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High Occupancy Vehicle Pooled Fund Study

HOV Lane Enforcement Handbook

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16. Abstract

Enforcement is a critical element to the successful operation of a high-occupancy vehicle (HOV) facility. In the most congested metropolitan areas, the problem of HOV lane violators is acute, with documented violation rates on some facilities running well into the double digits. Recent initiatives, such as high-occupancy toll (HOT) lanes and the use of low-emission vehicles on HOV facilities, add a new dimension to the enforcement process. Enforcement agencies increasingly recognize the need for developing smarter, more efficient strategies to combat violators. This handbook is a resource to this end. Its purpose is to provide a better understanding of enforcement needs as they relate to the planning, design, and operations of HOV facilities, and to highlight policies, procedures, supporting legislation, strategies, and technologies for improving the efficiency of enforcement practices in the face of an increasingly diverse user base of carpool, toll-paying, and low-emission vehicles.

Enforcement considerations pertaining to a range of HOV facility types are presented in the handbook. Guidance, best practices, and practitioner experience are assembled in an easy-to-use format for facility planning, design, operations, and enforcement personnel. A general introductory/summary chapter (Chapter Two) is also provided to facilitate use of this reference guide by other audiences. Topics dealt with in the handbook include enforcement considerations in the facility planning phase; enforcement-related design elements for HOV facilities; and analysis of operational strategies, techniques, and best practices for enforcement. Enforcement issues associated with HOT facilities, a comprehensive review of federal and state laws pertaining to HOV/HOT lanes (including rules for exempt vehicles), and a survey of technologies applicable to HOV and HOT lane enforcement are also addressed in the handbook.

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CHAPTER ONE
INTRODUCTION

Welcome to the *High-Occupancy Vehicle (HOV) Lane Enforcement Considerations Handbook*.

Purpose and Goals of Handbook

This handbook serves as a guide for HOV lane enforcement considerations affecting the development, use, and implementation of HOV facilities. Its purpose is to provide a better understanding of enforcement needs as they relate to the planning, design, and operations of HOV facilities, and to highlight policies, procedures, supporting legislation, strategies, and technologies for improving the efficiency of enforcement practices.

Intended Audience and Handbook Use

The handbook has as its intended audience all agencies having a role in the planning, management, operation, and enforcement of HOV and high-occupancy toll (HOT) facilities, including representatives from state departments of transportation (DOTs), state and local law enforcement agencies, metropolitan planning organizations (MPOs), and transit agencies. Targeted end users of this handbook include planners, engineers, operations personnel, and public safety and enforcement agencies involved in the development and implementation of HOV enforcement policies and programs. This handbook may also prove useful to agency management personnel, policy makers, and other individuals interested in HOV enforcement.

Handbook Features

The handbook includes a number of user-friendly features. The following icons are used throughout the handbook to highlight at-a-glance previews of the handbook and chapters, 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 HOV lane enforcement.

This icon highlights **Keys to Successful Practices** related to HOV lane enforcement.

This icon highlights **Case Study Examples** pertaining to HOV lane enforcement.

Chapters at a Glance

Chapter Two—Overview of HOV Lane Enforcement

This chapter provides a high-level discussion of the importance, benefits, and challenges of enforcement that agencies face when operating HOV facilities. Information contained in this chapter is intended for audiences with limited or no experience in HOV lane enforcement, but who are familiar to some degree with general HOV lane concepts. This chapter begins by describing the nature of HOV enforcement. Factors that create new urgency for effective enforcement are identified, such as new federal performance requirements, the emergence of HOT projects, and recent liberalization of eligibility rules for low-emission vehicles. This chapter next summarizes key HOV lane enforcement issues and identifies the major challenges and implications of integrating enforcement considerations into HOV facilities. The remaining sections of this chapter provide a detailed overview of the key HOV enforcement topics discussed in subsequent chapters of the handbook. These sections are provided for readers who desire a more condensed treatment of the material in this handbook. Readers who prefer a more in-depth discussion of the handbook topics are advised to skip the overview sections of this chapter and proceed to Chapter Three.

Chapter Three—Enforcement Considerations in HOV Facility Planning

This chapter discusses the aspects of enforcement relevant to HOV facility planning. The first section of this chapter identifies relevant stakeholders in the facility planning phase and summarizes their respective roles in the enforcement planning process. An overview of pertinent steps in the facility planning process is presented in the next section, noting the role that enforcement considerations should play. The third section of this chapter illustrates some favorable and unfavorable consequences to HOV enforcement operations that result from differences in facility planning approaches, examining the experiences of the I-394 and I-495 HOV facilities in Minneapolis, Minnesota, and Long Island, New York, respectively.

Chapter Four—Enforcement Considerations in HOV Facility Design

This chapter analyzes enforcement considerations in HOV facility design. Relevant stakeholders in the facility design phase are identified, and their respective roles in the enforcement design process are summarized. An overview of the facility design process is presented, noting the role that enforcement considerations should play at each step in this process. This chapter addresses key facility design issues affecting enforcement, offering a discussion of certain general design features and their impact on enforcement effectiveness. Geometric design standards for enforcement features prescribed in the American Association of State Highway and Transportation Officials (AASHTO) *Guide for High-Occupancy Vehicle Facilities* are reviewed for the main types of HOV facilities.

Chapter Five—Enforcement Considerations in HOV Operations

This chapter focuses on the role of enforcement as it pertains to HOV facility operations. The first section of this chapter identifies the relevant groups and agencies involved in HOV operations and the development of enforcement policies and programs. The components of an enforcement program pertaining to HOV facility operations are next discussed. General enforcement strategies and specific enforcement techniques and tactics are reviewed, and guidance is provided for selecting appropriate strategies and tactics for different types of HOV facilities. Additional considerations for enforcement program management, performance monitoring, and communication of HOV enforcement information are presented. Throughout this chapter, case study examples articulate the concepts presented. The last section of this chapter discusses the operational aspects of the enforcement campaign developed by the northern Virginia HOV Enforcement Task Force, and the first year impact of the campaign on violations along HOV facilities in northern Virginia.

Chapter Six—Enforcement Considerations for HOT Facilities

This chapter discusses HOT facilities and addresses the planning, design, and operational issues associated with enforcement along this type of facility, as well as the challenges to HOV enforcement posed by conversion of HOV facilities to HOT facilities. The first section of this chapter provides an overview of HOT facilities, including a description of the key characteristics of this type of project, a summary of existing HOT facilities, and a brief discussion of core HOT operating concepts. The next section of this chapter presents the major stakeholders involved in HOT projects and highlights the changes to institutional interrelationships that may occur among them in the context of HOT development. Further sections of this chapter discuss the issues in planning, design, and operations of HOT facilities that present additional challenges or require different approaches from those pertaining to HOV facilities. The concluding sections of this chapter discuss the implementation approaches and issues encountered in converting HOV facilities in Houston, Texas; San Diego, California; and Minneapolis, Minnesota, to HOT operations, and present a case study on the unique aspects of the SR 91 Express Lanes in Orange County, California.

Chapter Seven—Enforcement Considerations for Exempt Vehicles on HOV Facilities

This chapter discusses enforcement considerations pertaining to some of the exempt vehicle classes permitted on HOV facilities, particularly the class of low-emission vehicles and of law enforcement and emergency services vehicles. The first section of this chapter surveys the regulatory and legislative treatments regarding HOV exemptions for these vehicles at the federal and state levels. Current guidance for exempt vehicles, based on review of existing and proposed policies, as well as recommendations from recent study efforts, is presented in the following section. The last section of this chapter discusses the Virginia HOV Enforcement Task Force findings and recommendations regarding exempt vehicle usage on HOV facilities in northern Virginia.

Chapter Eight—Legislative and Judicial Issues in HOV and HOT Enforcement

This chapter provides a comprehensive discussion of key legislative and judicial issues affecting enforcement along HOV facilities. The relevant entities having roles in the legal and judicial aspects of HOV/HOT enforcement are described. The main legislative issues affecting enforcement are identified and illustrated by pertinent examples in federal and state legislation. These issues encompass legislative treatments concerning the authority and jurisdiction of enforcement agencies, vehicle eligibility on HOV/HOT facilities, standards of evidence for violations, provisions for funding of enforcement operations, and the nature and severity of penalties for HOV/HOT violations. Judicial issues, such as support for the penalty structure, scheduling support, and communications between enforcement and judicial agencies, are also discussed.

Chapter Nine—Enforcement Technologies

This chapter reviews technologies applicable to HOV enforcement, beginning with a discussion of the different requirements posed by HOV and HOT facilities. The additional requirements for verification of tolls on HOT facilities are outlined, and the various available enforcement countermeasures to common HOT violations are discussed. The next section of the chapter discusses the various technologies available for HOV and HOT enforcement. A survey of prior research and implementation projects for vehicle occupancy verification is provided, and technological implementations for enforcement along HOT facilities in two cities (Houston, Texas, and Minneapolis, Minnesota) are examined.

Appendix A—Glossary

This appendix contains a glossary of terms associated with HOV enforcement, focusing on terms and abbreviations used in the handbook.

Appendix B—References

This appendix contains the references used in the handbook.

CHAPTER TWO
OVERVIEW OF HOV LANE ENFORCEMENT

Chapter at a Glance

This chapter provides a high-level discussion of the importance, benefits, and challenges of enforcement that agencies face when operating HOV facilities. Information contained in this chapter is intended for audiences with limited or no experience in HOV lane enforcement, but who are familiar to some degree with general HOV lane concepts. This chapter begins by describing the nature of HOV enforcement and identifies factors that create new urgency for effective enforcement. The remainder of this chapter summarizes the key HOV lane enforcement issues contained in subsequent chapters of the handbook.

Section headings in this chapter:

- The Role of HOV Enforcement
- The Need for HOV Enforcement
- Chapter Overviews

The Role of HOV Enforcement

HOV facilities represent one approach used in metropolitan areas throughout the county to help address traffic congestion, mobility, and air quality concerns. The travel time savings and improved trip time reliability offered by HOV facilities provide incentives for commuters to change their travel mode from driving alone to carpooling, vanpooling, or riding the bus. In this way, HOV lanes increase the people-moving capacity rather than vehicle-moving capacity of congested travel corridors.

Enforcement is a critical element to the successful operation of an HOV facility. The purpose of an HOV enforcement program is to ensure that operating requirements, including vehicle occupancy levels, are maintained to protect HOV travel time savings, to discourage unauthorized vehicles, and to maintain a safe operating environment. 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.

Enforcement policies and programs perform a number of important roles. The development of enforcement policies and programs will help ensure that all of the appropriate agencies are involved in the process and that all groups have a common understanding of the project and the need for enforcement. The enforcement process encompasses not only the detection and on-site ticketing of violators but a

continuum that extends through adjudication of citations via the court system. Policies, legislation, procedures, and agreements with the affected enforcement agencies need to be in place, and enforcement agencies have to be stakeholders in decisions that influence design, operation, and performance monitoring activities. This same information can be provided to the public, especially travelers in the corridor, to help introduce the HOV facilities and to communicate the guidelines for use of the lanes.

The Need for HOV Enforcement

The growing need for effective enforcement has been spurred by both long-term and more recent transportation developments.

As the nation's highways become increasingly congested, the temptation for non-eligible drivers to cheat and make use of an HOV lane becomes larger. In the most congested metropolitan areas, this problem is acute, with documented violation rates on some facilities running well into the double digits. Enforcement in such heavily congested corridors becomes problematic, as heightened police activity on the HOV lanes can often exacerbate slowdowns by inducing "rubbernecking." Enforcement agencies increasingly recognize the need for smarter, more efficient strategies to combat violators.

More recently, congestion pricing projects, including 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. Congestion 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. In addition, some states are allowing other forms of exemptions, namely low-emission vehicles, which add a new dimension to the enforcement process. New policies, strategies, and technologies are needed to support the greatly increased complexity of the enforcement task required for such a diverse user base.

Recently enacted federal legislation has expanded the options for state agencies to experiment with tolling on existing highways. Such initiatives are seen as one way to help fund overdue improvements in many congested corridors. Along with increased flexibility, the federal rules impose additional responsibilities on state transportation departments. Agencies responsible for HOT facilities must establish, manage, and support an enforcement program that ensures the operating performance of these facilities is not degraded. Agencies are further required to limit or discontinue the use of the facility by tolled single-occupant vehicles (SOVs) if the presence of these vehicles has degraded the operation of the facility.

Chapter Three Overview—Enforcement Considerations in HOV Facility Planning

Consideration of enforcement issues should occur as early in the planning process as is feasible. Given the relative lack of specific facility details at the regional- and corridor-level planning stages, the facility planning level is often the point at which substantial consideration of enforcement issues should take place. Early efforts to address enforcement issues in the planning process can facilitate subsequent design and operational decisions, and bring greater awareness and sensitivity on the part of other project members and agencies. This section discusses the pertinent steps in the facility planning process having important enforcement considerations.

