyzed in the 1999 Caltrans study were 35 percent higher on Saturdays than on weekdays. The 24-hour volumes on Saturday were also higher than weekday volumes on three other HOV lanes. The recent assessment of the Los Angeles County HOV lanes conducted by the Los Angeles Metropolitan Transportation Authority found that weekend use of the HOV lanes represented 30 percent to 50 percent of peak-hour demand, with some HOV lanes recording volumes higher than 50 percent. This information provides a guide for other areas considering extending HOV operating hours to 24/7.

The average travel speeds can also be examined and the potential travel time savings for HOVs can be estimated. This information can be compared to the criteria established in the HOV performance monitoring program.

Project Goals and Objectives. The goals and objectives identified for an HOV system in an area or for a specific project can be used to help guide the examination of changing peak-period or extended operating hours to 24/7 operation. Changing to 24/7 operations would be supportive of goals and objectives related to providing incentives to encourage HOV use at all times, managing congestion throughout all time periods, enhancing mobility options, improving transportation management for special events, and supporting air quality and environmental efforts.

Type of HOV Lane. Currently, 24/7 operating hours are typically found with concurrent flow HOV lanes and two-way exclusive HOV lanes. Given the limited number of two-way exclusive HOV lanes, all of which currently operate on a 24/7 basis, concurrent flow HOV lanes that currently operate during the peak-periods represent the type of HOV facilities that might be considered for extending to 24/7 operation. Contraflow HOV lanes would not be logical candidates, and exclusive reversible HOV lanes would require some time to close, reverse the direction of operation, and reopen.

Use of Lane during Other Time Periods. As noted in the previous scenario, the current use of the lane during the non-HOV operating time period will have a major impact on the groups affected by the change. If the lane is currently open to general-purpose traffic during non-HOV operating periods, concerns may be raised by travelers in the corridor, the public, and policy makers. If the lane is currently closed to all traffic, no user groups should be negatively impacted.

The Minneapolis I-394 MnPASS HOT case study illustrates this point. The operating hours on the seven miles of concurrent flow lanes were changed from peak-direction, peak-period to 24/7 when the MnPASS project was implemented. The operating hours on the three-mile reversible section were changed from extended hours to 6:00 a.m. to 1:00 p.m. eastbound and 2:00 p.m. to 5:00 a.m. westbound. The concurrent flow HOV lanes had been open to general-purpose traffic during other times, while the reversible section was closed to all traffic. Public and policy maker concerns with the 24/7 MnPASS operation on the concurrent flow lanes resulted in a change back to the original operating hours. The almost 24/7 operating hours on the reversible section have been continued.

Bus Operations. The impact on bus operations from changing from peak-period or extending operating hours to 24/7 operation may be relatively small. Bus services are typically oriented around peak-period work trips and bus use of HOV lanes during the evening/early morning hours and weekends is usually low or non-existent. Weekday bus use of HOV lanes may start as early as 4:00 a.m. to 5:00 a.m. to meet peak-period demands, however, and may continue into the early evening. Consideration of 24/7 operations may be influenced by plans to extend bus service into current non-operating time periods, the implementation of weekend service, or the implementation of BRT.

System Connectivity. Changing to 24/7 operation may be considered to coordinate with operating hours on other HOV lanes in a corridor or area.

Enforcement. Changing from peak-period or extended operating hours to 24/7 will require enforcement over a longer period of time. The ability to enforce the changes in operating hours during the new time period should be examined. Additional enforcement personnel will probably need to be deployed during the extended time periods. Extra enforcement would typically be needed when the changes are first made and on a periodic basis thereafter to ensure compliance.

Safety. Potential safety concerns should be examined when changing from peak-period or extended operating hours to 24/7 is being considered. Safety concerns will typically be facility-specific and will relate to the design and operation of the lane. There may be fewer safety concerns with extending the operating hours to 24/7, since HOVs are currently using the lanes.

Changes in Signing. Changes in signs and pavement markings will be needed with extending HOV operating hours to 24/7. The costs associated new signs and pavement markings represent a one-time cost that will depend on the number and length of the HOV lanes, and the number and type of signs.

Operating Costs. The impact on operating costs from changing to 24/7 operation will relate primarily to the need for operating and enforcement personnel to be deployed over a longer time period. Given the logical focus on concurrent flow HOV lanes with this possible scenario, the costs associated with enforcement personnel during the new HOV operating periods would typically be the major additional operating expense with the change to 24/7 operation.

Benefits. The potential benefits from changing to a 24/7 operation will be related to the travel time savings realized by users during the new operating time periods and any savings to public transit operators. A benefit-cost ratio can be calculated based on the estimated dollar value of the travel time savings to these users.

Perceptions of HOV Lane Users. Existing and potential HOV lane users – carpoolers, vanpoolers, and bus riders – could be expected to support a change to 24/7 operations. Bus operators and public transit agencies operating service in the corridor should also support the change.

Perceptions of General-Purpose Freeway Lane Users. As noted in the previous scenario, opposition to a 24/7 designation can be expected from single-occupant drivers if they are currently allowed to use the HOV lane during the non-HOV time periods. The Minneapolis case study provides an example of the reaction from travelers in the corridor and the public to a change to 24/7 operations as part of a HOT project. These groups may be supportive of extending the operating hours on a lane closed to all users during the non-HOV periods as it may be viewed as benefiting all user groups.

Perceptions of Policy Makers. The perceptions of policy makers toward changing peak-period or extended hours to 24/7 operations will depend partly on the reaction from users, non-users, and the public. If these groups support the change, policy makers are also likely to be supportive of 24/7 operation. If some of these groups oppose the change, policy makers may be less supportive, even if the operating agencies have provided information on the need for the change and possible benefits.

MnPASS 24/7 Operating Hours – I-394 Lanes, Minneapolis

The final I-394 HOV lanes in Minneapolis opened in 1992. The HOV lanes include two different designs. The operating hours on the seven-mile concurrent flow section were 6:00 a.m. to 9:00 a.m. in the eastbound direction (into downtown Minneapolis) and 4:00 p.m. to 7:00 p.m. in the westbound direction. The operating hours for the three-mile two-lane, barrier-separated, reversible section were 6:00 a.m. to 10:00 a.m. eastbound and 2:00 p.m. to 7:00 p.m. westbound. The operating hours changed significantly in May 2005 with the implementation of the MnPASS HOT project. The operating hours in the concurrent flow section were changed to 24/7 in both directions of travel. The operating hours in the reversible section were changed to 6:00 a.m. to 1:00 p.m. eastbound and 2:00 p.m. to 5:00 a.m. westbound. Thus, the implementation of the MnPASS project represented a change from primarily a peak-period, peak-direction HOV operation to a 24/7 HOT/HOV operation in the seven-mile concurrent flow section. This change resulted in an increase in traffic congestion in the morning westbound direction of travel on a portion of the freeway with the concurrent flow lane. Commuters in the corridor reacted negatively to the congestion and the increased travel times caused by the change. The Minnesota Senate passed a resolution supporting rescinding the tolls in the off-peak direction and other policy makers voiced support for changing the operating hours. Mn/DOT made some initial changes in operating hours in response to these concerns. In August, 2005 the operating hours on the concurrent flow lane section were further reduced to 6:00 a.m. to 10:00 a.m. eastbound and 2:00 p.m. to 7:00 p.m. westbound. These hours were close to the operating hours used previously with the HOV lane. The operating hours on the reversible section were not changed. The extended hours did not have an impact on traffic in the general-purpose lanes in this section, as the lanes had been closed to all traffic under HOV operations.

Reducing Peak-Period or Extended Operations

This scenario focuses on reducing peak-period or extended HOV operating hours. Possible changes include starting the HOV designation later in the morning or afternoon and ending the HOV operating time earlier in the morning or evening. These options may be considered in response to actual low use levels during these time periods or perceptions of policy makers and the public related to use levels during these time periods. The impact of this scenario on HOV lane users and travelers in the general-purpose freeway lanes will depend primarily on the type of HOV lane, the anticipated use of the lane during the previous HOV operating hours, current vehicle volumes in the HOV lane, and the level of congestion in the general-purpose freeway lanes.

As discussed in this section, HOV lane users and public transportation services may be negatively impacted by reducing peak-period or extended operating hours. Most peak-period HOV lanes have high utilization levels throughout the operating periods. HOV lanes with extended operating hours are also well used. Further, HOV lane users may view a reduction in current operating hours as a step toward eliminating the HOV designation altogether. Motorists in the general-purpose freeway lanes and the public may view this change positively if they are able to use the HOV lane during the previous HOV-only operating period. This type of change may not have a significant impact on any user group if the HOV lane is closed to all traffic during the previous HOV operating hours. For example, the operating hours on the exclusive reversible HOV lanes in Houston have been modified slightly over the years, including lengthening and then reducing extended operating hours. These minor changes in operating hours at times well before or after the peak-periods on HOV lanes that are closed to all traffic during non-HOV operating periods do not seem to have had a major impact on HOV lane users or non-users.

Congestion Levels in the HOV and General-Purpose Freeway Lanes. The vehicle volumes, travel times, and trip time reliability in the HOV lanes and the general-purpose freeway lanes should be examined for the time periods being considered for reducing HOV operations. Vehicle volumes in the HOV lanes and in the general-purpose freeway lanes are at their highest during the morning and afternoon peak-hours. While vehicle volumes and congestion levels may be slightly lower during the "shoulders" of the peak-period or during extended operating hours, most HOV lanes and general-purpose freeway lanes are well used throughout these time periods.

The vehicle volumes, travel time, and trip time reliability in the HOV lane and the general-purpose freeway lanes during these time periods can be compared to the measures of effectiveness and the minimum and maximum vehicle volumes identified in the HOV performance monitoring program or other highway performance criteria. This information can be used to gauge the potential impacts on the HOV lane and the general-purpose freeway lanes from reducing HOV operating hours.

The recent performance monitoring program sponsored by the Los Angeles County Metropolitan Transportation Authority found that the HOV lanes in Los Angeles County are well used throughout the day. Use during the mid-day on many HOV lanes was 30 to 50 percent of the peak-hour demand.

Project Goals and Objectives. The goals and objectives for an HOV project or those associated with the HOV and transportation system in an area will influence consideration of reducing peak-period or extended HOV operating hours. In general, this scenario would not be supportive of the goals and objectives associated with HOV projects in most areas.

Type of HOV Lane. The type of HOV lane and use during non-HOV time periods will influence the impact of reducing peak-period or extended HOV operating hours. Reducing operating hours on exclusive reversible HOV lanes that are closed to all vehicles during non-HOV hours would negatively impact those HOVs using the facility during the specific time period. Vehicle volumes and congestion may increase in the general-purpose freeway lanes as these vehicles shift from the HOV lane to the freeway lanes. Reducing operating hours on a contraflow HOV lane would also have a negative impact on users during the specific time period and would increase congestion in the peak-direction freeway lanes. Reducing operating hours on concurrent flow HOV lanes open to general-purpose traffic at other times would have a negative impact on HOVs. The impact on the general-purpose freeway lanes and the total freeway will depend on how vehicles are redistributed based on opening the HOV lane to general-purpose traffic.

Use of Lane during Other Time Periods. As noted above under the type of HOV lanes, how the HOV lane is anticipated to be used during the time periods previously reserved for HOVs will influence the potential impact of reducing peak-period or extended operating hours. If the HOV lane is closed to all traffic during the reduced hours, the reduction would negatively impact the HOVs using it during the time period and vehicle volumes in the general-purpose freeway lanes would increase as the HOVs move to these lanes. If the lane is open to general-purpose traffic during the previous HOV-only operating time, HOVs would be negatively impacted, but single-occupant vehicle drivers may realize short-term benefits if the overall freeway operates at a higher level of service.

Bus Operations. Reducing peak-period or extended HOV operating hours may have a negative impact on bus operators and bus riders. Since bus services are typically oriented around peak-period work trips, reducing HOV operating hours during these times of the day would require buses to operate with general-purpose traffic. Weekday bus use of HOV lanes may start as early as 4:00 a.m. to 5:00 a.m. and continue to 6:00 p.m. to 8:00 p.m. to meet peak-period demands. The number of buses operating during the time period being considered for reduction, and the number of passengers on the buses, should be examined. The impact on bus travel time savings, trip time reliability, and operating costs should also be estimated to determine the possible impact from the reduced operating hours.

System Connectivity. Reducing operating hours on one HOV lane may impact the operation of other HOV lanes in the area. HOV system connectivity issues should be examined in analyzing the potential impacts of reducing peak-period or extended HOV operating hours. Consideration may be given to providing continuity in operating hours on HOV lanes in a corridor or metropolitan area.

Enforcement. The ability to enforce the new HOV operating hours should be examined. The transition periods when general-purpose vehicles are allowed to use the lane and when the HOV requirement goes into effect are especially critical times for enforcement. The Seattle case study in the scenario addressing opening 24/7 HOV lanes to general-purpose traffic in the evenings indicates that violation rates can be expected to increase slightly prior to the start of opening the lanes to general-purpose traffic and before the start of the HOV restricted period. Additionally, reducing peak-period or extending operating hours may result in more violators using a lane during the most congested time of the day when maintaining the travel time savings and trip time reliability is key to encouraging HOV use.

Safety. Potential safety concerns should be examined when reducing peak-period or extended HOV operating hours are being considered. Potential safety concerns with reducing peak-period or extended operating hours will largely depend on the type of HOV lane and the use during the reduced time period. Safety issues associated with reducing operating hours on exclusive reversible HOV lanes that are closed to all traffic during non-HOV operating periods may be relatively minor. Safety concerns with reducing operating hours on concurrent flow HOV lanes open to general-purpose traffic at other times may focus on the potential for increased conflict between HOVs and general-purpose traffic during the transition periods when the HOV restrictions go into effect and when they are lifted.

Changes in Signing. Changes in signs and pavement markings will be needed with any modification in operating hours. The one-time costs associated new signs and pavement markings should be considered in the assessment of reducing peak-period or extended HOV operating hours. The extent of the needed changes and the potential costs will relate to the number of HOV lanes, the length of these lanes, other HOV lanes in the area, and the types of signs in use.

Operating Costs. The impact on operating costs from reducing peak-period or extended HOV operating hours will depend on the type of HOV lane. Cost savings may be realized on exclusive reversible HOV lanes and contraflow HOV lanes if the reduced operating hours translate into reduced hours for field personnel and enforcement officers. The impact on operating costs for concurrent flow HOV lanes may be mixed or minor. While some cost savings in enforcement personnel might be realized from shorter operating hours, extra enforcement personnel may be needed during the transition periods, offsetting any possible cost savings.

Benefits. The potential benefits on traffic congestion from reducing peak-period or extended HOV operating hours will depend on the vehicle volumes in the HOV lane and the general-purpose freeway lanes during the time periods being considered and the new use of the lane during those time periods. If the HOV lane has low utilization during the period being considered, there may be little impact if the lane is closed to all traffic during the previous operating hours. If the HOV lane is underutilized and the general-purpose freeway lanes are congested during the time period being considered, and general-purpose traffic is allowed to use the lane, short-term benefits may be realized in traffic flow on the total facility. If both the HOV lane and the general-purpose freeway lanes are congested, the change in operating hours may not benefit any user group.