Identify and Involve Appropriate Stakeholders

Care should be taken to ensure all relevant stakeholders are included in the facility planning process. Depending on the design of the facility, different agencies may have overall project responsibility. No matter which agency takes the lead, state and local police involvement during the planning process will ensure that the needs of enforcement personnel are being addressed and that the facility being planned will be enforceable. As the project evolves, this becomes more critical.

As the planning process proceeds, it is beneficial to also include members of the judicial system that will be responsible for enforcing the fines and penalties. Legislators may also need to be consulted during the planning process if existing laws affecting HOV facility enforcement require modification. Policing jurisdictions may be reluctant to get involved or even participate in the planning if there are no formal arrangements; therefore, enforcement responsibilities need to be discussed early on.

Identify Preliminary Enforcement-Related Design and Operational Issues

Identifying potential enforcement issues related to the design and operation of HOV facilities can serve the interests of both planners and enforcement agencies. Some of the more salient issues are discussed below.

Design Screening

The degree to which an HOV facility can be effectively enforced is profoundly dependent on both the type of facility and the presence of adequate enforcement and/or refuge shoulders. As recommended in design references such as the AASHTO *Guide for High-Occupancy Facilities*, a minimum 4.2 m (14 ft) shoulder provides enhanced safety and the many favorable options for enforcement locations along an HOV facility. Traffic law enforcement personnel should be intimately involved in this aspect of the planning process to obtain their valuable insight into the nature of possible enforcement problems that may be encountered, and to gain their support and sensitivity to the constraints within which the transportation engineer has to work. In many cases, compromises may have to be made in terms of the final design concept and/or the desired enforcement program. The

constraints within which both the design agency and the enforcement agency must work should be clearly defined and mutually understood.

Funding and Costs

Funding for enforcement is another consideration that must be addressed in the planning process. The physical elements of planning, designing and constructing enforcement areas may be eligible for federal funding. However the actual ongoing enforcement will depend on the agency with the enforcement responsibility. Depending on which agency assumes this responsibility, funding may have to compete with all types of enforcement as well as other, more critical responsibilities of the entire state. If transit police or other agency personnel are used for enforcement, a higher priority may be given to the enforcement of the HOV lane, as opposed to other traditional policing responsibilities. A combination of local and state funds is typically used to finance ongoing enforcement efforts, although some facilities have been able to secure federal earmarks for HOV enforcement. Additionally, revenue from penalties is seldom redirected back into HOV enforcement activities.

Enforcement Staffing and Scheduling

The number of enforcement personnel assigned to cover an HOV facility can be highly variable between very similar projects. The level of effort assigned to each HOV project is dependent on many factors, with the most significant ones being facility length, facility operation, the degree to which a facility is conducive to enforcement activities, the types of enforcement strategies, and the availability of enforcement personnel. Enforcement agencies also need to consider institutional and human resource issues when assessing the manpower requirements for HOV enforcement.

Identify Objectives

In the context of enforcement, the general overriding objectives in planning an HOV facility are to achieve a low level of violations and a high level of safety. Generally, the target violation rate of 10 percent or less is commonly held as a suitable objective. Violation rates under 5 percent are generally considered "good," while violation rates exceeding 20 percent are regarded as unacceptably high. Target violation rates may be influenced by the type of HOV facility, with contraflow and barrier-separated facilities having the lowest rates (typically 0 to 10 percent) and non-separated contraflow facilities having the highest rates (10 to 20 percent). For example, the California Department of Transportation (Caltrans) *HOV Guidelines for Planning, Design, and Operations* recommends violation rates under 10 percent—most HOV facilities in the southern part of the state are buffer-separated concurrent flow, while those in the northern part are not.

Chapter Four Overview—Enforcement Considerations in HOV Facility Design

The term "enforcement area" is used to refer to a number of potential design treatments that provide space for police personnel to monitor an HOV facility, to pursue a violator, and to apprehend a violator and issue a citation. Space adjacent to

an HOV lane is required for these functions. The enforcement requirements should be coordinated with the enforcement personnel early in the design process. This permits them to become familiar with the concept of the project, anticipate any additional requirements, and make suggestions for the design that may make enforcement simpler, safer, more efficient, and in compliance with state/local law.

General Design Elements for Enforcement

A variety of enforcement practices may be used on a facility. The design of enforcement areas should be sufficiently versatile so that enforcement personnel may employ a relative diversity of enforcement strategies. In addition, local or state laws regarding how enforcement is carried out should be considered. The facility design should therefore be developed in consultation with the enforcement agency. Some key general considerations should remain foremost throughout the facility design process.

Provide Adequate Shoulders and Vehicle Refuge Areas

HOV lanes should be designed so that they can be safely and efficiently enforced. The safety of police personnel, as well as travelers in the HOV lane and the general-purpose lanes, should be key considerations in the design process. HOV lane project success is jeopardized by poorly designed and unsafe enforcement areas that will not be used. The following design features should therefore be considered essential:

- For any type of HOV facility, a wide continuous 4.3 m (14 ft) shoulder should be provided for enforcement and safety-related activities.
- If shoulder widths must be narrowed to accommodate overpasses, the length of the restricted cross section should be minimized, and periodic enforcement and refuge zones should be provided.
- On barrier-separated facilities, full shoulders should be provided on both sides, although only one need be 4.3 m. Concurrent flow facilities should incorporate a minimum 4.3 m (14 ft) median shoulder and a 1.2 m (4 ft) buffer adjacent to the general-purpose lanes, with periodic enforcement areas sheltered by concrete barriers.

Choose Proper Locations for Enforcement and Observation Areas

The primary type of infraction that enforcement officers confront is occupancy violation, which requires the ability to see inside a vehicle. Enforcement and observation areas should therefore be situated such that:

- The locations provide a safe vantage point from which officers can easily observe vehicles, and which provide good lighting for viewing vehicle interiors.
- The locations do not render officers highly visible to motorists far upstream on the facility. Locations that telegraph the presence of police give violators too much advance notice and may allow violators to evade apprehension if an intermediate access point is available.

- Enforcement zones should not be placed under bridge decks, overpasses, or any other location where enforcement personnel may be endangered by falling or thrown debris.

Consider Limiting Facility Access to Enhance Enforcement

The number of access points along an HOV facility contributes to the ease or difficulty with which the facility can be enforced:

- Barrier-separated facilities possess many of the operational characteristics of "tunnel" facilities, one of which is an irrevocable commitment to using the facility. This attribute makes barrier-separated facilities generally easy to enforce, especially if motorists have no opportunity for access other than at the beginning and the end of the facility (i.e., no intermediate facility access is provided).

- For concurrent flow HOV projects, consider buffer separation with limited access locations. Non-separated lanes do not have the HOV lane physically separated by barriers, traffic posts, or other implements from the general traffic lanes, thereby providing the motorist with a multitude of locations with which to violate the HOV regulations.

Choose Ingress and Egress Locations Carefully

For limited access facilities, locations should be designed to meet the traffic demand but should also be upstream of likely bottleneck locations on the general-purpose lanes, to prevent conflicting weaving maneuvers by HOV and general-purpose lane traffic in congested conditions.

Recommendations for Dedicated Enforcement Locations

Two general classifications for enforcement areas are often used. These categories relate to barrier-separated and non-barrier-separated HOV treatments. The two approaches are low-speed enforcement areas at entrance and exit ramps, and high-speed settings along the HOV mainline.

Low-speed enforcement areas are usually located at access points on busways, HOV lanes on separate rights-of-way, and barrier-separated freeway projects. Specific locations may include ramps, reversible lane entrances, and queue bypasses where vehicle speeds are relatively slow, usually below 75 km/hr (45 mph). Low-speed enforcement areas are often designed to provide for monitoring, apprehension, citing of violators, and, where practicable, violator removal from the HOV facility.

High-speed enforcement areas are recommended if an HOV lane includes a number of at-grade access locations with speeds at or above 75 km/hr (45 mph), or lacks continuous shoulders wide enough for enforcement. These areas are usually designed either for monitoring traffic or for monitoring and apprehending violators, and are spaced periodically along the facility. For either application, police personnel often prefer that periodic enforcement areas be designed in conjunction with full outside shoulders (barrier-separated facilities) or full 1.2 m (4 ft) outside buffers (concurrent flow facilities).

Table 2-1 summarizes the design features for low- and high-speed enforcement areas as recommended by the National Cooperative Highway Research Program (NCHRP) *HOV Systems Manual* and the AASHTO *Guide for High-Occupancy Vehicle Facilities*.

Table 2-1. Design Recommendations for Enforcement Areas.

Design Feature	Recommendations for Enforcement Area	
	Low-Speed Enforcement	**High-Speed Enforcement**
Locations	• Access points along barrier-separated HOV facilities, such as ramps, reversible lane entrances, and queue bypasses	• Spaced every 3.2–4.8 km (2–3 miles) along the mainline HOV facility
Length	• 30–60 m (100–200 ft)	• 30 m (100 ft) for monitoring only • 394 m (1300 ft) for monitoring and apprehension
Shoulder Width	• 3.6–4.3 m (12–14 ft)	• 4.24.5 m (14–15 ft)
Approach Taper	• 2:1 or 9.1 m (30 ft)	• At least 20:1
Departure Taper	• 10:1 or 45.7 m (150 ft)	• At least 80:1

Enforcement Design Considerations for Specific Facility Types

The ease or difficulty associated with enforcement will be related to the type of HOV facility and specific issues in the area. Each HOV operating concept reflects different enforcement needs, requiring different provisions.

Barrier-Separated Freeway HOV Facilities

Reversible barrier-separated HOV facilities are generally the easiest type of facility to enforce, primarily due to the limited number of access points. Barrier-separated lanes also act as a deterrent to potential misuse since violators are trapped in the lanes with few options to evade detection. Other features of these facilities include:

- Reversible HOV lanes have the fewest number of access points, making surveillance and apprehension at entrances or exits efficient and effective.

- The geometric requirements for a reversible facility provide enforcement pockets within the ramps that can serve as low-speed enforcement areas for the opposing direction.

- Two-way facilities require an enforcement shoulder if mainline enforcement is desired since there are no unused elements of the HOV lane roadway in which enforcement vehicles can perform their operations. Additional design features such as barrier offsets may need

to be considered to help ensure safe places where mainline enforcement can be performed.

- Two-way facilities may have more options for accessing the lanes, reducing the likelihood that enforcement can be performed exclusively at entrances or exits.

Concurrent Flow HOV Lane Facilities

Concurrent flow HOV lanes provide little or no physical separation from the adjacent freeway lanes. As a result, concurrent flow lanes are the most difficult type of HOV lane to enforce since single-occupant vehicles may merge in and out at will. The perception of enforcement, as much as an actual enforcement presence, is an important attribute to managing lane violations on these facilities, and the more effective the design is at meeting this objective, the better enforcement needs are addressed. The following design features are therefore recommended:

- Where full 4.3 m (14 ft) median shoulders are not available, mainline enforcement areas should be considered at regular intervals, with typical spacing of 3.2 to 4.8 km (2 to 3 miles). A sufficient length should be provided to pull over a violator and, once cited, allow the violator to safely reenter the traffic stream. The minimum length required for this operation is approximately 400 m (1300 ft), excluding tapers.

- Adequate space for median shoulders on concurrent flow facilities is tremendously important. The absence of a center median shoulder has an adverse impact on the safety of enforcement activities since police are forced to apprehend violators by taking them across potentially congested general-purpose lanes to the right shoulder of the freeway.

- On buffer-separated facilities, painted buffers between 1.2 m and 3.6 m wide should be avoided since some drivers may perceive and use the space as a breakdown lane.

- Additional safety features, including a protective barrier for the officers monitoring traffic, a median opening that allows the officer to observe both directions of the HOV lane operation, lighting, audible warning markers, and removal of any barrier-top glare screen in the affected area, should be considered when designing for concurrent lane enforcement.

Contraflow HOV Facilities

A contraflow HOV lane typically includes a single entrance area and a single exit although multiple access points may be provided. Generally, two separation approaches are used for contraflow facilities. The first uses plastic pylons that are manually inserted into holes in the pavement to separate the traffic lanes, while the other uses a moveable barrier to create the contraflow HOV lane. Personnel are typically positioned at the upstream entrance to the contraflow lane to monitor and enforce lane operations, and prevent wrong-way maneuvers.

Queue Bypass HOV Facilities

Queue bypass lanes are special HOV priority treatments for HOVs at freeway ramp meters, toll plazas, and ferry landings in some areas. These types of treatments allow HOVs to travel around other vehicles waiting in line at these facilities. The following key points should be considered when designing these types of HOV treatments:

- Enforcement has been one of the major problems associated with HOV bypasses at metered ramps. When motorists have a clear view of the entire length of the ramp, violators are able to tell if enforcement activities are taking place. In this case, it may be desirable to provide screens to obscure enforcement vehicles from the view of motorists.