Perceptions of HOV Lane Users. HOV lane users will likely not favor reducing operating hours since they will be negatively impacted. Further, HOV lane users may view the change as a first step toward elimination of the HOV lane altogether.

Perceptions of General-Purpose Freeway Lane Users. Depending on the vehicle volumes in the HOV lane and the general-purpose freeway lanes and the use of the HOV lane during the previous HOV-only time period, general-purpose traffic may realize short-term benefits from this scenario. It is interesting to note that the experience in Seattle indicates a relatively low awareness among motorists and the public to the change opening the east side HOV lanes in the evening after the first year of operation.

Perceptions of Policy Makers. The perceptions of policy makers may be influenced by the perceptions of their constituents, as well as the information provided to them by the operating agencies. Policy makers may be influenced by strong vocal support for or against changes in HOV operating hours, including reducing peak-period or extended HOV hours of operation.

Reducing 24/7 to Extended or Peak-Period Operation

This scenario focuses on reducing 24/7 HOV operating hours to extended or peak-period operating hours. This change may be considered in response to low use levels during certain time periods or perceptions on the part of the public and policy makers that the HOV lanes are under utilized at these times. This scenario represents a major change in the HOV lane operating philosophy for an area. Rather than providing priority treatment for HOVs at all times, this change would focus primarily on peak-period commute trips. There are no case study examples of changing 24/7 HOV operations to extended or peak-period hours.

Congestion Levels in the HOV and General-Purpose Freeway Lanes. The vehicle volumes in the HOV lanes and the general-purpose lanes will typically be lower during the off-peak periods, including the mid-day, evening, and early morning hours. Comparing the vehicle volumes during these time periods with the target identified in the measures of effectiveness and the minimum and maximum vehicle volumes identified in the HOV performance monitoring program can help identify the need for changes and the possible impacts on HOV lane users and travelers in the general-purpose freeway lanes. In some cases, the HOV lane volumes may be high throughout most periods of the day and on weekends. In other cases, the vehicle volumes may be lower, but the HOV lanes may still be well utilized. For example, 24-hour volumes on the El Monte Busway analyzed in the 1999 Caltrans study were 35 percent higher on Saturdays than on weekdays. The 24-hour volumes on Saturday were also higher than weekday volumes on three other HOV lanes. The recent assessment of the Los Angeles County HOV lanes conducted by the Los Angeles Metropolitan Transportation Authority found that mid-day weekend use of the HOV lanes represented 30 percent to 50 percent of peak-hour demand, with some HOV lanes recording volumes higher than 50 percent.

The average travel speeds in the HOV lanes and general-purpose freeway lanes should be examined and compared against the criteria established in the HOV performance monitoring program. Since vehicle volumes are typically lower during the evening/early morning hours and on weekends, travel speeds should be higher and travel times should be shorter. As noted in the Los Angeles case study in the next scenario, weekend volumes in the HOV lanes and the general-purpose freeway lanes may still be significant, resulting in the HOV lanes providing travel time savings and trip time reliability to HOVs.

Bus Operations. Reducing 24/7 HOV operating hours to peak-period or extended hours may have a relatively minor impact on public transit services since bus services are typically oriented around peak-period work trips. Bus use of HOV lanes during the evening/early morning hours and weekends is usually low or non-existent. Weekday bus use of HOV lanes may start as early as 4:00 a.m. to 5:00 a.m. and end around 6:00 p.m. to 8:00 p.m. to meet peak-period demands. This scenario would have a negative impact on BRT systems and areas with extended mid-day, evening, and weekend bus service.

System Connectivity. The impact of reducing 24/7 HOV operations to peak-period or extended hours on system connectivity will depend on the number of other HOV lanes in the area and the hours of operation on these facilities. Examining this impact will be important if there are multiple HOV lanes in an area and the change is being considered on just one lane or just some facilities.

Enforcement. Reducing 24/7 operating hours to peak-period or extended hours will probably result in the need for extra enforcement during certain periods, especially if the change is made on a concurrent flow HOV lane that will be open to mixed traffic during the previous HOV-only time period. As noted previously, the transition periods when the HOV requirement goes into effect and when the lane is open to general-purpose traffic are critical times for enforcement. The Seattle case study in the next scenario indicates that violation rates may increase slightly prior to the start of opening the lanes to general-purpose traffic and before the HOV restricted period starts.

Safety. Potential safety concerns should be examined when reducing 24/7 HOV operating hours to peak-period or extended hours are being considered, especially if general-purpose traffic will be allowed to use a lane during the previous HOV-only operating period. Safety concerns will typically be facility-specific and will relate to the design and operation of the lane. As noted in the Seattle case study in the next scenario, safety was a concern in the opening of the HOV lanes to evening general-purpose traffic. Approximately $1.6 million in safety improvements were made prior to the change in operating hours. The improvements included installing left-hand rumble strips, increasing clear zones, and adding guardrails.

Changes in Signing. Changes in signs and pavement markings will be needed with any modification in operating hours. The one-time costs associated new signs and pavement markings should be considered in the assessment of reducing 24/7 operations to peak-period or extended operating hours. The cost of these changes will depend on the number of HOV lanes, the length of these lanes, and the number and the type of signs. As noted previously, this scenario represents a major change in the HOV operating philosophy in an area. As a result, additional signs may be needed to ensure an understanding of the new operating hours.

Operating Costs. The impact on operating costs from changing from 24/7 operations to peak-period or extended hour operations will depend on the type of HOV lane and use during the previous HOV-only time periods. The impact of this change on concurrent flow HOV lanes may be minor or mixed, as enforcement tends to be the most significant cost associated with operating concurrent flow HOV lanes. Enforcement is not typically a problem during the periods being considered in this scenario, however, and extra effort is not usually provided during these periods. Additional enforcement personnel will probably be needed with a change from a 24/7 operation, especially during the transition periods when the HOV designation goes into effect and when it is lifted.

Benefits. The potential benefits on traffic congestion and the person movement capacity of the total facility will depend on vehicle volumes in all lanes during the time periods being considered and the use of the HOV lane during the previous HOV-only time periods. The Seattle case study in the next scenario, which opens the HOV lanes on the east side to general-purpose traffic in the evenings, indicates there was little impact in the performance of the total freeway from the change.

Perceptions of HOV Lane Users. HOV lane users who might be negatively impacted by reducing 24/7 operations would typically not favor this change. Reducing 24/7 operating hours to peak-period or extended operating hours will impact HOV user groups differently. HOV lane users making recreational, social, and personal trips are more likely to be negatively impacted by reducing 24/7 HOV operations to peak-period or extended hours. HOV users making work trips during peak-period would probably not notice any different from this change. Individuals in the HOV time periods being reduced may feel their travel needs are not being given the same consideration or priority as peak-period commute trips. In addition, although not directly affected by the change, peak-period HOV lane users may voice concern that this change represents a first step toward elimination of the HOV lane altogether.

Perceptions of General-Purpose Freeway Lane Users. Motorists in the general-purpose freeway lanes may benefit from this change if the HOV lane is open to all traffic during the previously HOV operating hours. As a result, non-HOV lane users and the public may support reducing 24/7 operating hours. As noted in the Seattle case study example presented in the next scenario concerning opening 24/7 HOV operations to general-purpose traffic in the evenings, however, many non-users were not aware of the change after the first year of the pilot program.

Perceptions of Policy Makers. The perceptions of policy makers related to reducing 24/7 HOV operating hours to peak-period or extended hours will be partially influenced by the perceptions of their constituents, as well as their perceptions of traffic congestion, mobility, and techniques for addressing these issues. Policy makers in some areas have expressed interest over the years in reducing 24/7 operations.

Modifying 24/7 Operation to Allow General-Purpose Traffic in the Evenings or on Weekends

Interest has periodically been expressed by policy makers and the public in some areas related to opening HOV lanes that operate on a 24/7 basis to general-purpose traffic in the evenings and on weekends. This interest may be the result of perceived or actual lower vehicle volumes in the HOV lanes during these time periods.

As noted in the case studies, assessments of opening HOV lanes during these time periods have been conducted in Los Angeles in 1999 and the Puget Sound region in 2002. In Los Angeles, the study recommended that no changes be made in the operating hours. In the Puget Sound region, a pilot project was implemented in 2003 opening HOV lanes on the east side of Seattle to general-purpose traffic from 7:00 p.m. to 5:00 a.m. seven days a week.

Currently, HOV lanes that operate on a 24/7 basis are primarily concurrent flow HOV lanes and two-way exclusive HOV lanes. A 24/7 designation is used on most concurrent flow lanes and the El Monte Busway in Southern California. Prior to the pilot program described in the case study, concurrent flow HOV lanes in the Puget Sound region also operated on a 24/7 basis.

Congestion Levels in HOV and General-Purpose Freeway Lanes. The vehicle volumes in the HOV lanes and the general-purpose freeway lanes should be analyzed during the time periods being considered for access by general-purpose vehicles. Vehicle volumes on all facilities may be lower during the evening/early morning hours, on weekends, and on holidays. The vehicle volumes during these time periods can be compared to measures of effectiveness and the minimum and maximum vehicle volumes identified in the HOV performance monitoring program or other highway performance criteria.

In some cases, the HOV lane volumes may be higher on weekends. In other cases, the vehicle volumes may be lower, but the HOV lanes may still be well utilized. For example, 24-hour volumes on the El Monte Busway analyzed in the 1999 Caltrans study were 35 percent higher on Saturdays than on weekdays. The 24-hour volumes on Saturday were also higher than weekday volumes on three other HOV lanes. The 1999 Los Angeles study also found that most freeways operated at a LOS C on weekends, indicating that opening the HOV lanes to general-purpose traffic would not have a significant benefit. The 2000 assessment of the Los Angeles County HOV lanes conducted by the Los Angeles Metropolitan Transportation Authority found that weekend use of the HOV lanes represented 30 percent to 50 percent of peak-hour demand, with some HOV lanes recording volumes higher than 50 percent.

The average travel speeds in the HOV lanes and general-purpose freeway lanes should be examined and compared against the criteria established in the HOV performance monitoring program. Since vehicle volumes are typically lower during the evening/early morning hours and on weekends, travel speeds should be higher and travel times should be shorter. As noted in the Los Angeles case study, weekend volumes in the HOV lanes and the general-purpose freeway lanes may still be significant, resulting in the HOV lanes providing travel time savings and trip time reliability to HOVs.

Project Goals and Objectives. The goals and objectives for the HOV system or an HOV project should be reviewed in assessing the potential of opening an HOV lane to general-purpose traffic in the evenings and on weekends. This change may or may not be supportive of HOV or other transportation goals and policies.

Type of HOV Lane. HOV lanes that may operate on a 24/7 basis include busways, exclusive two-way HOV lanes, and concurrent flow HOV lanes. Interest in opening 24/7 HOV facilities in the evenings and on weekends to general-purpose traffic has occurred primarily in areas with concurrent flow HOV lanes.

Use of Lane during Other Time Periods. This scenario focuses on allowing general-purpose traffic to use an HOV lane in the evening, on weekends, and on holidays that were previously restricted to HOV use. As a result, single-occupant drivers and the public would typically favor this change.

Bus Operations. Bus services on concurrent flow and two-way exclusive HOV lanes are typically oriented around peak-period work trips. Bus use of HOV lanes during the evening/early morning hours and weekends is usually low or in many cases non-existent. Weekday bus use of concurrent flow HOV lanes may start as early as 4:00 a.m. to 5:00 a.m. to meet peak-period demands, however. If opening 24/7 HOV lanes to general-purpose traffic during the evening is being examined, ensuring that he change does not negatively impact buses during the transition periods in the morning and the afternoon will be an important consideration.

System Connectivity. The impact of opening HOV lanes that operated on a 24/7 basis to general-purpose traffic in the evenings and on weekends will have on system connectivity should be examined. The Puget Sound case study provides an example of opening the HOV lanes on the east side of Seattle to general-purpose traffic in the evenings, while maintaining the 24/7 designation on other HOV lanes in the region.

Enforcement. Enforcement issues associated with opening HOV lanes which currently operate on a 24/7 basis to general-purpose traffic during the evenings and on weekends will focus primarily on the transition periods when the HOV requirement is lifted and when it goes back into effect. The Seattle case study indicates that violation rates can be expected to increase slightly prior to the start of opening the lanes to general-purpose traffic at 7:00 p.m. and before the HOV restricted period starts again, which is 5:00 a.m. in Seattle.

Safety. Potential safety concerns should be examined when options to open HOV lanes in the evenings and on weekends are being considered. Safety concerns will typically be facility-specific and will relate to the design and operation of the lane. As noted in the Seattle case study, safety was a concern in opening of the HOV lanes in the evening to general-purpose traffic.

Approximately $1.6 million in safety improvements were made on the HOV lanes prior to the change in operating hours. The improvements included installing left-hand rumble strips, increasing clear zones, and adding guardrails.

Changes in Signing. Changes in signs and pavement markings will be needed with any modification in operating hours, including opening lanes that operate on a 24/7 basis to general-purpose traffic in the evenings and on weekends. The one-time costs associated new signs and pavement markings will depend on the number and the length of HOV lanes being considered and the type and number of signs.

Operating Costs. Consideration should be given to possible changes in operation that may be required with opening 24/7 HOV lanes to general-purpose traffic during the evenings and on weekends. An example of a possible change in operations relates to access, which was one of the elements considered in the 1999 Los Angeles assessment. The concurrent flow HOV lanes in Los Angeles have limited access, with HOVs allowed to enter and exit the lanes only at specific points. The operating scenario is different than Seattle, where most of the concurrent flow HOV lanes have unlimited access, allowing HOVs to enter and exit the lanes at any point.

The major impact on operating costs from opening 24/7 HOV lanes to general-purpose traffic in the evenings and weekends will relate to extra enforcement personnel needed during the transition periods. Based on the experience in Seattle, additional enforcement personnel may be needed to ensure compliance with the HOV requirement during the transition periods when a lane is open to general-purpose traffic and when the HOV designation goes back into effect.

Benefits. The potential benefits on traffic and congestion levels from opening 24/7 HOV lanes to general-purpose traffic in the evenings and on weekends may be limited. The Puget Sound case study indicated that there was very little change in the performance of the freeways during the evening hours. No noticeable change in the congestion levels of the general-purpose freeway lanes was observed. A small increase of 1 to 3 mph was noted on a few freeway segments in the time period after the 7:00 p.m. opening of the lanes to general-purpose traffic.

Perceptions of HOV Lane Users. HOV lane users may not favor opening the lanes to general-purpose traffic during the evenings and on weekends. Individuals making recreational and personal trips may use the HOV lanes during these time periods, as opposed to commuters who typically compromise the majority of weekday peak-period users. Thus, this change may negatively impact a specific user groups who may feel their travel needs are not being given the same priority as commuters. Further, all HOV lane users may be concerned that this change represents the first step toward elimination of the HOV lanes.

Perceptions of Non-Users. Since motorists in the general-purpose freeway lanes may benefit the most from the change, they should support the modifications. It is interesting to note that the experience in Seattle indicates a relatively low awareness among motorists and the public to the change of opening the east side HOV lanes in the evening after the first year of operation.

Perceptions of Policy Makers. Policy makers in some areas have expressed interest in opening 24/7 HOV lanes to general-purpose traffic during the evenings and on weekends. This interest has been evident even in areas such as Seattle and Southern California, where the HOV lanes are well used. Policy makers would probably be supportive of these changes if they feel the operation of the HOV lanes during weekday peak-periods would not be negatively impacted, and if their constituents favor the change.