- Bypass lanes that are physically separated from the general lanes enhance enforcement and safety by eliminating possible interaction between HOVs and general traffic.

- An optional ramp meter signal status indicator that faces the enforcement area may be placed at the HOV bypass. This enables an enforcement officer to determine if vehicles are violating the ramp meter and allows officers to simultaneously enforce both the ramp meter and the HOV bypass lane.

Table 2-2 highlights some of the recommended enforcement features associated with different types of HOV facilities.

Table 2-2. Recommended Enforcement Features for Different Types of HOV Lane Facilities.

Type of HOV Facility	Preferred Enforcement Features	Minimum Enforcement Features
Barrier Separated (Two-Way and Reversible)	• Enforcement areas at entrances and exits • Continuous enforcement shoulder	• Enforcement areas at entrances or exits
Concurrent Flow	• Continuous median (left-side) enforcement shoulders with periodic barrier offsets • Continuous right-side buffers	• Periodic mainline enforcement areas • Monitoring areas • Continuous right-side buffers
Contraflow	• Enforcement area at entrance • Continuous inside shoulder	• Enforcement area at entrance
Queue Bypass Treatments	• Enforcement area on right-side shoulder • Continuous right-side shoulder • Duplicate signal head facing enforcement area at ramp meters	• Enforcement monitoring pad with continuous right-side shoulder downstream

Chapter Five Overview—Enforcement Considerations in HOV Operations

An enforcement program can be considered successful if compliance rates on an HOV facility are within the established goals and if the enforcement function is accomplished in a safe and cost-effective manner. Irrespective of the particular strategies or techniques employed, certain general practices have been shown to enhance the effectiveness and safety of enforcement activities:

Maintain a visible enforcement presence. Enforcement efforts have greater deterrent effect if they are visible to other motorists. Police personnel should conduct apprehensions and issue citations in designated enforcement areas adjacent to the HOV lane. HOV violators should not be removed to other areas of the freeway for ticketing unless there is no room along the facility for safe conduct of these activities.

Use minimally intrusive enforcement techniques. Although visible enforcement is desirable, heavy enforcement can be disruptive to traffic as it usually induces rubbernecking. The California Highway Patrol has been a leader in practicing non-intrusive enforcement techniques and recommends that officers

- Reduce the use of emergency lighting during traffic stops;
- Avoid multiple patrol vehicles at one location;
- Have no more than one car waiting to be ticketed at any time;
- Refrain from standing outside the vehicle; and
- For concurrent flow lanes, release violators cited in the median back into the HOV lane.

General Enforcement Strategies

Enforcement strategies for HOV facilities can generally be categorized into the four basic approaches described below. All of these strategies may be appropriate for consideration with the various types of HOV projects, and the most effective approaches and techniques will vary somewhat for different types of facilities. To some extent, the level of relative priority assigned by the enforcement agency to the HOV enforcement program is usually indicated by the type of enforcement strategy selected.

Routine enforcement represents the normal level of police patrols in an area, irrespective of the presence of an HOV facility. Generally, routine enforcement may be an appropriate strategy if

- An HOV facility has become well established and the violation rate is at a low or locally accepted level;
- The design or operation of an HOV facility makes it relatively easy to monitor; or

- Resources are not available to fund other approaches, leaving routine enforcement as the only alternative available.

Special enforcement is characterized by continuing, systematic manpower allocations and enforcement tactics specifically dedicated to enforce HOV violations. A special enforcement strategy is appropriately employed when the need for HOV enforcement is great, and may employ some of the following approaches:

- Approaches may include assigning an enforcement vehicle specifically to an HOV lane, adding extra patrols in a corridor with an HOV facility, or locating enforcement personnel along a facility during all operating hours.

- Special enforcement activities may be accomplished by reallocating existing personnel, hiring additional enforcement during key operating periods, or utilizing existing personnel on an overtime basis.

Selective enforcement strategies seek to induce a high level of motorist compliance by applying routine and special enforcement strategies in an unscheduled manner, thereby not allowing motorists to predict when enforcement will occur. Such strategies are usually favored under the following situations:

- Selective enforcement is usually applied periodically to specific problem areas where violations of the HOV facility have been observed.

- Selective enforcement may also be undertaken in response to a number of different events, such as opening a new HOV facility, increasing facility vehicle occupancy requirements, extending operating hours, or making other significant operating changes.

- Since the special enforcement activity in a selective enforcement program is of a temporary nature, the extra enforcement personnel are generally made available by a reassignment of manpower from other duties.

Self-enforcement involves self-regulation by HOV lane users and motorists in the general-purpose lanes. Self-enforcement is usually used with other approaches, rather than as the only enforcement strategy. Seattle's HOV Lanes Education and Support (HERO) program provides the best example of a self-policing HOV enforcement effort.

Enforcement Techniques

A variety of enforcement techniques can be used to monitor HOV facilities to enhance compliance. These techniques focus on providing surveillance of the lanes, detecting and apprehending violators, and issuing citations or warnings to violators.

Although no one enforcement technique equates specifically to one type of HOV facility, some approaches may be more appropriate for consideration with certain HOV projects. In addition, most areas use more than one technique. The choice of enforcement technique(s) should be based on factors such as the geometric constraints of the facility, the resources available for enforcement, and the goals and

objectives of the enforcement plan. Table 2-3 highlights some of the comparative advantages of the different enforcement techniques.

Table 2-3. Comparison of Selected Enforcement Techniques.

Enforcement Technique	Advantages	Disadvantages
Stationary Enforcement Patrols	• Time efficient (no pursuit required) • High degree of safety with sufficient lane cross sections • Highly visible enforcement presence • Effective for monitoring and surveillance	• Requires diversion of personnel or additional personnel • Limited locations • Enforcement locations may be circumvented by motorists on facilities with many access points
Roving Enforcement Patrols	• Operate anywhere on the HOV facility • Does not require reallocation of personnel	• Greater apprehension times • Disruptive if shoulder/refuge areas not available • Less favorable vantage point for observation
Team Patrols	• Divides the detection and apprehension tasks • Offers greater flexibility for facilities with non-optimal design elements	• Requires twice the personnel per apprehension • Not supported in jurisdictions where apprehending officer must also witness the violation
Citations or Warnings by Mail	• Greater safety since violators do not have to be apprehended • Requires a smaller refuge area • Highly time efficient	• Currently not supported in law without apprehension of violator • Officer cannot conclusively verify occupancy—greater possibility of error

Stationary patrols involve the assignment of enforcement personnel at specific locations along an HOV facility. These may be dedicated enforcement areas or locations that provide the necessary vantage points and space for enforcement personnel.

Roving enforcement patrols involve enforcement vehicles patrolling the length of the HOV facility, either on the HOV facility or on the adjacent freeway. Further, patrols may cover the total facility, or they may be assigned to specific segments or zones, provided that a safe area for apprehension and citation exists.

Team patrols are various combinations of stationary and roving patrols working in unison to monitor an HOV facility and to apprehend violators. The team approach is generally utilized on HOV projects when it is impossible, or considered unsafe, for a single officer to detect and apprehend a violator. In this case, one officer detects the HOV violation and subsequently informs another officer stationed downstream for the purpose of apprehension.

Citations or warnings by mail may be used by enforcement personnel if they have been granted the legal authority to do so. This eliminates the necessity of stopping a vehicle violating the HOV requirement. The violators may be observed by police officers on the spot or with the aid of cameras and other advanced technologies. Due to successful legal challenges, however, no provisions for issuing citations by mail are currently in effect with HOV facilities.

Management of the Enforcement Plan

A detailed enforcement manual is highly recommended for effectively managing a complex HOV enforcement program. This manual should provide descriptions of the HOV project, system operations, enforcement procedures, and reference information. A detailed enforcement manual will reduce the chances of misunderstandings among project personnel, enforcement officers in the field and enforcement agency management personnel as to the functions and responsibilities of each group. Periodic reviews and updates of the manual should be conducted to reflect subsequent changes in enforcement practices, and incorporate lessons learned. Consideration may also be given to abbreviated versions of the manual that can be used to quickly orient newly reassigned field personnel.

Performance Monitoring

Performance monitoring programs provide the ability to determine if the goals and objectives of an enforcement program are being achieved. Such a monitoring program is required to determine compliance levels, provide a basis for fine-tuning enforcement operations, and identify problems that may need to be addressed. Evaluations may also be needed to meet federal or state requirements.

Basic enforcement data useful for performance monitoring and evaluation include violation rates and the number of citations issued. Beyond these measures, the agency responsible for funding or operating the enforcement program may want to consider the possible benefits that can be derived from an expanded monitoring effort. One of the prime benefits of a comprehensive monitoring program is that it can provide empirical support for operational or policy decisions. This is particularly valuable in the case where budgets for enforcement activities are constrained and operating agencies must find the most efficient means to ensure effective enforcement along the HOV facility.

Communicating Enforcement Information

Public awareness is essential in any new enforcement program. As the level of planned enforcement for an HOV project increases, the need and importance of a public education program increases. The public awareness campaign should be a continuing effort that serves to aid enforcement. If the public is made to understand the HOV operating strategy and its restrictions, the tendency to violate may be reduced. Furthermore, enforcement agencies uniformly concur that a public awareness program that notifies the public of enforcement activities increases the effectiveness of the enforcement effort.

The primary message that should be transmitted with respect to HOV enforcement education should be a simple statement of what the law states and what is prohibited, what will be done if a violation of that law occurs, and what the consequences are if a violator is apprehended or cited. Other messages may be integrated into this, including an explanation of the purposes of enforcement and appeals for mutual cooperation for the public benefit. This information should be provided on an ongoing basis through signing along the facility, as well as in marketing brochures and materials.

Media Relations

Well-placed and positive media stories represent a basic approach to getting key information to the public. This approach is often worth more than paid advertising. A major focus of media relations should be on soliciting the media for help. Press releases and press conferences, editorial board and assignment editor briefings, and media tours can all be used to heighten awareness and increase visibility of the enforcement program. Radio and television talk shows dealing with news, features, or special segments may also be appropriate communication mechanisms. Some areas have also had success working with the local traffic reporters.

A proactive program for dealing with media inquiries can benefit an enforcement program by promoting media perceptions of accessibility. Such perceptions on the part of the media make it more likely that the HOV facility operator and enforcement agencies will be given earlier opportunities for input on enforcement-related media coverage.

Chapter Six Overview—Enforcement Considerations for HOT Facilities

High-occupancy toll lanes are HOV lanes that allow lower-occupancy vehicles to have access to the facility for a toll. In order to make maximum effective use of the available space on HOV lanes, several communities have installed electronic tolling systems on HOV facilities to allow them the flexibility of varying their eligibility and essentially "selling" unused capacity in the HOV lane. While an increasing number of state DOTs are studying the HOT lane concept as a strategy to improve urban highway service, currently, there are only five operating HOT facilities in the United States.

Operational Concepts for HOT Facilities

In the context of HOT lanes, the term "operating concept" refers to the process by which vehicles on the HOT facility are differentiated into toll and HOV users. Two types of operating concept are currently being used on existing HOT facilities:

HOV-ineligibles tagged. Vehicles not meeting the eligibility/occupancy requirements for the HOT facility (those paying to use the facility) are the only vehicles required to have a toll transponder. At a stationary enforcement zone or through roving patrols the vehicle occupancy is first checked, and for vehicles not meeting occupancy requirements the toll payment must also be verified. Automated violation enforcement systems (VES) have thus far not been implemented under this scenario, since not all vehicles are required to have transponders. All HOT facilities, with the exception of SR 91, utilize this operating strategy

Universal tag. Under this operating concept, all vehicles in the HOT lane are required to have a toll transponder, including HOVs, and VES using photographic methods are used to enforce toll payment. Users in vehicles that meet the eligibility/occupancy requirements for the HOT facility (those that get a free or discounted trip) are required to access a special lane to receive a reduced (or zero) toll for the trip. The special lane could be an in-line pullout on the main lanes, or a

pullout lane on a ramp or in a connecting park-and-ride facility. At this discount/credit lane the vehicle occupancy is visually verified. This scenario follows the model used on toll facilities with electronic toll collection (ETC). Currently, SR 91 in Orange County is the only HOT facility to employ this operating strategy.

Enforcement Considerations in HOT Facility Planning

Given the greater institutional and operational complexity associated with HOT projects, the planning process is necessarily more involved. The addition of a toll revenue element magnifies the importance of enforcement, which makes consideration of enforcement issues critically important in the planning stage. The following sections discuss key issues in HOT facility planning.

Identify and Involve Appropriate Entities

HOT projects require an unprecedented degree of multi-agency cooperation. Ownership and operating structures may vary widely and involve organizations ranging from for-profit private sector developers to toll authorities, local planning organizations, transit agencies, and state departments of transportation:

- Early outreach to legislators is crucial to insuring that the requisite legal structures and authority are available to enforcement agencies.
- Depending on the size of the HOT project, planning should include early agreements between enforcement agencies to establish response and enforcement protocols across multiple jurisdictions.
- As the planning process proceeds, outreach to members of the judicial system will be essential if they are to properly understand HOT enforcement and be responsible for upholding the fines and penalties.

Identify Preliminary Enforcement-Related Design and Operational Issues

Given the increasingly critical role of enforcement to the ultimate success of a HOT project, stakeholders should consider design and operation issues that have the potential to disproportionately impact enforcement effectiveness.

Choose an operational concept. The choice between "HOV-ineligibles tagged" and "universal tag" operating concepts is perhaps the most critical decision to be addressed in the planning of HOT facilities since it profoundly influences many aspects of HOT facility design and operations:

- The "HOV-ineligibles tagged" concept, though the dominant choice for current HOT facilities, inherits many of the enforcement difficulties associated with traditional HOV facilities. Ultimately, manual verification by enforcement personnel is necessary to identify both occupancy and toll violations under an "HOV-ineligibles tagged" operating concept.
- A HOT facility under the "universal tag" operating concept is much more amenable to automated enforcement techniques. VES that are state-of-the-practice technologies used by toll authorities for toll

evasion can be readily employed. The principal drawback to this operating concept derives from the requirement for HOV users to seek out their credit or toll exemption by using a separate lane and a specially designated toll reader. The "universal tag" operating concept also requires enabling legislation to mandate universal use of transponders on a HOT facility, which can impose delays for HOT projects on tight deadlines.

Estimate costs and funding. It is essential that realistic HOT enforcement cost estimates be considered early in the planning process since adequate HOT enforcement is an expensive proposition. Available information on HOT enforcement budgets indicates costs ranging from $2300 per lane per km up to $5600 per lane per km ($3700 to $9000 per lane/mile). While enforcement costs for HOT facilities are typically higher than HOV facilities, additional funding sources are available to HOT projects in the form of start-up federal demonstration funds and revenue from toll operations.

Define enforcement objectives. A low level of HOT violations is essential for the long-term success of the facility. Effective enforcement has economic value to the extent that it helps maintain the base of toll users. In contrast, ineffective enforcement can discourage toll-paying commuters if these users perceive that violators are at low risk of incurring penalties for their actions. A related benefit accrues to HOT facility revenue if low-occupancy violators are persuaded by enforcement efforts to become paying toll customers so that they may travel legitimately on the HOT lanes.

The changes wrought to federal law in 2005 by the Safe Accountable Flexible and Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) impose specific performance objectives for HOT facilities. Agencies responsible for HOT facilities must establish, manage, and support an enforcement program that ensures the operating performance of these facilities is not degraded.

Enforcement Considerations in HOT Facility Design

Since nearly all freeway HOT lanes have resulted from conversions of prior HOV facilities, HOT projects have used traditional highway design standards and HOV guidelines maintained by AASHTO, state DOTs, and local governments. Certain facility design elements can have a substantial influence on HOT enforcement effectiveness, among them:

Location of enforcement and observation areas. The type of facility, the type of HOT operating concept, and the capabilities of the technologies used to assist enforcement officers all combine to dictate the most effective observation and enforcement locations on HOT facilities:

- For a barrier-separated facility using a "universal tag" operating concept, HOV traffic may be segregated into a special lane at the tolling area to bypass the ETC readers. Officers in this case need only observe traffic in the special lane for occupancy violations, with toll violations in the non-HOV lane being handled by automatic photo or video enforcement.

- For barrier-separated facilities using an "HOV-ineligibles tagged" operating concept, the presence of toll and HOV traffic on HOT lanes requires enforcement officers to differentiate not only between HOV and non-HOV vehicles, but also between legitimate (toll-paying) and illegitimate low-occupancy vehicles. In the absence of other effective technological countermeasures, it is advantageous to locate some observation and/or enforcement areas slightly downstream of tolling areas on the facility so that officers can observe transponder status (as shown by a roadside indicator beacon) as well as vehicle occupancy in the tolling zone.

- Buffer-separated HOT facilities preclude many of the approaches described above since toll evaders can potentially enter and exit at will along the length of the facility by illegally crossing the buffer. There are thus no optimal stationary locations for toll enforcement of all violators as would exist for barrier-separated facilities. This disadvantage may be overcome though appropriate ETC technology, such as mobile automatic vehicle identification (AVI) readers mounted in roving patrol vehicles.

Facility ingress and egress locations and spacing. The toll aspect of HOT lanes favors more limited access locations. As with HOV lanes, this can be accomplished by using a painted stripe or buffer zone, or a physical barrier. Additional considerations include the following:

- Physical barriers are preferred for permanent HOT lane installations because they provide better access control and are more effective at reducing violations and maintaining premium traffic service. Since there are often significant speed differentials between the general-purpose lanes and HOT lanes, physical barriers also help maintain safety by preventing potential violators from crossing the buffer into the HOT lanes and disrupting the traffic flows.

- Access points and tolling zones should be considered together. For effective tolling, a vehicle must periodically be "captive" in the HOT lane for a sufficient distance so as to guarantee that it passes through a tolling zone. Judicious placement of access and toll areas can help reduce the temptation for vehicles to "dodge" tolls by exiting before the toll zone and re-entering downstream.

Adequate signage. Accurate, informative signs explaining the operational procedures of HOT lane facilities, such as toll information, are important for safety and enforcement. Informed drivers are less likely to commit unsafe last-minute maneuvers or inadvertently violate the HOT lane. Good signage is particularly important when variable tolls are involved. These can involve either time-of-day tolls or a dynamic pricing system that changes price according to the level of congestion in the parallel general-purpose lanes and the availability of excess capacity on the HOT lane(s). Signage for HOT lanes should generally adhere to the standards prescribed for HOV facilities in the federal *Manual on Uniform Traffic Control Devices (MUTCD).*

Enforcement Considerations in HOT Operations

Enforcement programs play an expanded role in HOT operations, due to the increased complexity of the enforcement task and the inherently greater importance of enforcement to the continuing success of a HOT facility. HOT lanes in particular depend on public acceptance of the tolling concept, and effective enforcement provides a visible means of promoting the fairness and integrity of the facility. The following sections discuss key issues in HOT enforcement operations.

Role of Technology

Enforcement personnel must deal with two major types of violations on HOT facilities—those involving a violation of minimum occupancy requirements, and the related problem of toll evasion. Given the limitations of automated technologies and the difficulties of verifying the number of occupants in a vehicle, the enforcement of occupancy requirements mandates routine visual inspection. Toll evasion presents a complementary problem for enforcement personnel, in that visual inspection cannot conclusively verify toll payment, but the problem is readily amenable to technological countermeasures.

Since HOT lanes depend heavily on ETC technology, they can potentially exploit the latest advances in automated toll enforcement. The degree to which toll enforcement can be automated is critically limited by the type of operating concept used on the HOT facility. "Universal tag" facilities can utilize photo or video enforcement systems and mailed citations as the principle enforcement mechanism since all vehicles (including HOV) must have toll transponders to use this type of facility. "HOV-ineligibles tagged" facilities are constrained in their ability to employ automated techniques and instead utilize technologies to assist manual enforcement methods.

Citations and Fines

Violations on most HOT facilities are handled under existing laws regulating HOV lane usage, rather than being classified as toll evasion. It is important in implementing a HOT conversion that existing fines be reviewed and, if necessary, updated. The concept of HOT lanes—selling "unused" capacity in the HOV lanes —means that the potential negative impact of uncontrolled violators on HOT revenue, person-movement capacity, and public approval can be large. Penalties for violations must be adequate to discourage the willful violator such that reliance on dedicated enforcement officers can be minimized. Currently, aggregate penalties on HOT/HOV projects in the United States vary from $45 to $351 for a first offense.

Performance Monitoring

While the information gathered by a monitoring program may not differ substantially from that discussed for HOV facilities, the importance of performance monitoring to continuing enforcement operations can arguably be seen as greater in the context of HOT facilities. Here, each violation has a direct economic impact on the HOT facility in the form of lost revenue from toll evasion. Since all HOT facilities utilize toll revenue to some extent for funding enforcement activities, excessive violations can financially impair enforcement efforts when greater expenditures in this area are most needed. Additionally, performance monitoring has acquired critical importance with recent changes to federal law. State agencies

that allow exceptions to HOV requirements must certify to the secretary of transportation that they have established a program to monitor, assess, and report on the operation of the facility and the impact of HOT vehicles and other low-emission and energy-efficient vehicles.

Chapter Seven Overview—Enforcement Considerations for Exempt Vehicles on HOV Facilities

Exempt vehicles qualify to use HOV facilities without regard to minimum occupancy requirements. The reasons for granting minimum occupancy exemptions may be related to overall HOV goals and objectives, or may be motivated by the desire to recognize or advance a public benefit.

Low-Emission Vehicles

Federal legislation allows states to authorize HOV occupancy exemptions for certain low-emission vehicles as a means of encouraging the purchase and use of these vehicles and improving air quality.

Federal Rules for Low-Emission Vehicles

Federal law permits states to allow two types of low-emission vehicles on HOV facilities. The Safe Accountable Flexible and Efficient Transportation Equity Act: A Legacy for Users of 2005 defines these two types of vehicles:

- **Inherently low-emission vehicles (ILEVs**)
  - Vehicles must be manufactured to use a dedicated non-gasoline clean fuel.
  - Environmental Protection Agency (EPA) certified clean fuels include compressed natural gas (CNG), liquid natural gas (LNG), hydrogen, ethane, methane, or liquified petroleum gas.
  - Clean fuel aftermarket conversion vehicles do not qualify.
- **Low-emission and energy-efficient vehicles (LEEEVs)**
  - LEEEVs include gas/electric hybrids meeting EPA Tier II emission standards and achieving a 50 percent increase in city fuel economy or not less than a 25 percent increase in combined city-highway fuel economy relative to a comparable vehicle that is an internal combustion gasoline fueled vehicle.
  - Alternative fuel vehicles (AFVs) meeting EPA Tier II emission standards also qualify.

SAFETEA-LU contains language outlining the provisions that must be followed to ensure that these vehicles do not seriously degrade operation of an HOV lane. A

state may revoke low-emission vehicle access to HOV lanes if the state determines such action is necessary.

State Rules for Low-Emission Vehicles

Eight states currently have legislation allowing ILEVs or other low-emission vehicles to use HOV lanes without meeting minimum occupancy requirements. Although the terminology differs, most descriptions of ILEVs and low-emission vehicles in the legislation either reference federal guidelines or appear to be in keeping with federal requirements.

Additional legislation in five states—Arizona, California, Colorado, Florida, and Georgia—adds hybrids to the list of vehicles allowed to use HOV lanes without meeting minimum occupancy levels if allowed or approved by federal law or federal agency regulations. California and Virginia already allow hybrid vehicles to access HOV lanes. Now that updated requirements for low-emission vehicles have been enacted under SAFETEA-LU, corresponding state legislation will require varying degrees of modification to better reflect the latest federal rules.

Enforcement Considerations for Low-Emission Vehicles

The challenges posed by exempt vehicles to HOV lane enforcement are more peripheral in nature than those presented by non-exempt vehicles. With the exceptions of Virginia and California, most states report having few registered ILEV or low-emission vehicles. For the comparatively few states that track ILEV or low-emission vehicle usage on HOV facilities, an even smaller number of such vehicles actually operate on the HOV lanes. Enforcement personnel do not usually need to perform the difficult task of verifying the number of occupants in low-emission vehicles, instead relying on external identification insignia. A number of issues may need to be considered when enforcing low-emission vehicle HOV use, among them:

Develop highly visible identifiers. Agencies responsible for enforcement of HOV facilities should play an active role in the design and selection process, and observe the following guidelines:

- Special stickers or decals should be large enough to permit identification at a distance and should be located on areas of the vehicle that can be readily seen by an observing officer.

- Special license plates for low-emission vehicles should incorporate distinctive elements such as graphic insignia and a designated prefix or suffix in the plate number.

- Signs should be posted along the HOV facility indicating permission for low-emission vehicles not meeting occupancy requirements to use the HOV lanes. These signs should incorporate the same design used in the low-emission vehicle identification stickers and plates so that enforcement personnel and motorists may more easily recognize these identifiers.

Determine type of citation and fine. Lawmakers should consider whether violations of the regulations for low-emission vehicles on HOV facilities should be

treated differently from violations of HOV occupancy restrictions. Specific violations may be considered for the failure of a low-emission vehicle to display the appropriate identifiers, and the misuse of low-emission vehicle stickers, decals, or license plates by owners of ineligible vehicles.

Clearly communicate regulations and fines. The regulations for use of the HOV facilities by low-emission vehicles and the penalties for violating these regulations should be clearly communicated to commuters and travelers in the corridors and the general public.

Provide outreach to judicial system. Experience with regular HOV enforcement efforts shows that ensuring that the judicial system is aware of and understands the regulations and fines is important to upholding citations. Extra outreach may be needed with judges and other groups to explain the exemption regulations and the fines and citations associated with violating the regulations.