Pilot Program Opening HOV Lanes in the Evening – Puget Sound Region

The HOV lanes in the Puget Sound Region have traditionally operated on a 24/7 basis. Most facilities are concurrent flow HOV lanes with unlimited access. The results of the ongoing HOV lane monitoring program document that the HOV facilities are well utilized during the morning and afternoon peak-periods. Surveys conducted as part of the monitoring program indicate that there is strong public support for HOV facilities in the area. At the same time, there has also been public and policy maker interest in allowing single-occupant vehicles to use the HOV lanes during the off peak-periods. Analysis conducted over the years indicated that there is little unused HOV capacity during the peak-periods, but that excess capacity does exist in the evening and early morning periods. At the direction of the Washington State Transportation Commission, WSDOT implemented a pilot program in 2003, opening the HOV lanes on the eastside of Seattle to general-purpose traffic from 7:00 p.m. to 5:00 a.m. The one-year evaluation of the pilot program indicated that the overall changes in system performance were small. Late evening vehicle volumes in the HOV lanes increased slightly, but speeds remained basically unchanged. Violation rates increased slightly. Before-and-after crash data were similar. While public awareness of the change appeared low, the general reaction was positive. More information on this case study is included in Chapter Seven.

Assessment of Opening HOV Lanes on Weekends and on Holidays – Los Angeles

Most HOV lanes in the Los Angeles area operate on a 24/7 basis. In response to a request from the Los Angeles County Board of Supervisors in 1999, Caltrans District 7 staff examined the feasibility and effectiveness of opening HOV lanes in the county to general-purpose traffic on weekends and holidays. There were 14 freeways with HOV lanes included in the study. Data on vehicle volumes in the HOV lanes and general-purpose freeway lanes, average speed and level-of-service, vehicle-occupancy, and violations were examined. The study identified possible advantages to opening the HOV lanes to general-purpose traffic on weekends and holidays. Potential advantages included increasing average travel speeds by reducing the freeway density and easing congestion during weekend construction and maintenance. The study recommended maintaining the 24/7 HOV designation for a number of reasons. First, the HOV lanes were being utilized effectively on weekends. Second, opening the HOV lanes to general traffic would provide only minor improvements to overall traffic conditions. Third, opening the lanes on weekends to general traffic would compromise the trip reliability of weekend carpoolers. Finally, opening the lanes on weekends to general traffic was not consistent with the objectives of the HOV program or current signing and striping of the facilities, which includes limited access points.

CHAPTER SEVEN – CASE STUDIES

Chapter-at-a Glance

This chapter highlights case study examples related to changing vehicle-eligibility requirements, vehicle-occupancy levels, and operating hours on HOV lanes. The case studies present documented experience with expanding eligible user groups to include carpools, HOT vehicles, and low-emission and energy-efficient vehicles. The case studies also examine experiences with decreasing and increasing vehicle-occupancy levels and changing operating hours. The following case studies are presented in the chapter.

- **Changes in Vehicle-Eligibility and Vehicle-Occupancy Requirements on the I-10 West HOV Lane in Houston**. This case study highlights the changes in vehicle-eligibility and vehicle-occupancy levels on the I-10 West HOV lane in Houston, including implementation of the *QuickRide* value pricing demonstration project.
- **Changes in Vehicle-Eligibility and Vehicle-Occupancy Requirements on the El Monte Busway in Los Angeles**. This case study summarizes the changes in vehicle-eligibility and vehicle-occupancy levels on the El Monte Busway on the San Bernardino Freeway in Los Angeles. Information is presented on the experience with the change from a 3+ to a 2+ vehicle-occupancy requirement required by state legislation is 2000.
- **Expansion of the I-15 HOV Lanes in San Diego to Include HOT Vehicles**. This case study highlights allowing single-occupant vehicles to use the I-15 HOV lanes in San Diego for a fee. This case study describes the experiences with the initial ExpressPass demonstration project, which involved a monthly fee, and FasTrak^{TM}, which uses ETC and variable pricing.
- **Expansion of the I-394 HOV Lanes in Minneapolis to Include HOT Vehicles**. This case study describes the I-394 MnPASS project, which expands the use of the I-394 HOV lanes to include toll-paying single-occupant vehicles. The MnPASS project uses variable pricing.
- **Low-Emission and Energy-Efficient Vehicle Use of the HOV Lanes in Northern Virginia**. This case study summarizes the experience with allowing hybrid vehicles to use the lanes in northern Virginia without meeting the vehicle-occupancy requirement.
- **Opening HOV Lanes on the East Side of Seattle to General-Purpose Traffic in the Evenings**. This case study summarizes the experience with opening HOV lanes on the east side of Seattle to general-purpose traffic from 7:00 p.m. to 5:00 a.m.

Changes in Vehicle-Eligibility and Vehicle-Occupancy Requirements on the I-10 West HOV Lane in Houston

The I-10 West HOV lane, located on the west side of Houston, Texas, is 13 miles in length. It is a one-lane, barrier-separated, reversible HOV lane located in the freeway median. There are two major park-and-ride lots located in the corridor with direct access ramps to the HOV lane. The Addicks park-and-ride lot has 2,428 parking spaces and the Kingsland lot has 2,247 spaces. There are also three park-and-pool lots in the corridor, with between 370 and 410 spaces each. The development and operation of the I-10 West HOV lane and the supporting components represent the joint effort of TxDOT and METRO.

As highlighted in Table 7.1, the vehicle-eligibility and the vehicle-occupancy requirements on the I-10 West HOV lane have been changed a number of times since the facility opened in 1984. Some of these changes were based on initial low use of the lane due to limited vehicle-eligibility requirements, while others were due to the success of the lane, which resulted in congestion in the lane during the peak-hours.

Only buses and authorized vanpools were eligible to use the I-10 West HOV lane when it was first opened in 1984. The authorization process included insurance requirements, driver training, and vehicle inspection. The vehicle-eligibility requirement and the authorization process reflected the approach used on the I-45 North contraflow demonstration project, which was opened in 1981 as the first HOV facility in Houston.

Table 7.1. Changes in Vehicle-eligibility and Vehicle-Occupancy Requirements on the I-10 West HOV Lane.

October 1984	è	Buses and authorized vanpools
April 1985	è	Buses, authorized vanpools, and authorized 4+ carpools
September 1985	è	Buses, authorized vanpools, and authorized 3+ carpools
November 1986	è	Buses, vanpools, and 2+ carpools
October 1988	è	Buses, vanpools, and 3+ carpools in a.m. peak-hour
September 1991	è	Buses, vanpools, and 3+ carpools in a.m. and p.m. peak-hours
January 1998	è	*QuickRide* – 2 person carpools use lane during 3+ period for fee

Table 7.2 highlights the use of the I-10 West HOV lanes during the first 12 years of operation. Approximately 50 vehicles used the lane during the morning peak-hour with the bus and authorized vanpool vehicle-eligibility requirement. Due to this low level of use, the lanes were opened to authorized 4+ carpools after six months of operation.

This change added approximately 10 vehicles to the morning peak-hour volume on the lane.

The vehicle-occupancy level was lowered again after six months to authorized carpools with three or more occupants. This change added some 100 vehicles to the morning peak-hour traffic stream. In April 1986 the vehicle-occupancy level was lowered to 2+ carpools and the authorization requirement was discontinued. The morning peak-hour volumes increased to approximately 1,200 vehicles after this change.

Table 7.2. Changes in Vehicle-Occupancy Requirements and Corresponding Vehicle Volumes on the I-10 West HOV Lane.

Vehicle-Eligibility and Vehicle-Occupancy Requirements	Date (Time after Opening)	AM Peak-hour HOV Lane Vehicle Volumes			
		Carpools	Vanpools	Buses	Total
Buses and Authorized Vanpools	October 1984		66	20	86
Buses, Authorized Vanpools and Authorized 4+ Carpools	April 1985 (6 months)	3	68	25	96
Buses, Authorized Vanpools, and Authorized 3+ Carpools	September 1985 (1 year)	53	59	31	143
Buses, Vanpools, and 2+ Carpools	November 1986 (2 years)	1,195	38	32	1,265
	November 1987 (3 years)	1,453	21	37	1,511
Buses, Vanpools and 3+ Carpools[1]	October 1988 (4 years)	510	24	36	570
	March 1989 (4½ years)	660	28	40	728
	December 1989 (5 years)	611	19	37	667
	1996 (12 years)	858	19	33	910

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

Carpool volumes in the HOV lane, as well as vehicle volumes in the general-purpose freeway lanes, increased over the next year, partly due to the economic recovery occurring in the Houston area. During this time, morning peak-hour vehicle volumes on the I-10 West HOV lane were regularly reaching or exceeding 1,500. The congestion resulting from these volumes, coupled with the design of the facility, reduced the travel time savings and travel time reliability bus riders, carpoolers, and vanpoolers had come to expect. In response to lower travel speeds in the HOV lane and complaints from bus passengers, the vehicle-occupancy requirement was increased in October 1988 from 2+ to 3+ during the period from 6:45 to 8:15 a.m. The 2+ occupancy requirement was maintained at other operating times.

The morning peak-hour vehicle volume dropped from approximately 1,400 to 510 after the change. This decline represented a 64 percent reduction in vehicle volumes. A corresponding drop of 33 percent in person volume also occurred. Use levels during the morning peak-hour increased to 660 vehicles in March of 1989. Although the vehicle and passenger volumes declined during the morning peak-hour, the AVO increased. The AVO was 3.1 prior to the change, 4.7 in March 1989, and 4.5 in December 1989.

Total vehicle volumes in the morning peak period declined from some 8,780 before the change to 7,523 in December of 1989. This change represents a 14 percent decline. Two person carpools declined by some 41 percent, while 3+ carpools increased by 68 percent. Bus ridership increased by 8 percent and vanpool passengers increased by two percent. Survey results and enforcement data indicate that some 2+ carpools shifted to earlier time periods, entering the HOV lane before the start of the 3+ requirement. Survey results further indicated that some 2+ carpools changed their travel routes to use the newly opened US 290 HOV lane, which had a 2+ requirement.

Further modifications have been made in the vehicle-occupancy requirements on the I-10 West HOV lane. In May 1990, the 3+ restricted period was changed slightly to 6:45 - 8:00 a.m. In September 1991, the 3+ requirement was implemented from 5:00 to 6:00 p.m. By 1996, morning peak-hour carpool volumes had increased to approximately 858 vehicles.

In the late 1990s, METRO and TxDOT staff began considering the potential of allowing two-person carpools to use the I-10 West HOV lane during the 3+ restricted period for a fee, reflecting the ongoing interest in maximizing use of the lane to benefit travelers. This approach was viewed as a way to increase use of the HOV lane without allowing it to become overly congested as it was in 1988 when the vehicle-occupancy requirement was raised to 3+. A feasibility study was conducted to explore the potential of a value pricing demonstration project on the I-10 West HOV lane.

A number of elements were examined during the feasibility study. These included assessing the available capacity and the potential demand at different pricing levels, legal and institutional issues, and public reactions. A variety of potential operational strategies were explored, including manual and automated payment techniques. The ability to charge for use of the HOV lane, the ability to enforce fines and penalties associated with not paying a toll, and other policy changes needed to implement a demonstration were explored.

The assessment indicated that METRO had the authority to charge for use of the HOV lane under specific conditions, that fines were enforceable with minor modifications, and that there were no critical policies prohibiting a demonstration. The study estimated that approximately 600 additional vehicles could be accommodated in the lane during the peak-hour while maintaining free flow operations.

Two focus groups were conducted as part of the assessment. One focus group was comprised of commuters who used the I-10 West Freeway and the other was composed of residents throughout Houston. The focus group participants were somewhat skeptical about the pricing concept. Both groups were also interested in how the revenue from the demonstration would be spent.

Based on the feasibility study, the decision was made to implement a demonstration project to test allowing two-person carpools to use the HOV lane for a $2.00 per trip fee during the 3+ occupancy requirement periods – 6:45 a.m. to 8:00 a.m. and 5:00 p.m. to 6:00 p.m. The demonstration, called *QuickRide*, which uses the automatic vehicle identification (AVI) system for electronic toll collection (ETC), was implemented at the end of January 1998. Individuals are required to register for the program and must have an active electronic tag account. By June 1998, 468 *QuickRide* electronic tags had been issued. In 2000, the demonstration was expanded to include the US 290 HOV lanes, only in the morning peak-hour. As of April 2003, there were 1,476 active *QuickRide* accounts.

Daily *QuickRide* use has grown slightly over time. In 1998, an average of 103 daily *QuickRide* participants used the I-10 West HOV lanes. By 1999, some 121 participants were using the program daily. Use levels from 2000 through 2005 remained relatively constant, averaging between 120 and 128 vehicles during the 3+ restricted peak-hour. Use levels are higher in the morning on the I-10 West HOV lanes, with some 68 percent of the daily participants traveling in the lane in the morning peak-hour.

Analysis of initial use levels indicated that each enrolled tag generated an average of one tolled trip every four days, producing an average of 115 to 120 total two-person carpool trips during the 1-1/4 morning hours plus the one evening hour. Approximately 6 percent of enrolled tags produced five or more trips per week. Approximately 25 percent of the tags had never been used as of June 1998. Many of these may belong to two-tag households.

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

Changes in Vehicle-Eligibility and Vehicle-Occupancy Requirements on the El Monte Busway in Los Angeles

This case study describes the changes in vehicle-eligibility requirements and vehicle-occupancy requirements on the El Monte Busway, San Bernardino Freeway (I-10) in Los Angeles, California. The case study highlights the impact of allowing carpools and vanpools to use an HOV lane initially opened to buses-only and lowering the vehicle-occupancy requirement from 3+ to 2+ based on state legislation.

The El Monte Busway on the San Bernardino Freeway is located in eastern Los Angeles County, stretching from El Monte to downtown Los Angeles. The Busway was opened in 1973 and 1974, making it one of the earliest HOV facilities in the country. A one-mile extension into the downtown area was opened in 1989, providing a link to the Los Angeles Union Railroad Station.

The two-way HOV facility includes two design treatments. From El Monte to I-710, the Busway is located in the center of the I-10 Freeway, separated from the general-purpose lanes by a 10.5-foot painted striped buffer. From I-710 to downtown Los Angeles, the Busway is located adjacent to, but separated from, the I-10 Freeway.

Three bus stations are located along the Transitway at El Monte, the California State University at Los Angeles (University Station), and the Los Angeles County University of Southern California Medial Center (Hospital Station). A direct HOV connector access ramp is located at Del Mar Avenue and a direct connector for buses is provided at the El Monte Bus Station. A total of 15 park-and-ride lots in the corridor are oriented toward the Busway, providing some 5,100 parking spaces to travelers. The El Monte Station park-and-ride is the largest, containing 2,100 spaces. Additional lots serve the Metrolink rail system, which also operates in the corridor.

The construction, financing, and operation of the Busway has been guided by a 1971 agreement and a series of amendments between the Southern California Rapid Transit District (SCRTD), now known as the Los Angeles County Metropolitan Transportation Authority (MTA), and the State of California Department of Public Works, now Caltrans. The state was responsible for designing, constructing, operating, and maintaining the Busway, and the District was responsible for designing, constructing, operating, and maintaining the bus stations and other bus elements of the projects. A number of federal, state, and local sources were used to fund the various elements of the project. Caltrans continues to be responsible for operating and maintaining the Busway and the freeway.

Table 7.3 highlights the major milestones in the history of the project. The 1971 agreement established a five-year experimental period. During phase one of the experimental period, which was to last two years, the Busway was to be reserved exclusively for buses, unless otherwise agreed to by both parties. The second phase, which encompassed the remaining three years, was to include at least one year with mixed bus and carpool use. The agreement also stated that if SCRTD was unable to conduct its operations for any reason, such as substantial service curtailment due to labor disputes, the state could elect to permit other vehicles to use the Busway.

The facility was opened to buses in January 1973. Operating hours were weekdays from 6:00 a.m. to 10:00 a.m. and from 3:00 p.m. to 7:00 p.m. Three-person carpools and vanpools were allowed to use the Busway in August 1974 in response to an SCRTD bus operators strike. Bus-only operations were resumed in October 1974 when the strike was settled.

Amendments to the agreement were signed in 1976 and 1981. The 1976 amendment formally opened the Busway to mixed-mode operation, allowing 3+ carpools during the morning and afternoon weekday peak periods. The amendment also requires the metering of carpools at ingress points if bus travel times are degraded due to high volumes of carpools. The peak-period operating hours were extended to weekends in 1977. The 1981 amendment extended the hours of operation for buses and carpools to 24 hours a day, seven days a week (24/7). It also established a critical value for determining if the Busway is becoming too congested and identified possible actions that may be taken to alleviate these conditions.

Table 7.3. Changes in Vehicle-Eligibility, Vehicle-Occupancy Levels, and Operating Hours – El Monte Busway.

January 1973	è	Partial opening of Busway. Operating hours 6:00 a.m. to 10:00 a.m. and 3:00 p.m. to 7:00 p.m.**,** Monday-Friday
June 1974	è	Opening of final 3.5 miles.
August 1974	è	SCRTD bus operators strike – 3+ carpools allowed on Busway.
October 1974	è	Strike settled – 3+ carpool use discontinued.
October 1976	è	Mixed-mode operation – 3+ carpools allowed on Busway.
1977	è	Operating hours extended to weekends (6:00 a.m. to 10:00 a.m. and 3:00 p.m. to 7:00 p.m.).
1981	è	Operating hours extended to 24 hours a day, 7 days a week (24/7).
1989	è	One-mile extension into downtown Los Angeles opened.
January 2000	è	Vehicle-occupancy requirements lowered to 2+ full time as required by California Senate Bill 63.
July 2000	è	Vehicle-occupancy requirement raised to 3+ during morning and afternoon peak periods and 2+ at all other times as required by California Assembly Bill 769.

The initial agreement outlined a data collection, monitoring, and evaluation program to be conducted during the five-year demonstration. These activities were completed and a series of reports were prepared documenting the various stages of the project, with the final report covering the mixed-mode operations. None of the agreements address the potential need to lower the vehicle-occupancy requirement from 3+ if the facility is not utilized. The initial agreement provided that if at the conclusion of the test period it was determined that the bus/carpool operation should cease, the facility would revert to general highway use, with preferential treatment, to the extent justified, always provided to buses.

As noted previously, the El Monte Busway was the first freeway HOV facility in the Los Angeles area. The 3+ vehicle-occupancy requirement used on the Busway reflects both federal guidance and the state-of-the-practice during the 1970s and early 1980s. Starting in the mid-to-late 1990s, HOV lanes were added to a number of freeways in the area as part of Caltrans' efforts to address congestion and mobility in the region. Reflecting new federal guidance and current trends in carpooling, a 2+ vehicle-occupancy requirement was used with these facilities. With one exception, State Route (SR) 14, these lanes operate with a 2+ requirement on a 24/7 basis. SR 14 uses a 2+ requirement and operates only during the morning and afternoon peak periods as a demonstration project.

Use of the El Monte Busway has grown over time. Tracking this growth is somewhat difficult due to the different time periods used over the years to collect and present vehicle and passenger volumes. Table 7.4 highlights morning peak-hour use levels from points over the 30-year life of the facility. Peak-hour use of the lane has increased over the life of the facility, as has total daily use.

Table 7.4. Morning Peak-hour Utilization of the El Monte Busway.

Year	Bus	Passengers	Carpools/ Vanpools	Passengers	Total Vehicles	Total Passengers
1973 (May)[1]	21	766	–	–	21	766
1973 (Oct)[1]	67	1,526	–	–	67	1,526
1976	64	3,044	–	–	64	3,044
1988	70	3,190	765	2,610	835	5,800
1990	71	2,750	1,374	4,352	1,445	7,102
2000	84	2,980	944	2,887	1,028	5,867

[1]Estimates based on two-hour peak-period figures.

The number of buses using the lane and ridership levels increased significantly during the first three years of operation. From 1973 to 1976, the number of buses using the lane in the morning peak-hour, peak-direction of travel increased from 21 to 64, with a corresponding increase in passengers from 766 to 3,044. Daily bus ridership levels increased from 1,000 to 14,500 passengers during the three-year bus-only operations phase from 1973 to 1976. Allowing 3+ carpools on the facility in October 1976 did not cause a noticeable change in bus ridership levels. Overall daily utilization levels increased from approximately 14,420 bus riders, carpoolers, and vanpoolers in October 1976 to 20,440 in April 1978.

Use of the Busway continued to grow during the 1980s and 1990s, with peak-hour volumes averaging between 835 to 1,500 vehicles and 5,800 to 7,100 passengers. Bus ridership and carpooling over the two decades was influenced by a variety of factors including the status of the local economy, the oil crisis and the Arab oil embargo, the cost of gasoline and parking, and changes in employment locations and levels.

As with all freeways in the Los Angeles area, traffic volumes on I-10 are very heavy, especially during the peak-periods. The I-10 general-purpose freeway lanes are congested during the morning and afternoon peak periods. Volumes of 1,600 to 1,700 vehicles per lane and travel speeds of 20 to 25 mph were typically experienced on the freeway in the late 1990s and early 2000s. These conditions reflect a facility operating in a saturated condition.

In addition to monitoring general conditions on the HOV lanes on an annual basis, Caltrans has conducted periodic studies on different issues related to the operation of the El Monte Busway, HOV lanes in the Los Angeles area, and HOV facilities throughout the state. In 1999 Caltrans District 7 examined the feasibility and effectiveness of opening HOV lanes to general traffic on weekends and holidays. The study recommended maintaining the current 24/7 HOV designation for the following reasons:

- the HOV lanes are currently being utilized effectively on weekends,
- opening the HOV lanes to general traffic would provide only minor improvements to overall traffic conditions,
- opening the lanes on weekends to general traffic would compromise the trip reliability of weekend carpoolers, and
- opening the lanes on weekends to general traffic is not consistent with the objectives of the HOV program or current signing and striping of the facilities.

Caltrans and the MTA also examined the potential effects of opening the El Monte Busway to 2+ carpools. The analysis conducted by Caltrans in 1996 and by the MTA in 1999 concluded that allowing 2+ carpools would result in congestion on the Busway and disruption of bus travel time and trip reliability.

In 1999, the California legislature approved Senate Bill (SB) 63 lowering the vehicle-occupancy requirement on the Busway to 2+ persons. Caltrans District 7 was responsible for implementing the 2+ occupancy requirement change directed in SB 63 and for monitoring the effects of the legislation. Caltrans established the SB 63 Implementation Committee, comprised of representatives from appropriate agencies, to help support and coordinate the change. The Implementation Committee was comprised of representatives from the following agencies and Caltrans divisions:

- Caltrans Headquarters;
- Caltrans District 7 Maintenance, Signs & Delineation, and HOV Operations;
- Caltrans District 7 Traffic Investigations;
- Caltrans District 7 Traffic Management;
- Caltrans District 7 HOV Operations;
- Caltrans District 7 Public Affairs;
- Los Angeles Metropolitan Transportation Authority;
- Southern California Association of Governments;
- Foothill Transit;
- California Highway Patrol;
- Toll Operators; and
- Federal Highway Administration.

The SB 63 Implementation Committee met on a regular basis to help coordinate implementation, operation, and monitoring of the vehicle-occupancy requirement change. The responsibilities and activities of the various agencies and departments were identified and documented during initial meetings. Representatives from the various agencies assisted with monitoring different aspects of the demonstration. The committee also helped coordinate the change back to the 3+ peak-period operation based on Assembly Bill (AB) 769.

Caltrans monitored the affects of SB 63 on the operation of the Busway and the freeway. The results of the monitoring effort were summarized in regularly issued fact sheets and presented in an Executive Summary. The Caltrans monitoring effort focused primarily on vehicle volumes, person movement, travel speeds, and occupancy violation rates. A separate traffic safety analysis was also conducted by Caltrans. Foothill Transit monitored the affects of the 2+ demonstration on bus operating speeds, bus travel-times, on-time performance, service overtime, safety incidents, and customer complaints.

Prior to completion of the AB 769 demonstration project, Caltrans representatives met with the Implementation Committee to discuss ongoing operations of the El Monte Busway. Based on input from all stakeholders, an operational report and request was submitted to FHWA for consideration since the 3+ peak/2+ off-peak operation was identified as a significant change from the original operation of the Busway. FHWA approval was granted and the permanent dual 3+/2+ occupancy requirement continues in use today.

The Caltrans assessment covered the morning and afternoon peak periods, from 6:30 a.m. to 9:30 a.m. and from 3:00 p.m. to 7:00 p.m. In general, the morning peak-hour is 6:45 a.m. to 7:45 a.m. and the afternoon peak-hour is 4:30 p.m. to 5:30 p.m. Further, the analysis focused on the peak direction of travel during these time periods – westbound into downtown Los Angeles in the morning and eastbound out of the downtown area in the afternoon. Data collection efforts were conducted on the peak periods, although some information, such as bus volumes is based on the peak-hour. Off-peak conditions were not examined as traffic in the Busway and the general-purpose lanes usually reflect freeflow or relatively free flowing conditions.

Traffic conditions in the morning and afternoon peak periods are generally similar, with some variations. Slightly higher volumes are experienced in Busway in the morning peak period than in the afternoon peak period. The freeway general-purpose lanes experience the opposite trend, with vehicle volumes slighter higher in the afternoon peak periods. Information on the impact of the 2+ vehicle-occupancy requirement on travel speeds, vehicle volumes and persons per hour per lane (pphpl), bus operations, violation rates, safety incidents, crashes, and public reaction is presented next.

Travel Speeds. Peak-hour travel speeds in the Busway were negatively affected during the 2+ demonstration, declining from freeflow conditions at 65 mph to approximately 20 mph in the morning westbound direction. In the afternoon eastbound direction, travel speeds on the Busway decreased from 65 mph to 27 mph during the first month of the demonstration and then increased to 40 mph for the duration of the test.

A significant corresponding increase in travel speeds did not occur in the general-purpose lanes. Travel speeds in the general-purpose freeway lanes averaged 25 mph in the morning westbound peak-hour and 32 mph in the afternoon eastbound peak-hour before the demonstration. Travel speeds in the morning westbound direction increased to 37 mph on the general-purpose freeway lanes during the first month of the 2+ demonstration, but decreased to 23 mph for the remainder of the operation. In the afternoon, eastbound peak-hour general-purpose freeway lane travel speeds increased to 40 mph during the demonstration.

Travel speeds on both the Busway and the general-purpose freeway lanes returned to near pre-demonstration levels with the implementation of emergency legislation, AB 769, and the return to the 3+ occupancy requirement during weekday peak-periods. Travel speeds on the Busway increased to 45 mph in the morning and 55 mph in the afternoon peak-hours. Although lower than the pre-demonstration 65 mph, both of these speeds represent generally freeflow conditions. Travel speeds in the general-purpose freeway lanes were slightly lower than the pre-demonstration speeds at 20 mph and 28 mph for the morning and afternoon peak-hours, respectively. Travel speed data from the MTA HOV Performance Monitoring Program recorded approximately a month after the implementation of AB 769 indicated slightly higher peak-hour speeds in both the HOV and the freeway lanes.

Vehicle Volume and Persons per Hour per Lane. Examining changes in hourly volumes and changes in pphpl is important, as vehicle volumes may increase as the result of a change in the vehicle-occupancy requirement, but the total number of people being carried may decline or may increase at a much lower rate.

The number of vehicles on the Busway in the morning peak-hour increased from 1,100 to 1,600 during the 2+ demonstration, but the number of persons carried declined from 5,900 to 5,200. Thus, more vehicles carrying fewer people were on the Busway. Trends in the afternoon peak-period were different with hourly vehicle volumes increasing from 990 to 1,500 and person volumes increasing from 5,100 to 5,600.

Vehicle volumes in the general-purpose freeway lanes increased slightly or remained relatively constant over the three time periods, as did the number of pphpl. Thus, lowering the vehicle-occupancy rate on the Busway, and the subsequent increase in 2+ carpools, did not have a corresponding affect of lowering vehicle volumes in the general-purpose freeway lanes. The increase in vehicles may have resulted from latent demand in the corridor, with commuters diverting from other routes.

In the morning peak period, total vehicle volumes increased by 15 percent with the change to the 2+ operating requirement, but total person volumes increased by less than 1 percent. Similar trends were experienced in the afternoon peak-hours, with total vehicle volumes increasing by 9 percent and total person volumes increasing by less than 1 percent.

Bus Operating Speeds, Bus Travel-Times, and On-Time Performance. Prior to the enactment of SB 63, approximately 80 buses operated on the Busway during the morning peak-hour. This figure is one of the highest hourly bus volumes on exclusive or concurrent flow HOV facilities in the country.

Foothill Transit operates the majority of buses on the Busway, with the Metropolitan Transportation Authority (MTA) providing some service. Both express routes and local/express routes operate on the Busway. Overall, Foothill Transit buses make 500 trips per day on the Busway carrying some 18,000 passengers.

Foothill Transit monitored the effect of the change in the vehicle-occupancy requirement on its operations. Information regarding bus on-time performance, service overtime and operating costs, safety incidents, and customer complaints was collected over the course of the demonstration. Periodic fact sheets were published highlighting this information and a video was produced documenting some of the effects.

Lowering the vehicle-occupancy requirement to 2+ had a significant effect on bus operations. The increase in the number of two-person carpools, which caused congestion on the Busway, resulted in lower bus operating speeds, longer bus travel times and reduced on-time performance. The change also resulted in increases in service overtime and operating costs, increases in safety incidents, and increases in customer complaints.

Bus operating speeds slowed during the 2+ demonstration affecting overall bus travel times and on-time performance. Historically, buses operating on the Busway experienced freeflow speeds, averaging 65 mph prior to the 2+ demonstration. As noted previously, during the 2+ period, travel speeds for all vehicles in the Busway declined to 20 mph in the westbound direction during the morning peak period. In the afternoon peak-period travel speeds in the eastbound direction initially decreased to 27 mph and then stabilized at around 40 mph.

The slower operating speeds resulted in longer bus travel times and reduced on-time performance. Bus travel times from the eastern end of the Busway into downtown Los Angeles were 20 to 30 minutes longer during the morning peak-period. Schedule adherence and on-time performance dropped from an average of 88 percent in the fall of 1999 to 48 percent in May 2000. The consistent 20-minute travel time savings provided to bus passengers over vehicles in the general-purpose lanes was lost during the 2+ demonstration.