Communicate potential that exemption may be terminated. Numerous methods are available for communicating the possibility that access to HOV lanes by environmentally friendly vehicles or other exempt vehicles may be terminated in the future or in real time as operating conditions warrant. Potential communication methods should be targeted to the public at large, to travelers in corridors with HOV lanes, and to owners of the exempt vehicles.

Law Enforcement and Emergency Vehicles

Law enforcement and emergency vehicles enjoy explicit exemptions from HOV minimum occupancy requirements under certain conditions. The HOV Program Guidance provided by the Federal Highway Administration (FHWA) states that vehicles operated by federal, state, or local law enforcement personnel may be permitted to use HOV lanes as long as they are clearly marked law enforcement vehicles equipped with rooftop emergency lights and a siren. Officially marked emergency services vehicles, such as ambulances, fire and tow trucks, and emergency medical services vehicles are also allowed to use HOV lanes in areas throughout the country without meeting the minimum occupancy requirements. FHWA guidelines do not include an HOV exemption for unmarked agency vehicles or the personal vehicles of enforcement or emergency services personnel.

Enforcement Considerations for Law Enforcement and Emergency Vehicles

Generally, HOV lane use by law enforcement and emergency vehicles that are clearly marked and equipped with rooftop emergency lights and a siren is relatively low. However, law enforcement and emergency personnel traveling alone in their personal vehicles or in an unmarked agency vehicle when not on duty may be an issue in some areas of the country. In these cases, there is evidence to suggest that the exemption for law enforcement vehicles has been misconstrued to apply more to the driver of the vehicle being a law enforcement officer, rather than to the verification of the vehicle markings or type of vehicle being driven. Key practices for ensuring proper use of the HOV lanes by law enforcement and emergency vehicles include the following:

Establish policies and guidelines on use of HOV lanes by law enforcement and emergency vehicles. It is important to ensure that current policies and guidelines clearly articulate the types of law enforcement and emergency vehicles that can use an HOV lane without meeting the occupancy requirements. Recommended elements of such policies or guidelines include

- A policy stipulating that law enforcement officers using personal vehicles on the HOV lanes, as well as personnel using HOV lanes while driving unmarked government vehicles who are not on duty, should observe vehicle occupancy requirements (specific exceptions to this policy should be clearly noted);
- Guidelines that identify the required vehicle markings for eligible law enforcement and emergency service vehicles; and
- Standard procedures to safely accommodate law enforcement vehicles in emergency status (flashing lights, sirens) while using an HOV lane.

Clearly communicate policies and guidelines. The policies and guidelines should be clearly communicated to the agencies responsible for law enforcement and emergency services, policy makers, and the public. A number of approaches may be used to communicate these policies, including letters or directives from top law enforcement personnel to their staff, information on agency websites, newsletters, bulletins, and outreach through police unions and professional organizations. The guidelines should also be clearly communicated to HOV lane enforcement personnel in standard operating procedures. Enforcement efforts should be monitored to ensure the policies or guidelines are being implemented.

Chapter Eight Overview—Legislative and Judicial Issues in HOV and HOT Enforcement

As rulemaking bodies, legislatures have, within their respective scopes, considerable influence in many areas of HOV and HOT enforcement. The principal areas of legislation most pertinent to enforcement include the authority and jurisdiction of enforcement agencies, vehicle eligibility on HOV/HOT facilities, standards of evidence for violations, provisions for funding of enforcement operations, and the nature and severity of penalties for HOV/HOT violations.

Authorization and Allocation of Powers

The agency responsible for enforcing the operating requirements of an HOV facility must have the legal authority to do so. This authority must include the ability to issue citations to individuals violating vehicle eligibility regulations, vehicle occupancy requirements, hours of operation, speed limits, and other operating regulations.

HOV Facilities

The authorization and allocation of powers for enforcement of freeway HOV facilities is handled through a combination of state regulations and local ordinances, so long as those laws do not conflict with any federal regulations governing the

operation of federal-aid highways. Most commonly, such legislation designates primary responsibility for HOV enforcement to the state patrol or state police. Some states may instead assign primary HOV enforcement responsibilities to local or regional agencies. Other agencies with the power to enforce HOV requirements may include transit authorities.

HOT Facilities

HOT facilities generally require some form of dedicated enforcement, which can often be financed through toll revenue. In addition, HOT facilities may also be operated by private entities. Most state legislation authorizing HOT facilities includes provisions by which the facility operator can enter into contractual arrangements with various state or local enforcement agencies.

Authorized User Classes

Title 23 of the United States Code directs state departments of transportation or other responsible local agencies to establish minimum occupancy requirements for vehicles operating in HOV lanes, and defines exceptions to these requirements for certain classes of vehicles. As amended in 2005 by the Safe Accountable Flexible and Efficient Transportation Equity Act: A Legacy for Users, operating agencies are required to restrict the use of the HOV lanes to vehicles with at least two occupants. Motorcycles are also permitted, subject to safety restrictions that may be imposed by the operating agency. SAFETEA-LU also allows operating agencies to designate exceptions to the minimum occupancy rules for certain classes of vehicles, such as LEEEVs, "deadheading" designated public transit vehicles, and single-occupant vehicles paying a toll. The decision to permit exemptions for toll or low-emission vehicles imposes significant new enforcement and performance monitoring responsibilities on the operating agency. Agencies that allow low-emission vehicles and/or toll SOVs to use the HOV lanes must follow additional federal mandates for operating and monitoring HOV facilities to insure that performance is not degraded. Under SAFETEA-LU, agencies must restrict or eliminate exceptions for these vehicle classes if specific performance criteria are not met.

Admissible Evidence for Violations

Many, if not all, states use civil administrative procedures to deal with HOV violations, and some states have additionally passed legislation pertaining to prima facie evidence of HOV violations as a means of enabling "ticket by mail" enforcement programs. While decriminalization and legislation pertaining to prima facie evidence of vehicle occupancy violations have facilitated adjudication, they have thus far proved inadequate to permit further streamlining of the HOV enforcement process by techniques such as ticket by mail and automatic photo/video enforcement. The following recommendations are made after a review of state laws:

- If not already enacted, consider decriminalization of HOV violations to ease prosecutorial evidentiary burdens and facilitate adjudication.
- Consider additional legislative language to expand the definition of prima facie evidence for HOV violations if viable technologies for automated enforcement emerge.

- For HOT lanes, consider legislation requiring the display of toll transponders or other readily visible identifier.

Funding and Revenue

Funding for continuing enforcement efforts on HOV facilities is limited to that which is available through normal or special legislative appropriations and interagency agreements although the level of funding from these sources may sometimes be substantial. Well-financed enforcement programs such as these are often exceptions, however, and many HOV facilities must make do with budgets that support little more than routine enforcement. Independent continuing sources of revenue, such as the revenue from the collection of HOV fines, are typically not directly available to enforcement agencies although there has been a recent state legislative effort to make this source available.

HOT lanes, unlike HOV lanes, do benefit from state legislation that permits the financing of enforcement efforts through toll revenue generated by these facilities. HOV and HOT facilities are also eligible for pre-implementation and implementation federal funds under the Value Pricing Pilot Program (VPPP). These funds can be used to support pre-project study activities and to pay for enforcement planning and implementation costs.

With regard to funding and revenue, the following recommendations are made after a review of state laws:

- For HOV lanes, consider legislation that permits a portion of HOV fine revenue to be allocated toward continuing HOV enforcement efforts.

- For HOT lanes, ensure that authorizing legislation for these facilities contains provisions for reimbursement of enforcement costs from toll revenue.

Citations and Fines

Legislation governing the citation and fine structure for HOV violations incorporate several characteristics, each of which influences the potential effectiveness of enforcement and violator behavior:

Controlling legislation. Laws for HOV violations can be enacted on the state or local level. Alternatively, existing state or local laws can be used to enforce HOV regulations. However, laws explicitly addressing HOV violations at the state level have a greater chance of being uniformly applied.

Type of violation. On buffer-separated or non-separated HOV facilities, enforcement personnel must concern themselves with an additional type of HOV violation. Motorists who violate the buffer or double lines indicating prohibited access to the HOV lane pose a serious safety hazard to traffic in the HOV and general-purpose lanes.

Fine amounts. Fines constitute the chief deterrent against HOV violators. Fine assessments for HOV violations vary widely among the various states, and the

general experience with fines for non-compliance with HOV facility operating requirements is that higher fines equate to lower violations.

License penalties. Next to the potential cost of a ticket, the possible imposition of demerits on a driving record provides the greatest deterrent to potential HOV violators. Demerits or "points" provide an additional weapon with which to combat persistent, repeat violators since the higher insurance premiums and the possible loss of driving privileges resulting from multiple point assessments can impose substantial costs and inconvenience.

The following guidance is offered for HOV citations and fines after a review of state laws:

- Consider enacting state laws that explicitly categorize HOV violations so as to facilitate consistent enforcement and adjudication.
- Consider enacting specific laws for buffer violations on HOV facilities.
- Enact uniform state rules for HOV penalties to reduce inconsistent judicial fine assessments, and to facilitate public awareness of fine amounts.
- Set fine amounts to a level that constitutes a credible deterrent to potential violators.
- Enact escalating fine structures with substantial penalties for repeat offenders.
- Consider multi-year periods for the tracking of repeat offenders to maximize effectiveness of an escalating fine structure.
- Consider changes to motor vehicle codes that would categorize HOV violations as moving violations.
- Consider implementing demerit points for HOV violations to deter repeat violators.

Judicial Support for Citations and Fine Structure

A good enforcement program can be undermined by the judicial branch of government if the judicial branch does not uphold the citations issued by the enforcement agency. If a police officer continually finds his citations being overturned in traffic court, he is often inclined to issue fewer citations for the offense in question. Knowledgeable motorists may also become aware of certain traffic citations that are not being upheld by the traffic court system, particularly if publicized in the news media.

In addition to judicial unfamiliarity with HOV laws, the time spent by officers supplying witness testimony against defendants poses another difficulty for enforcement. These extra hours can increase the expense of enforcement as well as divert manpower, and it is in the best interest for enforcement and judicial agencies

to closely coordinate the scheduling of testimony to minimize any possible delays that officers may experience while performing this activity.

Communication between Enforcement and Judicial Agencies

It is important that judges develop an appreciation for the objectives of the HOV project and the enforcement approach needed to achieve the objectives. Briefings for traffic court judges regarding an HOV facility and its associated traffic regulations can be an important consideration influencing court attitudes. Judicial appreciation of the merits of the HOV facility helps toward developing the proper judicial support for the project. Specifically, the judges should be informed of

- The objectives of the HOV facility project;
- The traffic regulations applied to achieve the objectives;
- The enforcement approach;
- Previous court rulings, if any, on similar projects; and
- The legal basis for the restrictions and enforcement procedure.

Efforts to improve judicial awareness of HOV enforcement issues should commence as early as the planning phase of an HOV or HOT project, and should be intensified in advance of operational changes to the facility.

Chapter Nine Overview—Enforcement Technologies

Most attempts at developing enforcement technologies specifically for HOV facilities have focused on vehicle occupancy detection and eligibility verification. Similar to license plate recognition (LPR) systems, a vehicle occupancy detection system utilizes one or more cameras and illumination sources to collect images from the interior of passing vehicles.

The presence of mixed toll and carpool vehicle traffic on high-occupancy toll lanes adds an additional challenge to effective enforcement. Regular toll lanes are amenable to automated enforcement techniques, such as LPR in combination with AVI. However, usage of toll transponders on HOT lanes is not required for HOVs, while additional verification of vehicle occupancy is needed. Enforcement personnel must not only identify low-occupancy vehicles, but also verify proper toll payment by these vehicles.

Technologies for Vehicle Occupancy Detection

Technologies for occupancy detection systems have been developed and tested over nearly two decades. Systems range in complexity from operator-monitored video cameras to automated processing of infrared composite images. To date, none of these systems are in regular use because they have either proved themselves inadequate for the task or have yet to progress past the point of limited field tests.

No automated occupancy verification system has been able to demonstrate comparable accuracy (low false alarm rate) and reliability to other existing automated systems now in widespread use (e.g., LPR and ETC).

Video systems. Video systems have been deployed in the past for vehicle occupancy detection. While video continues to serve a useful role in HOV facility monitoring, it has not proven adequate for the task of vehicle occupancy verification. The collective experience from several studies and implementation projects has concluded that video methods are not as reliable as live visual inspection.

Infrared and multi-band infrared systems. No occupancy detection systems based on infrared imaging have ever been implemented on HOV facilities although a few recent field tests have been conducted. The primary potential benefit offered by infrared systems is the ability to operate in darkness as well as daylight. Infrared systems otherwise suffer from many of the same shortcomings as conventional video, especially with respect to heat-blocking or metallic vehicle window tint. Infrared systems are also substantially more expensive than conventional video systems.