Service Overtime and Operating Costs. The slower bus operating speeds, longer travel times, and reduced on-time performance also caused declines in service productivity. Bus operators finishing their runs late were frequently not able to return for a second trip in the corridor. To fill these voids and to maintain schedules, extra buses and operators had to be dispatched when available.

At some points during the demonstration, as many as 10 extra buses and operators were staged in the downtown area to help ensure that trips were not missed and schedules were maintained. Foothill Transit estimated that the personnel and fuel costs associated with providing these extra buses were approximately $1,250 per weekday. Over the course of the demonstration, Foothill Transit allocated close to $150,000 for the extra buses and operators. If the 2+ requirement had been continued, the annual cost of providing the additional buses would have been approximately $325,000.

Violation Rates. The changes in vehicle-occupancy levels significantly affected the violation rates on the Busway. The violation rates declined during the 2+ demonstration, as 2+ person carpools which would previously have been cited became authorized users. Field observations, reports from Foothill Transit operators, and interviews with CHP officers indicated that the number of buffer violations increased significantly during the 2+ demonstration. In most cases, these violations were due to carpools exiting the Busway illegally to avoid the congestion and slow travel speeds in the lane.

The violation rates increased significantly during the early phase of the 3+/2+ operations. Extra enforcement and enforcement that is more visible was not provided during the initial 3+/2+ operation. As a result, it appears that many 2+ carpools continued to use the lane during the 3+ peak-period. In response to concerns over these high violation rates, CHP undertook an aggressive enforcement program in January 2001. Elements of the program including briefings for all CHP shifts, press releases and radio broadcasts highlighting the correct occupancy requirements and announcing increased enforcement of the rules, and four weeks of enforcement saturation with extra offices assigned to the Busway. These efforts resulted in the violation rates returning to levels similar to those before the 2+ demonstration.

Safety Incidents. Foothill Transit operators record safety incidents as part of their daily reporting. During 1999 an average of 13 safety incidents a day were reported by operators on the El Monte Busway. During the 2+ demonstration the number of recorded safety incidents increased substantially. For example, on January 27, 140 safety incidents were reported by Foothill Transit operators.

The most frequently cited problems were rapid deceleration of cars in front of buses, cars illegally crossing the double-lines, and improper merging of cars into and out of the Busway. Approximately 60 percent of the incidents occurred in the buffer separated section of the Busway. Although these incidents are not crashes, they represent the potential degradation of safety along the Busway.

Crash Data. The Caltrans District 7 Office of Freeway Operations in the Division of Operations conducted a safety study of the effects of SB 63 and AB 769 on the El Monte Busway. The study examined accident records six months before the 2+ vehicle-occupancy requirement became operational (July 1, 1999 to December 31, 1999); six months when the 2+ vehicle-occupancy requirement was in effect (January 1, 2000 to July 24, 2000); and 12 months when the 3+ peak-period and 2+ off-peak vehicle-occupancy requirement was in effect (July 25, 2000 to June 30, 2001).

In addition, the Busway was divided into two sections for the safety assessment to coincide with the different geometrics. The first segment included the section from Alameda Street to Route 710, which is physically separated from the freeway main lanes. The second section included the segment from the Route

710 interchange to the eastern terminus at Baldwin Avenue. The HOV lanes are separated from the general-purpose lanes by a painted buffer in this segment.

Data from the Caltrans District 7 Traffic Accident Surveillance and Analysis System (TASAS) were examined for each segment for the three time periods. Fatal accidents (FAT), fatal plus injury accidents (FAT +1), and total accidents were examined, along with the average or expected rates.

The overall result from the assessment was that no definite conclusion could be drawn indicating there were significant differences in crash rates or crash types during the three study periods. No crashes were recorded in the Busway during the six months prior to the enactment of SB 63. Five crashes were recorded in the HOV lane during the six months at the 2+ vehicle-occupancy requirement and eight crashes were recorded during the 12 months of 3+ peak/2+ off-peak operations. The number of crashes increased from the 3+ operations, but the differences are not statistically significant. There were also no apparent significant differences in the number of crashes by Busway section during these time periods. The accident rates for all three periods were lower than the average or expected rate.

Although the total number of crashes in the general-purpose freeway lanes increased during the 2+ and the 3+/2+ operating periods, these differences were not found to be significant. A significant difference was found in the number of crashes in the two study sections across all three time periods, with more crashes occurring in Section II. This section is longer than Section I and the entire segment experiences higher levels of congestion, while recurrent congestion is experienced in only limited parts of Section I.

Rear-end and side-swipe accidents, which are normally associated with congested conditions, accounted for some 80 percent of the recorded accidents in Section II, compared to 70 percent in Section I. The accident rates from fatal and fatal plus injury crashes on the general-purpose freeway lanes over all time periods are lower or close to the average expected rates. The total rates, however, are higher than average across all three time periods for the study sections, with the exception of eastbound Section I, which are lower. This trend was attributed to the high levels of congestion, especially in Section II.

Public Response. Caltrans, Foothill Transit, the MTA, and other agencies received letters, telephone calls, faxes, and E-mails related to the change to the 2+ occupancy level required by SB 63. The overwhelming majority of the correspondence and calls were critical of the change, with individuals complaining about the negative effects it had on their travel. Caltrans and Foothill Transit received the largest number of complaints. Although no total official log was maintained, it appears that at least 1,000 comments were received by the various agencies. Foothill Transit alone received almost 900 complaints from passengers.

Bus passengers were the most vocal group responding to the effects of the 2+ demonstration. Bus Riders noted 20- to 30-minute longer travel times with the 2+ requirement. Passengers reported missing connections to other buses and rail service, and being late for work, school, and daycare pick-ups. Riders reported having to adjust their schedules to leave earlier in the morning and to make arrangements in the afternoon for children and other responsibilities.

Individuals in existing 3+ carpools reported longer travel times and delays. These individuals indicated they had to adjust their schedules to leave earlier in the morning to arrive at work on time. Bus riders, individuals in 3+ carpools and vanpools, as well as others complained that the incentive for using these modes and the Busway was gone. Many of the individuals suggested the 2+ operations represented a step backward and was detrimental to achieving environmental, air quality, and energy goals.

It does not appear that motorists in the general-purpose freeway lanes were vocal in support of the 2+ demonstration. This lack of interest may be logical given the fact that the change to the 2+ requirement did not noticeably improve travel conditions in the freeway lanes.

Articles in the Los Angeles Times and the San Gabriel Tribune described the effects of the 2+ occupancy requirement on the Busway and the change back to a 3+ requirement during weekday peak periods. During the demonstration, media coverage focused on the increased congestion levels in the Busway, the decline in travel speeds, and the increase in trip times

Expansion of the I-15 HOV Lanes in San Diego to Include HOT Vehicles

The two-lane exclusive HOV facility on I-15 was opened in 1988 with a 2+ vehicle-occupancy requirement. The I-15 HOV lane is located on the northeast side of San Diego, California, and is approximately eight miles in length. There is one entrance and one exit. The lanes were open in the southbound direction from 6:00 to 9:00 a.m. and in the northbound direction from 3:00 to 6:30 p.m. and were closed at other times.

In 1996, approximately 1,800 vehicles were using the HOV lanes during the morning peak-hour, and the lanes were operating at a level-of-service C. During the same period, the adjacent four freeway lanes were carrying 12,000 vehicles, operating at a level-of-service F.

Interest in considering pricing on the HOV lanes emerged during the examination of potential transportation control measures in the regional air quality plan. The pricing approach was supported by the mayor of a suburban community in the corridor. This individual was elected to the State Assembly and sponsored the enabling legislation needed for the project.

The I-15 Freeway HOV Pricing project was one of the congesting pricing demonstrations funded as a result of the ISTEA of 1991. The project included two phases to test allowing single-occupant vehicles to use the I-15 HOV lanes for a fee. Table 7.5 highlights the different operating periods. The objectives of the demonstration included testing value pricing as a method of managing congestion on the freeways lanes, managing demand on the HOV lanes, expanding transit and ridesharing services in the corridor, and enhancing air quality in the region.

Table 7.5. Changes in Vehicle-Eligibility and Vehicle-Occupancy Requirements – I-15 HOV Lanes.

1988	è	Opening with 2+ requirement.
1996	è	*ExpressPass* –Single-occupant vehicles pay monthly fee.
1998	è	FasTrack™ – Single-occupancy vehicle use based on variable pricing.

The initial demonstration project and the ongoing HOT project represent the joint efforts of SANDAG, Caltrans, MTDB, and CHP. SANDAG is responsible for overall project management, Caltrans operates the HOV lanes, MTDB operates bus service in the corridor, and CHP is responsible for enforcement.

The initial demonstration project, *ExpressPass*, began in 1996. During this phase a limited number of monthly permits were sold to motorists on a first-come, first-serve basis. Drivers with permits could use the lanes without meeting vehicle-occupancy requirement, while carpools, vanpools, and buses continued to use the lanes for free. The monthly fee was first set at $50 in December 1996 and 500 permits were sold. In 1997, 700 permits were issued and the fee increased to $70. A permit waiting list of between 200 and 600 individuals existed over the course of this phase.

In April 1989, the FasTrak™ phase was implemented with electronic toll collection replacing the monthly passes. Variable fees for single-occupancy vehicle use of the HOV lanes are collected electronically. The fee depends on the congestion level in the HOV lanes and is recalculated each six minutes to maintain a level-of-service C. Fees typically range from $0.50 to $4.00 according to the time-of-day relative to traffic peaks, although the fee could reach as high as $8.00. Message signs located before the start of the lanes display the updated fee.

During the first month of *ExpressPass* phase, a 12 percent increase in traffic throughput occurred. Most of this increase was the result of new carpools rather than single-occupant vehicles. Before the demonstration, weekday traffic counts included 7,900 HOVs, accounting for 85 percent of the vehicles, and 1,400 single-occupant vehicle violators, accounting for 15 percent. Weekday traffic counts during the initial months of the *ExpressPass* phase included 9,300 HOVs, accounting for 80 percent of the vehicles, 1,025 *ExpressPass* users, accounting for 10 percent, and 200 single-occupant vehicle violators, accounting for 2 percent of the vehicles.

As of March 2005, there were approximately 18,670 active FasTrak™ accounts and some 27,700 transponders in use. In 2004 and 2005, the daily weekday average traffic using the I-15 HOV lanes ranged from a high of 22,341 in March 2004 to a low of 19,401 in February 2005. Over this time period HOVs accounted for approximately 75 percent to 78 percent of the total vehicle volumes. FasTrak™ users accounted for most of the remaining 22 percent to 25 percent, although there were a small percentage of invalid reads of toll tags and FasTrak™ violators. Approximately 80 citations and 14 verbal warnings are issued each month by CHP. Annual revenue generated from FasTrak™ users is approximately $1.2 million.

The revenue has been used to support operations of the system and to expand public transportation services in the corridor. The Inland Breeze bus service provides express trips into downtown San Diego and reverse commute trips to suburban destinations in the corridor.

Expansion of the I-394 HOV Lanes in Minneapolis to Include HOT Vehicles

Table 7.6 highlights the major milestones in the development and operation of the HOV lanes on I-394 in Minneapolis, Minnesota. An interim HOV lane, called the Sane Lane, was implemented in 1985 to help manage traffic during construction of I-394, which was built on the alignment of TH 12, and to introduce the HOV concept to travelers in the corridor. The complete facility was opened in 1992.

The I-394 HOV lanes are approximately 11 miles in length. There are two different sections of HOV lanes. A three-mile, two-lane, barrier-separated reversible section in located directly to the west of downtown Minneapolis. To the west of this section are seven miles of concurrent flow HOV lanes. There are two general-purpose lanes in each direction throughout the 11-mile segment of I-394. The reversible section connects to the A, B, C parking garages in downtown Minneapolis, which include an intermodal transfer facility, reduced parking for carpoolers, and links to the downtown skyway system. The lanes are operated by the Minnesota Department of Transportation (Mn/DOT) in coordination with Metro Transit, the Minnesota State Patrol, and local communities.

Initial operation of the HOV lanes varied by segment. The concurrent flow HOV lanes operated only in the peak-hours in the peak-direction of travel. The operating hours for the concurrent flow lanes were 6:00 a.m. to 9:00 a.m. in the eastbound direction and 4:00 p.m. to 7:00 p.m. in the westbound direction, Monday through Friday. The lanes were open to all traffic at other times. The operating hours on the two-lane reversible section were 6:00 a.m. to 10:00 a.m. eastbound and 2:00 p.m. to 7:00 p.m. westbound, Monday through Friday. The reversible lanes were closed at other times, with the exception of some weekends and evenings when the lanes were open to accommodate traffic for sporting and special events at facilities in downtown Minneapolis.

Interest in considering allowing single-occupant vehicles to use the HOV facilities emerged during the late 1990s and early 2000s. In 2003, state legislation was approved allowing a HOT project on the I-395 HOV lanes. A I-394 Express Lane Community Task Force was formed to help oversee the project. The Task Force includes 22 individuals appointed by the Governor, the Lieutenant Governor, and communities in the corridor.

Table 7.6. Changes in Vehicle-Eligibility and Vehicle-Occupancy Requirements – I-394 HOV Lanes.

1985	è	Interim HOV lanes open during construction of I-394.
1992	è	Complete. HOV lanes and freeway in operation. HOV operating hours – concurrent flow lanes 6:00 a.m. to 9:00 a.m. eastbound and 4:00 p.m. to 7:00 p.m. westbound, open to all traffic at other times. Two-lane reversible segment – 6:00 a.m. to 10:00 a.m. eastbound and 2:00 p.m. to 7:00 p.m. westbound, closed at all other times.
May 2005	è	MnPASS HOT project implemented – variable pricing operating hours – 24/7 on concurrent flow HOV lanes and eastbound 6:00 a.m. to 1:00 p.m. and westbound 2:00 p.m. to 5:00 a.m. on two-lane reversible.
August 2005	è	MnPASS operating hours changed on the concurrent flow section to 6:00 a.m. to 10:00 a.m. eastbound and 2:00 p.m. to 7:00 p.m. westbound, open to all traffic at other times.

The Task Force recommended implementing an HOT project, called MnPASS. The MnPASS project has a number of objectives. The first objective is to improve the efficiency of I-394 by increasing the person and the vehicle-carrying capabilities of the HOV lanes. The second objective is to maintain freeflow speeds for transit and carpools in the HOV lanes. The third objective is to improve highway and transit in corridor with the revenues generated from the project. The fourth objective is to deploy electronic toll collection, including tags, transponders, and readers to maintain travel speeds. The final objective is to employ new intelligent transportation system (ITS) technologies to facilitate dynamic pricing and in-vehicle electronic enforcement.

The MnPASS project was implemented in May 2005. Dynamic pricing is used on the project, with tolls based on the level of congestion in the HOV lane. The base toll is $0.25 and the maximum toll is $8.00. The project represents the first use of tolling in the Minneapolis-St. Paul metropolitan area and in Minnesota.

MnPASS represents the first HOT project on concurrent flow HOV lanes. The previous unlimited access to the I-394 concurrent flow HOV lanes was changed to limited access points as part of the project. There are five eastbound and six westbound access points in the concurrent flow lane section. The MnPASS tags are read electronically as vehicles enter the lanes at these locations and the occupancy requirement is visually checked by enforcement personnel.

Increased enforcement has been provided through partnerships with the Minnesota State Patrol, the Metro Transit Police, and the local county police departments. Violating the MnPASS HOV lanes is classified as a petty misdemeanor with $130 fine.

The revenues for MnPASS are being used first to pay for the project infrastructure, administration, maintenance, and operations. By state law, any additional revenue must be split 50 percent for transit improvements and 50 percent for corridor improvements. All improvements must be in the I-394 area.

The initial hours of operation were 24/7 on the seven-mile concurrent flow HOV lanes and eastbound from 6:00 a.m. to 1:00 p.m. and westbound from 2:00 p.m. to 5:00 a.m. on the three-mile two-lane reversible section. These operating hours represented a significant change from those used since the I-394 HOV lanes opened in 1992.

Thus, the implementation of the MnPASS program represented a change from a primarily peak-hours, peak-direction HOV operation to a 24/7 HOV/HOT operation in both directions on the concurrent flow lanes. This change had a significant impact on traffic congestion in the morning westbound direction of travel. The response from commuters in the corridor to this situation was very negative. The Minnesota Senate passed a resolution supporting rescinding the off-peak tolls and other policy makers voiced support for a change.

In response to these concerns, Mn/DOT made some initial changes in the operating hours. In August, the operating hours were further reduced to 6:00 a.m. to 10:00 a.m. in the eastbound direction and 2:00 p.m. to 7:00 p.m. in the westbound direction. These hours are the same operational hours used with the concurrent flow HOV lanes from 1992 to 2005. The hours on the two-lane reversible section were not changed as the extended hours on the two-lane reversible section did not impact traffic in the general-purpose lanes, since the HOV lanes had been closed during these periods prior to the MnPASS program.

Numerous methods were used to communicate with travelers in the corridor and with the public about the MnPASS project. Information on how to purchase toll transponders and how to use the MnPASS lanes was provided through print and electronic media, the Mn/DOT Website, and other methods. Individuals can purchase transponders on-line and at the MnPASS Customer Service Center. A total of 4,057 transponders were purchased prior to the opening of the project. Another 1,594 transponders were sold during the first week of the project, and 1,864 transponders were purchased over the next nine weeks. After the first 10 weeks of the project 7,515 transponders had been purchased or accounts opened and 47 accounts had been cancelled, bringing the total active accounts to 7,468. As of December 2005, some 8,700 transponders had been purchased.

The number of daily MnPASS trips on weekdays grew from 916 on the first day of operation to an average of 3,400 by the 10th week. A high of 4,039 MnPASS users were recorded on one day during the 11th week of operation. The maximum toll reached $8.00 on four days during the first 10 weeks of operation. The maximum toll on most days averaged between $3.25 and $4.00, and the weekday average toll was under $1.00 over the initial 10-week period.

During the morning peak-hour, volumes in the HOV lane increased by some 316 vehicles by the third quarter of 2005. MnPASS vehicles accounted for 476 vehicles, or 16 percent, of the total 2,928 vehicles using the HOV lane. HOVs and a few violators accounted for the remaining 84 percent of vehicles using the lane. The number of HOVs declined by approximately 167 vehicles and the AVO declined from 3.41 to 2.88.

Low-Emission and Energy-Efficient Vehicle Use of the HOV Lanes in Northern Virginia

This case study examines the use of the I-394 HOV lanes in northern Virginia by hybrid vehicles. State legislation approved in 1993 established a clean special fuel license plate for special fuel vehicles. The legislation defines clean special fuel as any product or energy source used to propel a highway vehicle, the use of which, compared to conventional gasoline or reformulated gasoline, results in lower emissions of oxides of nitrogen, volatile organic compounds, carbon monoxide or particulates or any combination thereof. The term is defined to include compressed natural gas, liquefied natural gas, liquefied petroleum gas, hydrogen, hythane (a combination of compressed natural gas and hydrogen), and electricity. The legislation does not specifically mention the EPA ILEV requirements.

State legislation approved in 1994 allows vehicles with clean special fuel license plates to use the HOV lanes in Virginia without meeting the minimum-occupancy requirements. Subsequent legislation in 1996, 1999, and 2003 extended the sunset date, which is currently July 1, 2006.

In 2000, hybrid vehicles became available in the state and the Virginia DMV was requested to determine if these vehicles were eligible for clean special fuel vehicle license plates. The DMV, in consultation with the Virginia Department of Environmental Quality, initially determined hybrids were not eligible for the clean special fuel license plates. After several citizens approached their state legislators about the issue, however, the determination was reversed. Currently, hybrid vehicles are included on the list of vehicles eligible for clean special fuel license plates.

Only vehicles with clean special fuel license plates are authorized to use the HOV lanes in Virginia without meeting the occupancy requirements. An individual must apply to the Virginia DMV for the special plates. A vehicle owner must submit the application and documentation to the DMV headquarters Special License Plate and Consignment Center. Staff at the Center reviews the application and documentation and determines if the vehicle qualifies for the clean special fuel license plate. The special plates and an invoice are sent to the owner of qualifying vehicles. Figure 7.1 illustrates the Virginia clean special fuel license plate.

Figure 7.1. Virginia Clean Special Fuel License Plate.

The number of clean special fuel license plates issued annually in Virginia from 1994 through 2005 is shown in Table 7.7. As of October 2004, a total of 10,413 clean special fuel license plates had been issued in the state. In the six years from 1994 and 1999, a total of 78 clean special fuel license plates were issued. In the almost five years from 2000 to October 2004, with hybrids qualifying for the HOV exemption, a total of 10,335 clean special fuel license plates were issued. This increase is directly attributed to hybrid vehicle owners applying for the special clean fuel license plates.

Table 7.7. Virginia Clean Special Fuel License Plates.

Year	Number of License Plates Issued
1994 – 1999	78
2000	32
2001	300
2002	1,448
2003	2,612
2004[1]	5,943
TOTAL	10,413

[1]Through October 2004.

Table 7.8 presents the number of clean special fuel license plates issued to different types of clean fuel vehicles. Hybrid vehicles comprise the vast majority of the license plates issued, accounting for almost 95 percent of the total. In comparison, no other type of low-emission or energy-efficient vehicle comprises more than 1.3 percent of the total.

The issuance of clean special fuel vehicle license plates can also be tracked by county and city. Between 1994 and March 2004, the vast majority of the clean special fuel vehicle plates were issued in counties and cities in northern Virginia. Clean special fuel plates issued to vehicles in Arlington, Fairfax, Fauquier, Loudon, Prince William, Stafford, King George, and Spotsylvania Counties – which are all in northern Virginia and are served by the I-95, I-395, I-66, and Dulles Toll Road HOV lanes – account for approximately 93 percent of the total clean special fuel license plates issued in the state. Some 2 percent of the clean special fuel license plates were issued to vehicles in the Newport News/Norfolk area, the other location in the state with HOV lanes.

WASHCOG has an ongoing program for monitoring and reporting on the use of HOV facilities in northern Virginia. Vehicle and vehicle-occupancy counts are conducted twice a year, along with other data collection activities. Since the fall of 2003, the number of vehicles with clean special fuel license plates has been included in the counts, with field data collection personnel counting license plates at specific points along the HOV lanes.

Table 7.8. Type of Vehicle Receiving Virginia Clean Special Fuel License Plates.

Type of Clean Fuel Vehicle	Number of Special License Plates Issued	Percentage
Ethane	23	0.4%
Hybrid	5,032	95%
CNG	70	1.3%
Electric	63	1.2%
Hydrogen	28	0.5%
LNG	8	0.15%
Methane	1	–
Liquefied Petroleum Gas	8	0.15%
Natural	67	1.3%
Total[1]	5,300	100%

[1]Through March 2004.

The results from the ongoing monitoring program show that owners of vehicles with clean special fuel license plates are using the HOV lanes in northern Virginia. In the fall of 2003, clean special fuel vehicles accounted for between 2 percent and 12 percent of the HOV volumes during the peak-periods on the different HOV facilities in northern Virginia. Counts from six days in October, 2004 indicate that clean special fuel vehicles accounted for between 11 percent and 17 percent of the vehicles in the HOV lanes on I-95 during the 6:00 a.m. to 9:00 a.m. peak-period in the northbound direction. These percentages translate into between some 844 and 1,422 vehicles with clean special fuel license plates using the HOV lanes during the three-hour period and the corresponding total vehicle volumes in the HOV lane ranged from 7,994 to 8,450. Some 6-7 percent, or 552 to 725 vehicles with clean special fuel license plates, were recorded in the HOV lanes at Glebe Road Station on I-395 inside the Beltway during three days in September 2004 during the same 6:00 a.m. to 9:00 a.m. peak period.

Concerns related to the use of HOV lanes by vehicles with the clean special fuel license plates have been voiced by different groups. In 2003 an HOV Enforcement Task Force was established by the Virginia Secretaries of Transportation and Public Safety. The Task Force was formed in response to growing concerns from numerous groups related to enforcement of the HOV lane restrictions in northern Virginia. The HOV Enforcement Task Force is composed of representatives from state, regional, and local transportation and enforcement agencies.

The Task Force issued reports in 2003 and 2005 examining a number of issues associated with the HOV lanes in northern Virginia. These issues include use of the HOV lanes by vehicles with clean special fuel license plates, use by law enforcement personnel traveling in their personal vehicles, vehicles entering the HOV lanes just prior to the restricted time periods, the fines and penalties for HOV lane violations, and other concerns.

The first report issued by the Task Force in August 2003 recommended that the clean special fuel vehicles license plate exemption not be extended from the current expiration day of July 1, 2006, pending the outcome of the federal reauthorization and the completion of the Transportation Research Council's regional value pricing program study. The second report, which was issued in January 2005 included analysis of additional traffic counts and clean special fuel vehicle use of the HOV lanes, which indicated that the number of clean special fuel vehicles using the I-95 HOV lanes are causing the lanes to operate at unacceptable levels of service. The report also noted that Virginia is second to California in the number of hybrid vehicles sold and that the number of hybrid models available and the sales of hybrid vehicles are projected to continue to increase.

Based on this information, the second Task Force report contains the following recommendations related to the use of HOV lanes by vehicles with clean special fuel license plates.

- Manage, both now and in the future, the number of clean special fuel plates issues as follows:

  For now –

  - The Department of Environmental Quality (DEQ) should adopt the SULEV standard for eligible hybrid vehicles, or equivalent state or federal emission standards, to help determine which hybrid vehicles quality for clean special fuel license plates, thereby maximizing the environmental benefits of such vehicles.
  - Oppose any extension of Virginia's clean special fuel license plate HOV occupancy exemption, which expires July 1, 2006.

- Eliminate the government-owned clean special fuel vehicles exemption specified under Virginia Code § 46.2-749.3.
- Allow clean special fuel vehicles license registrations to be valid for one year only (no multi-year registrations).

For future consideration, as necessary –

- Increase occupancy levels for hybrid vehicles.
- Increase the issuance fee for clean special fuel vehicle license plates from $10 per year to at least $500 per year (about $2 per day per commute, assuming 250 business days each year) and share the funds with law enforcement, to further their HOV enforcement efforts, and with VDOT to help maintain HOV facilities.
- Limit the hours that vehicles registered with clean special fuel vehicles license plates can enter HOV lanes exempt from occupancy requirements.
- Limit the number of vehicles registered with clean special fuel vehicle license plates that can be exempt to a set number and register then via lottery process.
- One or more combinations of the above options.

In addition, the Task Force recommended that a plan be developed detailing actions required in the event the HOV lanes reach capacity. Managing the expectations of hybrid owners and purchasers related to the 2006 exemption expiration date was identified to be included in the plan.

Legislation approved in 2006 extended the deadline for use of HOV lanes in the state by vehicles with clean special fuel license plates until July 1, 2007. The legislation also requires that a new distinctively different design be used for clean special fuel license plates issued after July 1, 2006. The design of the new clean special fuel license plates is to be developed by the Department of Motor Vehicles in consultation with the Department of State Police. The legislation limits use of the HOV lanes in the I-95/I-395 corridor to vehicles registered with and displaying the clean special fuel license plates issued prior to July 1, 2006. Finally, the legislation added a $25 fee for the clean special fuel license plates. For each $25 fee collected in excess of 1,000 registrations, $15 is paid to the State Treasurer and credited to a special non-revenue HOV Enforcement Fund for use by the Virginia State Police for enhanced HOV enforcement.

Opening HOV Lanes on the East Side of Seattle to General-Purpose Traffic in the Evenings

The HOV lanes in the Puget Sound region have traditionally operated on a 24/7 basis. Most of the HOV facilities in the area are concurrent flow HOV lanes located on the inside freeway lane. The HOV lanes have unlimited access, meaning HOVs can enter and exit at any point. Ongoing monitoring efforts indicate that there is both strong public support for the HOV lanes and heavy peak-period use. At the same time, there has been public and policy maker interest in allowing single-occupancy vehicles to use HOV lanes during off-peak periods, when HOV volumes are lower.

In 2002, WSDOT examined options for opening the HOV lanes to general-purpose traffic at different times. This analysis indicated that there was little unused HOV lane capacity during the peak-travel periods, but that excess capacity did exist in evening and early morning hours. The analysis identified some safety concerns with opening the HOV lanes to single-occupancy vehicles at these times and potential impacts on transit reliability. The HOV lanes are important for bus on-time reliability even outside the peak periods, as buses use the lanes during the mid-day to ensure maintaining afternoon schedules. Bus use during the evening and early morning hours is low, however.

In January 2003, the Washington State Transportation Commission agreed to conduct a two-year demonstration project opening the HOV lanes on the eastside of the Seattle metropolitan area to single-occupant vehicles from 7:00 p.m. to 5:00 a.m. seven days a week. Analysis indicated that this change would provide some congestion relief, while not degrading transit reliability. The analysis also indicated that safety should not be degraded significantly as long as specific roadway improvements were made.

The HOV lanes included in the demonstration project are I-405, SR 167, SR 520, and I-90 east of I-405. Prior to opening these HOV lanes to general traffic, WSDOT made a number of safety improvements, including installation of left-hand rumble strips, increased clear zones, and added guardrails. The cost of these improvements was approximately $1.6 million.

An ongoing monitoring and evaluation program was conducted on the HOV lanes as part of the overall HOV performance monitoring program in the region. The one-year evaluation of the new operating hours focused on five major elements. These elements were vehicle volumes in the general-purpose and the HOV lanes, roadway performance as defined by travel speed and frequency of congestion, violation rates, crashes, and public perception.

The one-year evaluation indicated that the overall changes in system performance were very small. Late evening vehicle volumes in the HOV lanes increased slightly, but speeds remained basically unchanged. Violation rates increased marginally. The number of crashes did not change significantly. While it appears much of the public did not know about the change, the general public reaction was positive. Information on each of the five elements examined in the one-year evaluation is summarized next.

Vehicle Volumes. Increases in HOV lane vehicle volumes occurred after 7:00 p.m. at most locations. Vehicle volume increases in the HOV lanes between 7:00 p.m. and 8:00 p.m. ranged from 89 to 589 vehicles. The level of the increases varied, however. Some slight increases also occurred just prior to the 5:00 a.m. morning start of the HOV lane restrictions. Corresponding reductions in vehicle volumes in the general-purpose lanes occurred at some locations.