Technologies for Toll Transponder Verification

Transponder verification refers here to any technologies or methods by which enforcement personnel can receive real-time information on the status of in-vehicle AVI transponders. Existing technology is available for addressing the problem of toll verification on HOT facilities. Solutions commonly involve communicating AVI toll or transponder information to enforcement personnel, allowing them to more fully concentrate on counting vehicle occupants. A transponder verification system ideally should address the most prevalent methods used to evade tolling on HOT facilities, among them:

- **No transponder**. While an enforcement officer can often verify the presence of a transponder by visual inspection, this process may be difficult in poor visibility conditions. Scofflaws may feel more confident in their ability to evade detection by enforcement personnel under these conditions.

- **Malfunctioning transponder.** This form of toll evasion can arise when physical damage or age degrades the performance of the transponder to the point where it can no longer be read by the AVI system.

- **Invalid transponder.** Some HOT facilities are located in areas served by multiple toll authorities. If these authorities do not have interoperability agreements with one another, then transponders issued by another toll authority may be used both to avoid the toll on the HOT facility and to possibly evade visual detection.

- **Masked transponder.** Most HOT programs provide enrollees with a foil-lined pouch that may be used to shield the transponder from detection by the ETC system. This pouch allows enrollees to avoid being charged when they operate a vehicle as a carpool instead of a

low-occupancy vehicle on the HOT lanes. The pouch can be misused, however, if the AVI billing reader is not located within sight of an enforcement or observation area. Violators may then temporarily mask their transponders as they pass under the reader and still have time to replace the transponder in the windshield before they pass an enforcement area.

Technological countermeasures exist for all of the above forms of toll evasion on HOT facilities. As may be expected, the most comprehensive measures have the greatest capability for detection, but even relatively simple systems can effectively combat some forms of toll evasion:

- **Indicator beacon.** One approach to transponder verification uses an AVI-activated overhead beacon mounted on the toll reader gantry to indicate when a toll transponder passes under the reader. Under this approach, enforcement personnel must be within the line of sight of the tolling zone in order to see both the overhead beacon and the triggering vehicle. Also, many ETC systems do not process billing transactions in real time, so this approach cannot determine if a transponder is linked to a valid toll account; it merely indicates that a readable transponder is present in the vehicle.

- **Handheld and in-vehicle systems.** Compact and portable transponder verification systems are available in handheld configurations, which are suitable in situations where a suspected violator has been pulled over by an enforcement officer. In-vehicle transponder verification systems enable enforcement officers to remotely verify transponders while driving alongside or behind vehicles in the HOT lanes.

CHAPTER THREE
ENFORCEMENT CONSIDERATIONS IN HOV FACILITY PLANNING

Chapter at a Glance

This chapter provides an analysis of enforcement considerations in HOV facility planning. The first section of this chapter identifies relevant stakeholders in the facility planning phase and summarizes their respective roles in the enforcement planning process. An overview of pertinent steps in the facility planning process is presented in the next section, noting the role that enforcement considerations should play. The third section of this chapter discusses two facilities, I-394 in Minneapolis and I-495 on Long Island, and briefly examines the operational results of their respective planning approaches.

Section headings in this chapter:

- Stakeholders with Enforcement-Related Planning Roles
- Enforcement Considerations in the HOV Facility Planning Process
- Case Studies: Planning and Enforcement

Stakeholders with Enforcement-Related Planning Roles

A number of agencies and groups should be involved in the planning process for HOV facilities. Most of these groups should remain involved in all subsequent aspects of the HOV lane development. The participation of the appropriate agencies and individuals is key to ensuring that potential enforcement issues are identified and incorporated in the screening of design alternatives, and that all groups have a common understanding of the project. Table 3-1 lists the various stakeholders having direct or indirect impact on enforcement elements in the facility planning phase of a project, and summarizes the roles they may play.

Table 3-1. Enforcement-Related Activities in HOV Facility Planning.

Stakeholder	Potential Roles and Responsibilities
State Department of Transportation	• Overall project responsibility on freeways and state-owned roads • Responsible for planning process or assisting with planning • Staffing multi-agency team or participating on team • Incident management planning
Transit Agency	• Overall project management with transitways • Supporting role on other HOV facilities • Responsible for planning process or assisting with planning • Bus operations planning • Staffing multi-agency team or participating on team
State and Local Police	• Lead role in planning for enforcement components • Coordination with judicial personnel • Participate on multi-agency team • Incident management planning
Local Municipalities	• Responsible for planning process or assisting with planning • Staffing multi-agency team or participating on team
Metropolitan Planning Organization	• May lead regional HOV lane planning efforts or corridor studies • Assist in multi-agency coordination among police agencies • May have policies relating to HOV lane facilities affecting enforcement • Participate on multi-agency team
Federal Agencies—FHWA and Federal Transit Administration (FTA)	• Funding support • Overall approval of steps in planning process • Provide technical assistance on enforcement components • Participate on multi-agency team
Consultants and Contractors	• May be hired to conduct overall planning, alternatives analysis, or other studies or to coordinate the construction activities and schedules • May assist in public education and outreach • May staff or assist with multi-agency teams
Public Groups	• May provide input on enforcement concerns • Provide feedback on public education efforts relating to enforcement
Elected Officials	• Assist in public awareness and education efforts relating to enforcement • Enable legislation facilitating enforcement
Judicial System—State and Local Courts	• Provide support for enforcing fines and penalties
Other Groups Including Fire and Other Emergency Services Personnel, Tow Truck Operations	• Input on facility selection • Assist with incident management planning

Enforcement Considerations in the HOV Facility Planning Process

This section of the chapter examines the role that enforcement considerations should play at each relevant step in the HOV facility-level planning process. Facility design issues, such as the selection of candidate HOV facility types, vehicle eligibility and occupancy requirements, traffic management and surveillance, public awareness, and other related issues, are discussed as they pertain to the enforcement planning process.

Effective enforcement is crucial to the success of an HOV facility. Accordingly, consideration of enforcement issues should occur as early in the planning process as is feasible. Given the relative lack of specific facility details at the regional and corridor level planning stages, the facility planning level is often the point at which substantial consideration of enforcement issues should take place. Early efforts to address enforcement issues in the planning process can facilitate subsequent design and operational decisions, and bring greater awareness and sensitivity on the part of other project members and agencies. This section discusses the pertinent steps in the facility planning process having important enforcement considerations.

Identify and Involve Appropriate Stakeholders

Care should be taken to ensure all relevant stakeholders are included in the facility planning process. Depending on the design of the facility, different agencies may have overall project responsibility. No matter which agency takes the lead, state and local police involvement during the planning process will ensure that the needs of enforcement personnel are being addressed and that the facility being planned will be enforceable. As the project evolves, this becomes more critical.

As the planning process proceeds, it is beneficial to also include members of the judicial system that will be responsible for enforcing the fines and penalties. Legislators may also need to be consulted during the planning process if existing laws affecting HOV facility enforcement require modification. Depending on the jurisdictional boundaries of the HOV project, the responsibility for enforcement could reside with the state, county, or municipal governments or any combination of the three. Policing jurisdictions may be reluctant to get involved or even participate in the planning if there are no formal arrangements; therefore, enforcement responsibilities need to be discussed early on. As will be discussed in Chapter Eight, the legal and judicial environment can either augment or hobble the effectiveness of HOV enforcement.

Identify Preliminary Enforcement-Related Design and Operational Issues

Identifying potential enforcement issues related to the design and operation of HOV facilities can serve the interests of both planners and enforcement agencies. Some of the more salient issues are discussed below.

Design Screening

The degree to which an HOV facility can be effectively enforced is profoundly dependent on both the type of facility and the presence of adequate enforcement and/or refuge areas. As recommended in design references such as the NCHRP *HOV Systems Manual*[1] and the AASHTO *Guide for the Design of High-Occupancy Vehicle Facilities*[2], a minimum 4.3 m (14 ft) shoulder provides enhanced safety and the many favorable options for enforcement locations along an HOV facility. Various alternatives for design cross sections are presented in Chapter Four. Traffic law enforcement personnel should be intimately involved in this aspect of the planning process to obtain their valuable insight into the nature of possible enforcement problems that may be encountered, and to gain their support and sensitivity to the constraints within which the transportation engineer has to work. In many cases, compromises may have to be made in terms of the final design concept and/or the desired enforcement program. The constraints within which both the design agency and the enforcement agency must work should be clearly defined and mutually understood.

Funding and Costs

Funding for enforcement is another consideration that must be addressed in the planning process. The physical elements of planning, designing, and constructing enforcement areas may be eligible for federal funding. However the actual ongoing enforcement will depend on the agency with the enforcement responsibility. Depending on which agency assumes this responsibility, funding may have to compete with all types of enforcement as well as other, more critical responsibilities of the entire state. Without additional funds specifically earmarked for HOV enforcement, an enforcement agency may feel that it cannot justify the reallocation of certain peak hour safety-related patrols. In cases where transit police or other agency personnel are used for enforcement, a higher priority may be given to the enforcement of the HOV lane.

A combination of local and state funds is typically used to finance ongoing enforcement efforts. Additional sources of funding for enhanced enforcement efforts are often difficult to procure. Even traditional revenue from penalties is seldom redirected back into HOV enforcement activities. Some facilities have been able to secure federal earmarks for HOV enforcement—federal Surface Transportation Program funds are used to partially finance enforcement activities along the Long Island Expressway HOV lanes[3]. State departments of transportation, in coordination with enforcement agencies, must consider the trade-offs associated with providing design features that are more easily enforced. The extra upfront construction costs necessitated by these features can provide greater safety for enforcement personnel, who can in turn more efficiently maintain a low violation rate.

Enforcement Staffing and Scheduling

The number of enforcement personnel assigned to cover an HOV facility can be highly variable between very similar projects. The level of effort assigned to each HOV project is dependent on many factors, with the most significant ones being facility length, facility operation, the degree to which a facility is conducive to enforcement activities, the types of enforcement strategies, and the availability of enforcement personnel[4]. Enforcement agencies also need to consider additional

institutional and human resource issues when assessing the manpower requirements for HOV enforcement:

- Most enforcement personnel are sworn peace officers because of the obvious need to cite moving violations. Opportunities may exist to have non-sworn personnel assist in enforcement activities such as spotting violators, and should be explored if feasible within the constraints of the facility design.
- The time spent by peace officers supplying witness testimony against violators can increase the expense of enforcement as well as divert manpower, and it is in the best interest for enforcement and judicial agencies to closely coordinate the scheduling of testimony to minimize this time. This issue is explored more thoroughly in Chapter Eight.
- Generally, HOV facilities will require at least occasional periods of elevated enforcement effort to maintain acceptably low violation rates. Enforcement agencies need to consider how the manpower requirements for these periods can be met, whether by temporary officer reassignment, overtime duty, or cooperation between different enforcement agencies.

Identify Objectives

In the context of enforcement, the general overriding objectives in planning an HOV facility are to achieve a low level of violations and a high level of safety. Generally, the target violation rate of 10 percent or less is commonly held as a suitable objective. Violation rates under 5 percent are generally considered "good," while violation rates exceeding 20 percent are regarded as unacceptably high. Target violation rates may be influenced by the type of HOV facility, with contraflow and barrier-separated facilities having the lowest rates (typically 0 to 10 percent) and non-separated contraflow facilities having the highest rates (10 to 20 percent). For example, the Caltrans *High-Occupancy Vehicle (HOV) Guidelines for Planning, Design, and Operations*[5] recommends violation rates under 10 percent—most HOV facilities in the southern part of the state are buffer-separated concurrent flow, while those in the northern part are not.

Case Study: Planning and Enforcement

The effects of differing approaches to HOV facility planning on enforcement are illustrated in the following examples. It should be noted that the difficulties in Minneapolis' planning process, described below, were not repeated when the facilities were successfully upgraded to HOT operations in 2005 (this facility is examined again in Chapter Six and Chapter Nine).

Minneapolis, Minnesota—I-394 and I-35W

On I-394 in Minneapolis, the section of the HOV project nearest downtown was a two-lane, barrier-separated reversible roadway 5 km (3 miles) in length (see Figure 3-1). Further out along the corridor, the HOV facility had transitioned to 6.5 km (4 miles) of part-time non-separated concurrent flow lanes, with signing and pavement markings distinguishing the HOV facility (shown in Figure 3-2).

Figure 3-1. I-394 Barrier-Separated HOV Lane before HOT Conversion

The part-time lanes operated in the respective peak direction/period to coincide with the reversible lanes. Prior to their conversion to HOT operation in 2005 as the MnPASS I-394 Express Lanes, the HOV lanes on I-394, as well as those on I-35W, were underutilized and suffered from excessive occupancy violations. The concurrent flow lanes on I-35W had high average peak period violation rates of 33 to 41 percent. Average peak period violation rates along the barrier-separated section of the I-394 facility ranged from 6 percent to 12 percent, while the concurrent flow sections reported rates of 19 to 24 percent.