Vehicle-occupancy levels decreased after 7:00 p.m. in those HOV lanes experiencing increases in vehicle volumes. This decrease was the result of increased single-occupant vehicles using the HOV lanes.

Some measurable changes in the HOV lanes occurred on freeways where congestion still occurs at 7:00 p.m., with the increase in total vehicle volumes. On freeways where congestion is minor or non-existent at 7:00 p.m., some shift in volumes from the general-purpose lanes to the HOV lane occurred, but the total facility vehicle volume did not change significantly.

Roadway Performance. The overall performance of the freeways changed very little as a result of the new operating hours. There was not a noticeable change in the frequency of general-purpose freeway congestion. The average general-purpose lane speeds on the most congested roadways – SR 167 and southbound I-405 – increased slightly by some 1-3 mph. There was also no major change in HOV lane performance. The analysis indicated that on a limited number of occasions and on a limited number of road segments, moderate numbers of general-purpose vehicles were able to avoid some general-purpose lane congestion by moving into the HOV lane. This shift did not appear to have changed the speed with which the congested general-purpose lane returned to normal operation, however.

Violation Rates. Violation of HOV requirements were monitored before-and-after the change in operating hours. The analysis indicated that there was a slight increase in the violation level just prior to the 7:00 p.m. start time of the new operating requirements. The increases in violation rates were generally small, with one exception. The actual violation rates ranged from 0 to 9 percent, except for SR 167. The violation rate on SR 167 in the southbound direction was approximately 16 percent prior to the change. After implementation of the new operating hours the violation rate just prior to 7:00 p.m. increased to approximately 25 percent, but declined 15 percent at the one-year evaluation.

Violation rates prior to the 5:00 a.m. start of the HOV requirements also increased on some HOV lanes, while violation rates declined on six HOV lanes. The highest violation rates were recorded again on SR 167 in the southbound direction. This location recorded a 25 percent violation rate prior to the change in operating hours and a 30 percent violation rate at the one-year evaluation.

Safety and Crashes. The safety concerns examined in the assessment of possible changes in HOV operating hours related primarily to the potential for an increase in the number of vehicles running off the road due to an increase in vehicle volumes in the HOV lanes. A second concern was that the change might impact the operation of planned HOV direct access ramps.

The majority of the eastside freeway HOV lanes are located adjacent to shoulders that are at least eight feet wide. Stopping sight distance was deficient along some segments, particularly on I-405, and a few unprotected fixed objects were in place. Collision data indicated that the facilities had similar run-off-the road experience as urban Interstates statewide.

As noted previously, approximately $1.6 million in safety improvements were made to address these concerns prior to implementation of the new operating hours. Examples of these enhancements included about 75 lane-miles of rumble-strips and 13 lane-miles of profiled edge stripes. A small number of median trees were removed and an additional guardrail was installed on I-90.

Before-and-after data for run-off-the-road crashes was examined as part of the one-year evaluation. The data was nearly identical and no obvious trouble spots were identified. It appears that the number of King County freeway collisions dropped by approximately 9 percent from 2002 to 2003.

Public Opinion. Public opinion was monitored after the change in operation through a survey of freeway users. A total of 5,349 surveys were mailed to motorists and 1,209 completed surveys were returned, accounting for a response rate of 23 percent. The survey included questions on awareness of the change in operating hours, perceptions on changes in freeway conditions, and impressions of the new operating hour policy and HOV lanes in general.

The survey results indicated that many motorists were unaware of the changes in HOV operating hours. Only 36 percent of the respondents indicated an awareness of the new operating hours. Respondents were asked to compare changes in driving maneuverability in the HOV lanes and the general-purpose freeway lanes in the evening hours before and after the change. The responses indicated that motorists perceived some improvements in conditions. The responses to the questions addressing the three changes were similar. Approximately 21-28 percent responded that freeway conditions were somewhat better, 31-39 percent responded conditions were unchanged, 3-4 percent reported conditions were worse, and 31-38 percent indicated they were unsure of any change.

There was a difference in the responses on changes in freeway conditions among motorists reporting an awareness of the new HOV operating hours and those indicating no knowledge of the change. Approximately 31-42 percent of the respondents who were aware of the change indicated that freeway conditions had improved, 39-48 percent thought conditions were unchanged, 1-5 percent reported conditions were worse, and 10-21 percent were unsure of any changes. In contrast, respondents reporting no knowledge of the new HOV operating hours indicated an uncertainty about changes in freeway conditions, with 43-52 percent responding they were unsure of any changes in freeway operating conditions.

Approximately 67 percent of the respondents agreed strongly or agreed somewhat to the statement that opening the HOV lanes to single-occupant vehicles from 7:00 p.m. to 5:00 a.m. was a good idea. Approximately 17 percent of the respondents disagreed strongly or disagreed somewhat to the change. The responses were generally the same for individuals reporting awareness of the changes in operating hours and those unaware of the change. Respondents who reported driving alone were more supportive of the change, with 73 percent either strongly agreeing or somewhat agreeing. Individuals who used carpools, vanpools, or transit were slightly less supporting of the change, with 59 percent either strongly agreeing or somewhat agreeing.

In response to a question on the affect the change in the HOV operating hour policy had on their overall opinion of the HOV lane network, approximately 41 percent of the respondents reported a significantly more favorable or a somewhat more favorable opinion. Approximately 50 percent indicated no change in opinion, and 10 percent reported a less favorable opinion. Current carpoolers, vanpoolers, and bus riders were less supportive of the change, while individuals who typically drove alone were more supportive.

APPENDIX A – REFERENCES AND ADDITIONAL RESOURCES

This appendix contains the references used in the handbook. It also provides additional resources related to topics associated with HOV vehicle-eligibility requirements, vehicle-occupancy levels, and operating hours.

CHAPTER TWO – EXECUTIVE SUMMARY

The following references provide a national overview of the benefits and use of HOV lanes. References on the other topics covered in the chapter are provided in the specific chapters.

Turnbull, K.F. *An Assessment of High-Occupancy Vehicle (HOV) Facilities in North America: Executive Report*. Federal Transit Administration, U.S. Department of Transportation, Washington, D.C., August 1992.

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CHAPTER FOUR – ASSESSING VEHICLE-ELIGIBILITY REQUIREMENTS

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CHAPTER SIX – ASSESSING HOV OPERATING HOURS

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Washington State Department of Transportation Website. “December 2004 Report Outlines Effects of Opening Most Eastside HOV Lanes to all Traffic at Night.” http://www.wsdot.wa.gov/HOV/Dec2004EvalReport.htm. January 17, 2006.

CHAPTER SEVEN– CASE STUDIES

I-10 West HOV Lane, Houston

Bullard, D.L. *An Assessment of Carpool Utilization of the Katy High-Occupancy Vehicle Lane and Characteristics of Houston’s HOV Lane Users and Non-Users*. Texas Transportation Institute, The Texas A&M University System, College Station, Texas, 1991.

Christiansen, D.L. and D.E. Morris. *An Evaluation of the Houston High-Occupancy Vehicle Lane System*. Prepared by the Texas Transportation Institute for the Texas State Department of Highways and Public Transportation in cooperation with the Federal Highway Administration, Washington, D.C., June 1991.

Christiansen, D.L. and D.E. Morris. *The Status and Effectiveness of the Houston Transitway System, 1989*. Texas Transportation Institute, The Texas A&M University System, College Station, Texas, 1990.

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Minnesota Department of Transportation. *I-394 HOV Reports*. St. Paul, Minnesota (prepared quarterly).

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I-395 HOV Lanes, Northern Virginia

Turnbull, K.F., *Potential Impact of Exempt Vehicles on HOV Lanes*. Federal Highway Administration, Washington, D.C., 2005

High-Occupancy Vehicle Enforcement Task Force. *Report of the High-Occupancy Vehicle Enforcement Task Force,* Virginia Department of Transportation, Richmond, Virginia, August 15, 2003.

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APPENDIX B – GLOSSARY OF TERMS

This appendix contains a glossary of terms associated with HOV performance monitoring, evaluation, and reporting. It focuses on terms used in the handbook. The glossary is based on the glossaries for the NCHRP HOV Systems Manual and the AASHTO Guide for High-Occupancy Vehicle Facilities.

Advanced Traffic Management System (ATMS): Remotely operated traffic management system for monitoring and managing operations of a freeway system including HOV lanes and arterial streets. Major elements of the system include surveillance, communications, and controls.

Articulated Bus: An extra-long, high-capacity segmented bus that has the rear portion flexible but permanently connected to the forward portion with no interior barrier to hamper movement between the two parts. The seated passenger capacity is 60 to 80 persons with space for many standees, and the length is from 160 to 70 ft. The turning radius for an articulated bus is usually less than that of a standard urban or intercity bus.

At-grade Access: Ingress/egress between an HOV facility and the adjacent general-purpose lanes that occurs with a direct merging maneuver. Contrast with Direct (Grade-separated) Access Ramps.

Auto Free Zone: An area, usually within a densely developed corridor, where all autos or all motorized vehicles are banned.

Automated Vehicle Identification (AVI): Use of overhead or roadside detectors to read and identify vehicles equipped with a transponder or similar device. Used for electronic toll collection and traffic management.

Automatic Vehicle Location (AVL): The use of advanced technologies such as global positioning systems (GPS) to monitor the location and movement of vehicles.

Average Vehicle Occupancy (AVO): The number of people divided by the number of vehicles (including buses) traveling past a specific point over a given time period.

Barrier-separated HOV Facility: A roadway or lane(s) built within the freeway right-of-way that is physically separated by barriers or pylons from other freeway lanes and is designated for the exclusive use of high-occupancy vehicles during at least portions of the day. These facilities can operate as reversible flow (i.e., inbound in the morning and outbound in the evening) or two-way (i.e., one or more lanes operating in each direction).

Benefit-cost Ratio (B/C): The ratio of the dollars of discounted benefits achievable to a given outlay of discounted costs.

Buffer Separation: A roadway area that is used to separate an HOV lane from a general-purpose lane.

Bus: A self-propelled, rubber-tired road vehicle designed to carry a substantial number of passengers, commonly operated on streets and highways. A bus has enough head room to allow passengers to stand upright after entering.

Bus Malls: Bus or transit streets that are reserved exclusively for use by public transit vehicles.

Bus Priority System: A system of traffic controls in which buses are given special advantages over other mixed-flow traffic (e.g., preemption of traffic signals or preferential lanes).

Bus Rapid Transit (BRT): While a precise definition of BRT is elusive, it is generally understood to include bus services that are, at a minimum, faster than traditional "local bus" service and, at maximum, include grade-separated bus operations. Essential features of BRT systems are some form of bus priority, faster passenger boarding, faster fare collection, and a system image that is uniquely identifiable.

Busway / HOV Facility in Separate Right-of-Way: A roadway or lane(s) developed in a separate right-of-way and designated for the exclusive use of high-occupancy vehicles (commonly buses only).

Capacity, Design (or roadway capacity): The maximum number of vehicles (vehicle capacity) or persons (person capacity) that can pass over a given section of roadway in one or both directions during a given period of time under prevailing environmental, roadway, and roadway user conditions, usually expressed as vehicles per hour or persons per hour. Operational capacity for an HOV lane should be less than this.

Carpool: Any vehicle (usually a private automobile) or arrangement in which two or more occupants, including the driver, share the use, cost, or both traveling between fixed points on a regular basis.

Central Business District (CBD): That portion of a city which serves as the primary activity center. Its use is characterized by intense business activity that serves as a destination for a significant number of daily work trips.

Clean Air Act Amendments of 1990 (CAAA): Federal legislation that establishes new requirements in metropolitan areas and states where National Ambient Air Quality Standards (NAAQS) attainment could be a problem.

Commute Trips: Trips that are taken on a daily or regular basis to work.

Concurrent Flow HOV Facility, Buffer-separated: A non-physically separated lane(s) containing buffer separation that is oriented to operate in the same direction as the adjacent general-purpose lanes. The facility is commonly the inside lane(s) of the freeway cross section, adjacent to the median barrier, and it is designated for the exclusive use of HOVs during at least portions of the day.

Concurrent Flow HOV Facility, Non-separated: A designated lane containing no buffer separation with the adjacent general-purpose lanes and oriented to operate in the same direction as the adjacent general-purpose lanes. The facility is commonly the inside lane and adjacent to the median barrier. Non-separated facilities commonly serve HOVs during portions of the day, reverting to a general-purpose lane during other periods.

Congestion Pricing: The policy of charging drivers a fee that varies with the level of traffic on a congested roadway. Congestion pricing is designed to allocate roadway space, a scarce resource, in a more economically feasibly manner.

Contraflow HOV Facility: A designated freeway lane or lanes (commonly the inside lane in the off-peak direction of general-purpose travel) designated for exclusive use by HOVs traveling in the peak direction during peak commuting periods. The lane is usually separated from the off-peak direction general-purpose lanes by a moveable barrier or plastic pylons.

Corridor: A broad geographical band that identifies a general directional flow of traffic. It may encompass streets, highways, and transit route alignments.

Cost-benefit Analysis: An analytical technique that compares the societal costs and benefits (measured in monetary terms) of proposed programs or policy actions. Identified losses and gains experienced by society are included, and the net benefits created by an action are calculated. Alternative actions are compared to allow selection of one or more that yield the greatest net benefits or benefit-cost ratio.

Deadheading: Segment of a trip made by a transit vehicle not in revenue service.

Delay: The increased travel time experienced by a person or vehicle due to circumstances that impede the desirable movement of traffic. It is measured as the time difference between actual travel time and free-flow travel time.

Department of Transportation (DOT): State agency responsible for administering federal and state highway funds.

Diamond Symbol: A uniform traffic control symbol used on signing and pavement markings to designate the restricted usage on HOV facilities.

Differential Pricing (Variable Pricing): Time-of-day pricing and tolls that vary by other factors like facility location, season, day-of-week, or air quality impact.

Direct (Grade-separated) Access Ramps: Ramps that provide ingress/egress between HOV facilities and support facilities or cross streets. Ramps of this type include flyover ramps, freeway-to-freeway direct connections, drop ramps, or T-ramps. Contrast with At-grade Access.

Directional Split: The distribution of traffic flows on a two-way facility.

Drop Ramp: This direct (grade-separated) access ramp design gets its name because it "drops" to the HOV facility from a cross street.

Dynamic Pricing: Tolls that vary in response to changing congestion levels, as opposed to variable pricing that follows a fixed schedule.

Electronic Toll Collection (ETC): This refers to electronic systems that collect vehicle tolls, reducing or eliminating the need for tollbooths and for vehicles to stop.

Emergency Vehicle: Any vehicle generally used in responding to an incident that has caused or may lead to life or injury threatening conditions or destruction of property. Examples are police, fire, and ambulance vehicles as well as tow trucks and maintenance vehicles.

Enforcement: The function of maintaining the rules and regulations to preserve the integrity of an HOV facility.

Federal Highway Administration (FHWA): Part of the U.S. Department of Transportation. FHWA is responsible for administering all federal-aid highway programs.

Federal Transit Administration (FTA): Formerly the Urban Mass Transportation Administration, part of the U.S. Department of Transportation. FTA is responsible for administering all federal-aid public transportation programs.

Flyover Ramp: This ramp design accommodates direct, high-speed connections between the general-purpose freeway lanes, park-and-ride lot, or other roadway with the HOV lane. These ramps get their name because they "fly over" the roadway to provide direct ingress/egress.

Freeway-to-freeway Direct HOV Connections: A ramp that provides a direct connection at the interchange of an HOV facility within one freeway right-of-way to an HOV facility within another freeway.

General-purpose Lanes: Travel lanes which are open to all vehicle types and/or occupancy levels along the roadway.

High-occupancy Toll (HOT) Lanes: HOV facilities that allow lower-occupancy vehicles, such as solo drivers, to use these facilities in return for toll payments, which could vary by time of day or level of congestion.

High-occupancy Vehicle (HOV): Motor vehicles carrying at least two or more occupants including the driver. An HOV could be a transit bus, vanpool, carpool, or any other vehicle that meets the minimum occupancy requirements, usually expressed as either two or more, three or more, or four or more persons per vehicle.

High-occupancy Vehicle (HOV) Lane: An exclusive traffic lane or facility limited to carrying high-occupancy vehicles (HOVs) and certain other qualified vehicles.

High-occupancy Vehicle (HOV) System: The collective application of physical facilities to support HOV operations, including HOV lanes, park-and-ride lots, park-and-pool lots, and/or other supporting facilities that are administered so as to effectively integrate all physical elements into a unified whole.

Ingress/Egress: The provision of access to/from an HOV or park-and-ride facility.

Inherently Low Emission Vehicles (ILEV): Alternative fueled clean air vehicles. Related terms include Zero-Emission vehicles (ZEVs), Ultra-Low-Emission (ULEV), and Super-Ultra-Low-Emission (SULEV) vehicles powered by alternative fuels.

Intelligent Transportation Systems (ITS): Advanced technologies and communication systems. In this guide, their application is to provide a remotely operated system for monitoring and managing the operation of an HOV and/or freeway facility to better assure acceptable traffic operation and improved responsiveness to incidents. Major elements are (a) surveillance—collection and processing of data by detectors and visible verification by closed circuit television, toll tags, or inductance loops; (b) communications—presentation of operational information to motorists through signs, delineation, signals, and/or auditory means; and (c) control—application of traffic restraints or direction of flow by signs, barrier gates, and signals.

Intermodal Facilities: Locations that allow travelers to change between transportation modes.

Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA): Federal legislation that mandated the way transportation decisions were made and funded over fiscal years 1992-1997. The Transportation Equity Act for the 21st Century was enacted June 9, 1998, as Public Law 105-178. TEA-21 authorizes the Federal surface transportation programs for highways, highway safety, and transit for the 6-year period 1998-2003.

Level of Service (LOS): A descriptive measure of the quality and quantity of transportation service provided the user that incorporates finite measures of quantifiable characteristics such as travel time, travel cost, number of transfers, etc. Operating characteristics of levels of service for motor vehicles can be found in the latest edition of the *Highway Capacity Manual*.

Line Haul: That portion of commute trip that is express (non-stop) between origin and destination.

Local Bus Service: Bus routes and service characterized by frequent stops and slow operating speeds.

Mode Shift: The shift of people from one mode to another (i.e., SOVs to HOVs).

National Environmental Policy Act (NEPA): Legislation enacted in 1969 that requires federally funded projects to conduct an environmental impact study (EIS) to evaluate potential impacts.

National Highway System (NHS): Interstate highways and other roads designated as important for interstate travel, national defense, intermodal connections, and international commerce.

National Intermodal Transportation System (also known as National Transportation System): Integrated system connecting major transportation facilities.

Nonattainment Area: A geographic area in which the level of a criteria air pollutant is higher than the level allowed by the NAAQS.

Off-line Station: A transit station that provides safe and sheltered locations for passengers to board buses or transfer between different bus routes or services, which is located adjacent to the freeway or at a point farther away from the HOV lane facility (contrast location with On-line Station).

Off-peak Direction: The direction of lower demand during a peak commuting period. In a radial corridor, the off-peak direction has traditionally been away from the CBD in the morning and toward the CBD in the evening.

On-line Station: A transit station that provides a safe and sheltered location for passengers to board buses or transfer between different bus routes or services, which is located directly along an HOV lane (contrast location with Off-line Station).

Paratransit Vehicle: Any form of intraurban demand-responsive vehicle such as taxis, carpools, etc., that are available for hire to the public. They are distinct from conventional transit as they generally do not operate on a fixed schedule.

Park-and-ride (P&R) Lot: A parking facility where individuals access public transportation as a transfer of mode, usually from their private automobiles. Public transportation usually involves express bus from the lot to a central business district or major activity center:

Park-and-Pool Lot: A parking facility where individuals rendezvous to use carpools and vanpools as a transfer of mode, usually from their private automobiles. The facility is not served by public transportation.

Peripheral P&R Lot: A facility that provides additional parking for businesses and land uses primarily surrounding the lot or in proximity. These facilities may be unintentional consequences of poor facility location. They may be served by high levels of transit, but productivity measured by transit ridership from the lot may be low.

Remote Long-distance P&R Lot: Lots located at greater distances from the primary activity center than the traditional suburban P&R lot. These facilities will often be located at the center of a smaller activity center, but provide parking and transit service to the distant primary center.

Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU): Authorizes federal surface transportation programs for highways, highway safety, and transit for 2005-2009.

Satellite Parking Facilities: Park-and-ride lots placed on the perimeter of the primary activity center or central business center. These facilities are designed to provide relatively inexpensive parking for commuters accessing the activity center without having to travel into the center. These facilities may be served by transit.

Suburban P&R Lot: Park-and-ride lot typically located in outer portions of the urban area, primarily serving commute-to-work travel between the suburbs and the central city or other major activity center. Transit services may be extensive, with routes provided to multiple locations. Alternatively, more restricted transit providing service only to the primary business center within the region may be offered.

Peak Direction: The direction of higher demand during a peak commuting period. In a radial corridor, the peak direction has traditionally been toward the central business district in the morning and away from the central business district in the evening.

Peak Hour: That hour during which the maximum demand occurs for a given transportation corridor or region, generally specified as the morning peak-hour or the evening peak-hour.

Peak Period: A portion of the day in which the heaviest demand occurs for a given transportation corridor or region, usually defined as a morning or evening period of two or more hours.

Preferential Parking: Parking lots or spaces reserved exclusively for HOVs only as a means to encourage ridesharing. They are usually located closer to a terminal or building entrance than other vehicle spaces and may also have a reduced parking fee.

Preferential Treatment: In transportation, giving special privileges to a specific mode or modes of transportation (i.e., bus lanes or signal preemption at intersections).

Price Elasticity of Demand: A measure of the sensitivity of demand for a commodity to a change in its price. It equals the percentage change in consumption of the commodity that results from a 1-percent change in its price. The greater the elasticity, the more price-sensitive the demand for the commodity.

Priority Lane: Lane providing preferential treatment to eligible vehicles.

Priority Lane Pricing: Concept of using congestion pricing on an HOV lane.

Public Transit (or Public Transportation): Passenger transportation service to the public on a regular basis using vehicles that transport more than one person for compensation, usually but not exclusively over a set route or routes from one fixed point to another. Routes or schedules of this service may be predetermined by the operator or may be determined through a cooperative arrangement.

Queue: A line of waiting vehicles or persons. For example, traffic at a bottleneck location or signal, or buses at a park-and-ride facility, or persons in line to board a bus.

Queue Bypass HOV Facility: A short, often non-separated lane, designated to operate in the same direction as the adjacent general-purpose traffic lanes through an isolated traffic bottleneck, a toll plaza, or a metered location. The lane is designated for the exclusive use of HOVs and provides a “head-of-the-line” advantage in bypassing queued traffic.

Ramp Meter Bypass: A form of preferential treatment in which bypass lanes are provided at a ramp meter for the exclusive use of HOVs.

Ramp Metering: A system used to reduce congestion on a freeway facility by managing flow from on-ramps. An approach ramp is equipped with a metering traffic signal that allows the vehicles to enter a facility at a controlled rate.

Reversible Lane: A lane on which the direction of traffic flow can be changed to utilize maximum roadway capacity during peak demand periods.

Ridesharing: The function of sharing a ride with other passengers in a common vehicle. The term is usually applied to carpools and vanpools.

Road Pricing: An umbrella phrase that covers all charges imposed on those who use roadways. The term includes such traditional revenue sources as fuel taxes and license fees as well as charges that vary with time of day, the specific road used, and vehicle size and weight.

Signal Preemption: A technique for altering the sequence or duration of traffic signal phasing using vehicle detection in order to provide preferential treatment for buses and emergency vehicles.

Signal Priority: Technique of altering the sequence or timing of traffic signal phases using special detection in order to provide preferential treatment.

Single-occupant Vehicle (SOV): Any vehicle carrying only the driver.

Slip Ramp: A type of at-grade access that can be used at the beginning or end of an HOV facility that provides an acceleration/deceleration taper.

Spot HOV Treatments: Techniques that may be used to give HOVs priority around a specific bottleneck or with special access to a facility.

Study Period: The time during which a study is being conducted, which could be one or more parts of a day, all day, or more than a day.

Supporting Facilities: Facilities that provide for the safe and sheltered transfer of passengers between different travel modes, bus routes or services. General types of these facilities include park-and-ride and park-and-pool lots, transit stations, intermodal facilities, and bus stops and shelters.

Time-of-Day Pricing: Facility tolls that vary by time of day in response to varying congestion levels. Typically, such tolls are higher during peak periods when the congestion is most severe.

Toll Road: A road where motorists are charged a use fee (or toll). Toll roads may have preferential pricing for HOVs.

T-ramp: This direct (grade-separated) access ramp design gets its name because it forms the letter “T” between the HOV lane and the connecting park-and-ride lot or cross street.

Transit Center (or Transit Station): A mode transfer facility serving transit buses and other modes such as automobiles and pedestrians. In the context of this document, transit centers can provide premium park-and-ride services, allowing passengers to connect with a number of transit routes and other services.

Transit, Light Rail (LRT): An urban railway system characterized by its ability to operate single cars or short trains in streets or exclusive right-of-way, capable of discharging passengers at track or car floor level.

Transponder: An electronic tag mounted on a license plate, built into a vehicle, or placed on the dashboard. The tag is read electronically by an electronic tolling device that automatically assesses the amount of the user fee.

Transportation Control Measures (TCM): A general term referring to transportation demand management (TDM), transportation systems management (TSM), and technology improvements that can be used to reduce regional emissions within a nonattainment area.

Transportation Demand Management (TDM): The operation and coordination of various transportation system programs to provide the most efficient and effective use of existing transportation services and facilities. TDM is one category of TSM actions.

Transportation Equity Act for the 21st Century (TEA-21): The Transportation Equity Act for the 21st Century was enacted June 9, 1998 as Public Law 105-178. TEA-21 authorizes the Federal surface transportation programs for highways, highway safety, and transit for the 6-year period 1998-2003.

Transportation System Management (TSM): Actions that improve the operation and coordination of transportation services and facilities to affect the most efficient use of the existing transportation system. Actions include operational improvements to the existing transportation system, new facilities, and demand management strategies.

Travel Time: The length of time it takes to travel between two points.

Travel Time Reliability: Term referring to the lack of variability in travel time that can be expected using different facilities.

Travel Time Savings: Time saved by using an HOV facility rather than the general-purpose lanes.

Value Pricing: A system of fees or tolls paid by drivers to gain access to dedicated roadway facilities providing a superior level of service compared to the competitive free facilities. Value pricing permits anyone to access the managed lanes, and the value of the toll is used to ensure that the management goals of the facility are maintained.

Vanpool: A prearranged ridesharing function in which a number of people travel together on a regular basis in a van, usually designed to carry six or more persons.

Violation Rate: The total number of violators divided by the total number of vehicles in HOV lane(s).

Volume to Capacity Ratio: The ratio of demand flow rates to capacity for a given type of transportation facility.

APPENDIX C – LIST OF ABBREVIATIONS

AASHTO: American Association of State Highway and Transportation Officials

ADA: Americans with Disabilities Act

ATMS: Advanced Traffic Management System

AVC: Automatic Vehicle Classification

AVI: Automated Vehicle Identification

AVL: Automatic Vehicle Location

AVO: Average Vehicle Occupancy

B/C: Benefit-cost Ratio

BRT: Bus Rapid Transit

CBD: Central Business District

CCTV: Closed-circuit Television

CFR: Code of Federal Regulations

CMAQ: Congestion Mitigation and Air Quality Program

CNG: Compressed Natural Gas

DMS: Dynamic Message Signs

DOT: Department of Transportation (State or Federal)

EPA: Environmental Protection Agency

ETC: Electronic Toll Collection

FHWA: Federal Highway Administration

FTA: Federal Transit Administration

GIS: Geographic Information System

HCM: Highway Capacity Manual

HOT: High-occupancy Toll

HOV: High-occupancy Vehicle

ILEV: Inherently Low Emission Vehicle

ISTEA: Intermodal Surface Transportation Efficiency Act

ITMS: Integrated Transportation Management Systems

ITS: Intelligent Transportation Systems

LOS: Level-of-service

LNG: Liquefied Natural Gas

LPG: Liquefied Petroleum Gas

LRT: Light Rail Transit

MOE: Measures of Effectiveness

MPH: Miles Per Hour

MPO: Metropolitan Planning Organization

MUTCD: Manual on Uniform Traffic Control Devices

NAAQS: National Ambient Air Quality Standards

NEPA: National Environmental Policy Act

NCHRP: National Cooperative Highway Research Program

NHS: National Highway System

NEPA: National Environmental Policy Act

P&P: Park-and-pool

pphpl: Persons per Hour per Lane

P&R: Park-and-ride

PZEV: Partial Zero Emission Vehicle

ROW: Right-of-way

RRT: Rail Rapid Transit

SAFETEA-LU: Safe, Accountable, Flexible, and Efficient Transportation Equity Act – A Legacy for Users

SOV: Single-Occupant Vehicle

SULEV: Super-Ultra Low-Emission Vehicle

TCM: Transportation Control Measure

TCRP: Transit Cooperative Research Program

TDM: Transportation Demand Management or Travel Demand Management

TEA-21: Transportation Equity Act for the 21st Century

TRB: Transportation Research Board

TSM: Transportation Systems Management

VMT: Vehicle Miles Traveled

vph: Vehicles per Hour

vphpl: Vehicles per Hour per Lane

APPENDIX D – AGENCY CONTACTS

The following agencies are participating in the HOV Pooled-Fund Study. The point of contact is listed for each agency.

Agency	Point of Contact	Telephone
California Department of Transportation	Tim Buchanan	916-654-6448
Georgia Department of Transportation	Daryl Cranford	404-656-5360
Tennessee Department of Transportation	Donald Dahlinger	615-741-3033
Virginia Department of Transportation	Chris Detmer	804-786-3599
Maryland State Highway Administration	Terrance Hancock	410-545-5675
Washington State Department of Transportation	Mark Leth	206-440-4487
Massachusetts Highway Department	Ken Miller	617-973-8064
New Jersey Department of Transportation	Laine Rankin	609-530-6539
Minnesota Department of Transportation	Nick Thompson	651-634-5310
New York Department of Transportation	Wayne Ugolik	631-952-6108