Enforcement officers had limited options for enforcement areas along the HOV facilities, and could only use the entrance and exit areas at each end of the barrier-separated section of the I-394 HOV lanes. The relatively open design of the concurrent flow lanes made enforcement difficult because it afforded violators easy opportunity and made enforcement activity far too prominent. The apprehension of violators on the median shoulders would often result in severe congestion on the general-purpose lanes due to onlooker delay. Enforcement was therefore restricted to roving patrols, which had to pull violators across the general-use lanes to the far right shoulder.

Figure 3-2. I-394 Non-separated HOV Lane before HOT Conversion

Many of the design deficiencies of the HOV facilities can be traced to an unproductive relationship between the Minnesota Department of Transportation and the enforcement agencies during the planning and design phases of the project. Enforcement agencies were not successful in their efforts to have additional desired enforcement elements incorporated into the facility design. As a result, the concurrent flow sections of the facilities were seldom enforced. However, with the conversion of I-394 to HOT operation, enforcement resources have been increased and early results indicate a drop in overall I-394 violation rates to approximately 10 percent.

Long Island, New York—I-495

The Long Island Expressway (LIE) HOV lane system is a two-way buffer-separated concurrent flow facility. It extends 64 km (40 miles) between the Queens/Nassau County border and Interchange 64 (State Route 112 in Medford). At a number of locations, access between directions for enforcement vehicles is provided via a slip ramp break in the concrete median barrier. This design enables official vehicles to park protected while observing traffic. Enforcement is provided by the Nassau County and Suffolk County Police Departments under a contract with the New York State Department of Transportation.

The LIE HOV lanes are limited access, allowing vehicles to enter or to exit only at designated locations. Crossing the buffer is a violation of law. Entrances are distinguished from exits, marked with overhead signs and pavement striping.

Figure 3-3. I-495 Buffer-Separated HOV Lanes

The typical HOV lane cross section varies by location. Generally, the segments east of Interchange 49 include a 3.7 m (12 ft) HOV travel lane in each direction that is separated from the general-purpose lanes by a 1.2 m (4 ft) painted buffer, and a nearly continuous 3.0 m–4.2 m (10–14 ft) median shoulder (as seen in Figure 3-3). The shoulders are used for enforcement pullovers and vehicle breakdowns.

To the west of Interchange 49, a 3.7 m (12 ft) lane is provided in each direction, but the buffer separating the HOV lane from the general-purpose lanes is reduced from 1.2 m (4 ft) to 0.6 m (2 ft), and the left-hand shoulder is typically replaced by a 0.6 m (2 ft) to 1.2 m (4 ft) buffer from the median barrier. In these narrower cross sections, enforcement areas are provided to the immediate left of the HOV lane at discrete locations.

Along segments to the east of Interchange 40, acceleration/merging lanes (at HOV lane entrances) and deceleration/merging lanes (at HOV lane exits) are provided (see Figure 3-4). However, along the segment to the west of Interchange 40, no such merging lanes can be provided due to constricted width of the LIE in the area. Table 3-2 summarizes the cross-sectional differences between the eastern and western segments of the LIE HOV lanes.

Figure 3-4. HOV Slip Ramp—I-495

Table 3-2. Cross-Section Design Features of the LIE HOV Lanes.

Design Feature	Location	
	West of Interchange 49	**East of Interchange 49**
HOV Lane Width	3.7 m (12 ft)	3.7 m (12 ft)
Median Shoulder Width	0.6–1.2 m (2–4 ft)	3.0–4.2 m (10–14 ft)
Buffer Width	0.6 m (2 ft)	1.2 m (4 ft)
Access to HOV Lane	Lane Change	Slip Ramp

The planning process for the Long Island Expressway HOV lanes benefited from the active involvement and input from enforcement agencies. When the planning for HOV lane operation was begun, the LIE HOV Task Force discussed at length many enforcement issues including the types of enforcement strategies that may be employed. In 1992, the New York State Department of Transportation (NYSDOT) arranged a field trip to Los Angeles and Orange Counties, California, for itself and key stakeholders, including representatives of the Nassau County and Suffolk County Police Departments and AAA of New York. An intensive two-day seminar was conducted involving panel discussions, meetings, and field observation of HOV lane operation and enforcement strategies. A report was prepared summarizing the lessons learned from the field trip, and included recommendations for a highly visible, dedicated enforcement strategy with a modest fine structure. HOV lane enforcement is accomplished via contracts with both Nassau and Suffolk County police departments, who provide dedicated, highly visible enforcement during weekday peak periods. The contracts, which are managed and administered by NYSDOT, are financed with federal surface transportation and other state funds. Peak period occupancy violation rates are approximately 5 percent on the facility, based on occupancy counts last taken in 1999 by overhead (viewing from overpasses) observers along the facility.

CHAPTER FOUR
ENFORCEMENT CONSIDERATIONS IN HOV FACILITY DESIGN

Chapter at a Glance

This chapter provides an analysis of enforcement considerations in HOV facility design. The first section of this chapter identifies relevant stakeholders in the facility planning phase and summarizes their respective roles in the enforcement design process. An overview of the facility design process is presented in the next section, noting the role that enforcement considerations should play at each step in this process. The third section of this chapter addresses key facility design issues affecting enforcement, and the concluding section discusses enforcement design considerations for the main types of HOV facilities.

Section headings in this chapter:

- Stakeholders with Enforcement-Related Design Roles
- Enforcement Concerns in the HOV Facility Design Process
- General Enforcement Considerations in HOV Facility Design
- Enforcement Design Considerations for Specific Facility Types

Stakeholders with Enforcement-Related Design Roles

As in the planning phase for an HOV facility, numerous agencies and groups will be involved in designing a project. The participation of the appropriate agencies and individuals is key to ensuring that all groups are involved in discussing the different design elements, that potential enforcement issues are identified and resolved prior to implementation, and that all groups have a common understanding of the project.

If a multi-agency committee or a multi-department team within an agency was formed during the planning phase of a project, this group may continue through the design process. A special subgroup or committee, comprised of the design personnel from various agencies, may be organized to address the specific design issues with HOV facilities. Table 4-1 lists the various stakeholders having direct or indirect impact on enforcement elements in the facility design phase of a project, and summarizes the roles they may play.

Table 4-1. Stakeholders with Enforcement-Related Design Roles.

Stakeholder	Enforcement-Related Design Role
State Department of Transportation	• Overall project management responsibilities with freeway projects • Lead on freeway HOV facility design • Traffic and incident management
Transit Agency	• Assist with facility design
State and Local Police	• Assist with design of enforcement elements • Traffic and incident management
State Highway Patrol	• Assist with design of enforcement elements • Traffic and incident management
Local Municipalities	• Assist with facility design • Coordinate with local roadway design access to HOV facility
Metropolitan Planning Organization	• Assist with facility design • Facilitate multi-agency cooperation
Federal Agencies—FHWA and FTA	• Funding support for facility design • Possible approval of design or steps in design process • Technical assistance on facility design
Other Stakeholders Including Rideshare Agencies, Emergency Medical Services, Tow-Truck Operators, Neighborhood Associations, Businesses, and the Judicial System	• Input on operational aspects of facility design elements

Enforcement Concerns in the HOV Facility Design Process

The design process for HOV facilities involves a number of steps, beginning with a review of the recommendations from the planning process and continuing to the selection of the final preferred design. This section reviews the various steps in the facility design process as identified in the NCHRP *HOV Systems Manual*[1]. In the following descriptions, enforcement-related design issues are noted at the relevant steps in the design process.

1. **Review recommendations from planning process.** At this initial stage of the design process, the results or recommendations from the planning process (typically a limited number of alternatives) are considered.

2. **Consider operational issues and opportunities.** The operating characteristics associated with the recommended HOV application should be considered early in the design process. Reviewing the operational issues and the opportunities related to the selected HOV alternative can assist in

identifying critical elements that may need to be addressed in the project design. The project design team, in consultation with state and local law enforcement, should be cognizant of the possible difficulties to enforcement posed by a particular HOV design alternative. Ideally, the feasibility, safety, and estimated operational costs of effective enforcement should play important roles in selection of facility design alternatives. Approaches to address these concerns can then be incorporated into the facility design.

3. **Obtain input from the public and local organizations.** The public involvement process started in the planning phase of a project should continue through the design process. Providing the public, business and neighborhood groups, and other organizations with the opportunity to participate early in the design process will help identify any issues and concerns that will need to be addressed.

4. **Assess specific characteristics of freeway/corridor.** The characteristics of the freeway being considered for the HOV project are examined in this step. Detailed assessments should be conducted for factors that may impose significant constraints on enforcement effectiveness, such as available right-of-way, intersection spacing, topographical contours and profiles, and corridor bottleneck locations. Although many of these items will have been examined in the planning stage, a more detailed analysis is usually needed in the design process.

5. **Develop preliminary designs.** This step includes the development of the preliminary designs for the specific HOV project. Although the complexity and level of detail will vary depending on the type of treatments considered, the design should be completed to a stage that allows all groups to understand the key enforcement components of the facility, to develop realistic cost estimates, and to outline an implementation schedule. Planners and project designers, in cooperation with enforcement agencies, should estimate the potential impact of each design alternative upon enforcement operations.

6. **Review preliminary designs with the public and local organizations.** The preliminary designs should be reviewed by the public, business and neighborhood groups, and other organizations along the freeway or corridor. Public education efforts to describe the basic enforcement parameters of the HOV project should be developed at this step. Essential information should be transmitted, including what the law states regarding use of the facility, what will be done if a violation occurs, and what the consequences are if a violator is apprehended and/or cited. Techniques for public involvement at this stage may include hearings, meetings, workshops, outreach efforts, newsletters, and other approaches.

7. **Select and finalize preferred design.** The comments received through the public involvement process should be reviewed, the preferred design selected, and any needed modifications made to the design plan. In selecting a preferred design for implementation, the enforceability of various design alternatives should be taken into consideration. For each design alternative, the project planning and design team should ask

themselves, "How difficult will it be to enforce the restrictions associated with each of these design alternatives?" The enforceability of a design alternative can be assessed in a number of ways, including public acceptability, costs (in terms of manpower and dollars), and probability of success. Possible modifications to the preferred design should be explored to alleviate as many potential enforcement problems as possible. The design can then be finalized and used to develop the plans and specifications for the project, and the actual construction and implementation process initiated.

Once the preferred HOV design concept has been selected, a comprehensive enforcement program should be developed. It is possible that several enforcement strategies, or more specifically several sets of procedures within a given strategy, may be applicable to the realistic enforcement objectives of any given HOV preferential treatment project. A careful review of the local legal environment and state statutory requirements should be made, particularly if innovative enforcement practices are under consideration. Budgetary and manpower constraints can be imposed early in this process to assist in screening out the enforcement strategies that consume resources in excess of those available. A few basic criteria that can be used to judge the performance of the various enforcement options include the projected violation rate and the projected cost of the enforcement program, given the parameters of the final design for the facility.

General Enforcement Considerations in HOV Facility Design

The term "enforcement area" is used to refer to a number of potential design treatments that provide space for police personnel to monitor an HOV facility, to pursue a violator, and to apprehend a violator and issue a citation. Space adjacent to an HOV lane is required for these functions. The enforcement requirements should be coordinated with the enforcement personnel early in the design process. This permits them to become familiar with the concept of the project, anticipate any additional requirements, and make suggestions for the design that may make enforcement simpler, safer, more efficient, and in compliance with state/local law.

Key Enforcement Design Recommendations

A variety of enforcement practices may be used on a facility. The design of enforcement areas should be sufficiently versatile so that enforcement personnel may employ a relative diversity of enforcement strategies. Some key general considerations should remain foremost throughout the facility design process and are described below.

Provide Adequate Shoulders and Vehicle Refuge Areas

HOV lanes should be designed so that they can be safely and efficiently enforced. The safety of police personnel, as well as travelers in the HOV lane and the general-purpose lanes, should be key considerations in the design process. HOV lane project success is jeopardized by poorly designed and unsafe enforcement areas that will not be used. In addition, local or state laws regarding how enforcement is

carried out should be considered. The facility design should therefore be developed in consultation with the enforcement agency.

For any type of HOV facility, a wide continuous 4.3 m (14 ft) shoulder should be provided for enforcement and safety-related activities—space saves lives. If shoulder widths must be narrowed to accommodate overpasses, the length of the restricted cross section should be minimized, and periodic enforcement and refuge zones should be provided. On barrier-separated facilities, full shoulders should be provided on both sides although only one need be 4.3 m (14 ft); see Figure 4-2 in the next section for an illustration. Concurrent flow facilities should incorporate a minimum 4.3 m (14 ft) median shoulder and a 1.2 m (4 ft) buffer adjacent to the general-purpose lanes (see Figure 4-5 in the next section), with periodic bi-directional enforcement areas sheltered by offset concrete barriers (see Figure 4-7 in the next section). Additional details and recommendations for other facility types are discussed in the next section of this chapter.

Choose Proper Locations for Enforcement and Observation Areas

The primary type of infraction that enforcement officers confront is occupancy violation, which requires the ability to see inside a vehicle. Good lighting and good visibility from a safe vantage point are needed to perform these enforcement functions. At the same time, the absence of any vantage point by which enforcement personnel can observe the HOV facility while remaining relatively unobtrusive may telegraph the presence of police and give violators too much warning. Enforcement zones should not be placed under bridge decks, overpasses, or any other location where enforcement personnel may be endangered by falling or thrown debris.

Consider Limiting Facility Access to Enhance Enforcement

The number of access points along an HOV facility contributes to the ease or difficulty with which the facility can be enforced. Barrier-separated facilities possess many of the operational characteristics of "tunnel" facilities, one of which is an irrevocable commitment to using the facility. This attribute makes barrier-separated facilities generally easy to enforce, especially if motorists have no opportunity for access other than at the beginning and the end of the facility (i.e., no intermediate facility access is provided). Contraflow lanes, which often have access points only at the termini of the HOV facility, are therefore among the easiest types of HOV facilities to enforce.

For concurrent flow HOV projects, consider buffer separation with limited access locations. Non-separated lanes do not have the HOV lane physically separated by barriers, traffic posts, or other implements from the general traffic lanes, thereby providing the motorist with a multitude of locations with which to violate the HOV regulations.

Choose Ingress and Egress Locations Carefully

For limited access facilities, locations should be designed to meet the traffic demand but should also be upstream of likely bottleneck locations on the general-purpose lanes, to prevent conflicting weaving maneuvers by HOV and general-purpose lane traffic in congested conditions. This situation occurred in the past at the eastbound HOV lane entrance on the San Bernardino Freeway (I-10) near Los Angeles, California. Here, the left shoulder of the freeway had been repaved and designated as a non-separated concurrent HOV lane leading to the separated facility via slip ramp. The 1-mile long section occurred near a major interchange suffering periodic congestion. Violators would use the HOV lane to bypass most of the congestion and then merge back into the general-purpose lane. In severe congestion, these merge maneuvers would cause additional congestion and accidents.

Recommendations for Dedicated Enforcement Locations

Two general classifications for enforcement areas are often used. These categories relate to the barrier-separated and non-barrier-separated HOV treatments. The two approaches are low-speed enforcement areas at entrance and exit ramps, and high-speed settings along the HOV mainline.

Low-speed enforcement areas are usually located at access points on busways, HOV lanes on separate rights-of-way, and barrier-separated freeway projects. Specific locations may include ramps, reversible lane entrances, and queue bypasses where vehicle speeds are relatively slow, usually below 75 km/hr (45 mph). Low-speed enforcement areas are often designed to provide for monitoring, apprehension, citing of violators, and, where practicable, violator removal from the HOV facility.

High-speed enforcement areas are recommended if an HOV lane includes a number of at-grade access locations with speeds at or above 75 km/hr (45 mph), or lacks continuous shoulders wide enough for enforcement. These areas are usually designed for monitoring traffic or for monitoring and apprehending violators. For either of these activities on barrier-separated facilities, police personnel often prefer that periodic enforcement areas be designed in conjunction with full outside shoulders. Most apprehension activities on these types of facility, if initiated on the HOV lane itself, are performed in the outside shoulder since state vehicle codes require that motorists being pursued by police move to the right. For concurrent flow facilities, where enforcement is usually conducted in the median shoulder, the preference is for periodic enforcement areas to be designed in conjunction with full 1.2 m (4 ft) outside buffers.

Table 4-2 summarizes the design features for low- and high-speed enforcement areas as recommended by the NCHRP *HOV Systems Manual* and the AASHTO *Guide for the Design of High-Occupancy Vehicle Facilities*.

Table 4-2. Design Recommendations for Low- and High-Speed Enforcement Areas[1, 2].

Design Feature	Recommendations for Enforcement Area	
	Low-Speed Enforcement	**High-Speed Enforcement**
Locations	• Access points along barrier-separated HOV facilities, such as ramps, reversible lane entrances, and queue bypasses	• Spaced every 3.2–4.8 km (2–3 miles) along the mainline HOV facility
Length	• 30–60 m (100–200 ft)	• 30 m (100 ft) for monitoring only • 394 m (1300 ft) for monitoring and apprehension
Shoulder Width	• 3.6–4.3 m (12–14 ft)	• 4.2–4.5 m (14–15 ft)
Approach Taper	• 2:1 or 9.1 m (30 ft)	• At least 20:1
Departure Taper	• 10:1 or 45.7 m (150 ft)	• At least 80:1

Enforcement Design Considerations for Specific Facility Types

As mentioned previously, the ease or difficulty associated with enforcement will be related to the type of HOV facility and specific issues in the area. Each HOV operating concept reflects different enforcement needs, requiring different provisions. Table 4-3 highlights some of the attributes associated with enforcing different types of HOV facilities.

Table 4-3. Example Enforcement Attributes Associated with Different Types of HOV Lane Facilities[1, 2].

Type of HOV Facility	Preferred Enforcement Features	Minimum Enforcement Features
Barrier Separated (Two-Way and Reversible)	• Enforcement areas at entrances and exits • Continuous enforcement shoulder	• Enforcement areas at entrances or exits
Concurrent Flow	• Continuous median (left-side) enforcement shoulders with periodic barrier offsets • Continuous right-side buffers	• Periodic mainline enforcement areas • Monitoring areas • Continuous right-side buffers
Contraflow	• Enforcement area at entrance • Continuous inside shoulder	• Enforcement area at entrance
Queue Bypass Treatments	• Enforcement area on right-side shoulder • Continuous right-side shoulder • Duplicate signal head facing enforcement area at ramp meters	• Enforcement monitoring pad with continuous right-side shoulder downstream

Barrier-Separated Freeway HOV Facilities

Two-way and reversible barrier-separated HOV facilities are generally the easiest type of facility to enforce, primarily due to the limited number of access points. Violators can be stopped at entry and exit points, where travel speeds are usually lower. Limiting access to a reversible HOV facility is crucial if the facility is to be operated in a safe and efficient manner. At each end, a system of gates should be considered to prevent wrong-way traffic from entering the facility. In addition to these features, this type of facility should also have a system of dynamic message signs (DMS) that informs commuters of the operational status of the facility (open or closed).

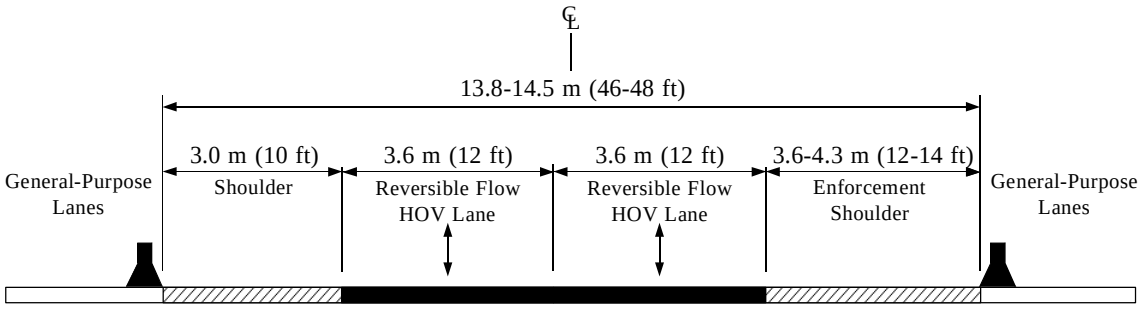
Figure 4-1. US 67 Reversible Barrier-Separated Facility in Dallas, Texas

Reversible Barrier-Separated HOV Facilities

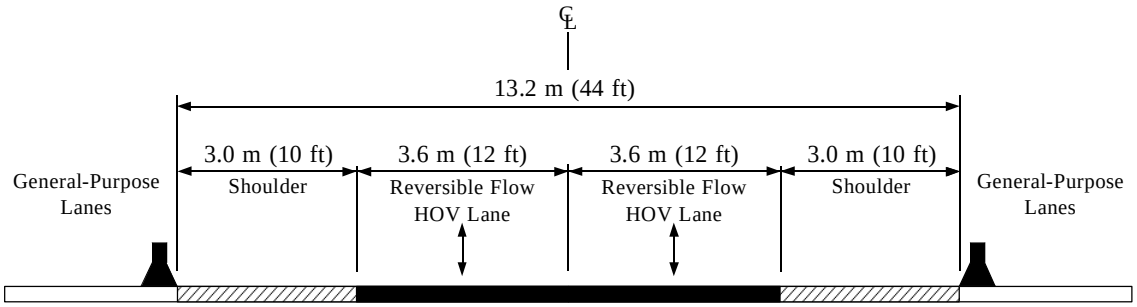
Reversible barrier-separated HOV lanes may be the easiest to enforce. The design of these facilities significantly reduces the number of access points and prohibits random ingress and egress (see Figure 4-1). Most HOV lanes of this type contain from one to five access locations, making surveillance and apprehension at entrances or exits efficient and effective. Barrier-separated lanes also act as a deterrent to potential misuse since violators are trapped in the lanes. In addition, the geometric requirements for a reversible facility provide enforcement pockets within the ramps that can serve as enforcement areas for the opposing direction. In some cases, these pockets are large enough to provide a means of removing violators by sending them out in the off-peak direction, thus penalizing the offending commuter with a travel delay as well. Designated shoulders or

other enforcement pockets located along the lane can serve to facilitate enforcement activities. Figure 4-2 provides examples of cross sections illustrating this approach.

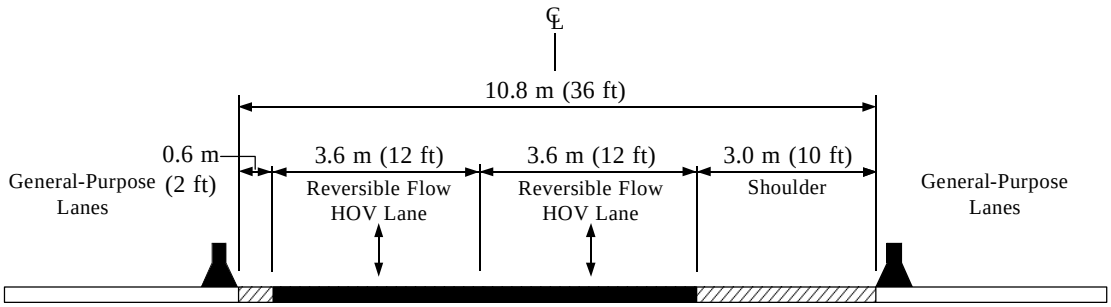
Figure 4-2. Examples of Cross Sections for Barrier-Separated Reversible HOV Lanes



DESIRABLE (WITH ENFORCEMENT SHOULDER)



DESIRABLE



MINIMUM[1]

[1] Operational treatments should be incorporated if the minimum design cross section is used. The minimum cross section should be used as an interim project or over short distances. Increased enforcement and incident management programs should be implemented to successfully operate the facility.

Two-Way Barrier-Separated HOV Facilities

Two-way barrier-separated HOV facilities offer the same advantage of limited ingress and egress as reversible HOV lane facilities. There are two differences, however, which make enforcement more difficult. First, if an enforcement shoulder is not provided, there are no unused elements of the HOV lane roadway in which enforcement vehicles can perform their operations. Second, because there may be more options for accessing the lanes, there is less likelihood that enforcement can be performed exclusively at entrances or exits. Additional design features such as barrier offsets or wider shoulders may need to be considered to help ensure safe places where enforcement can be performed. Enforcement areas at low-speed ramps should be considered as prime locations.

Concurrent Flow HOV Lanes

Concurrent flow HOV lane facilities provide little or no physical separation from the adjacent freeway lanes (see Figures 4-3 and 4-4). As a result, concurrent flow lanes are the most difficult type of HOV lane to enforce since single-occupant vehicles may merge in and out at will. The perception of enforcement, as much as an actual enforcement presence, is an important attribute to managing lane violations on these facilities, and the more effective the design is at meeting this objective, the better the design is at addressing enforcement needs.

A variety of treatments are currently used to separate the HOV lane from the general-purpose lanes, ranging from no separation other than additional paint striping to a narrow painted buffer. Each type of separation presents special enforcement considerations. The single barrier stripe provides separation within existing right–of–way but may limit enforcement capabilities in cases where the enforcement shoulder width is less than 4.3 m (14 ft).

Painted buffers present a different enforcement challenge. If the buffer is wider than 1.2 m (4 ft), some drivers may perceive and use the space as a breakdown lane, causing a safety hazard. Buffers between 1.2 m and 3.6 m wide should therefore be avoided. If limited access points are used with this treatment, weaving movements may be concentrated in these areas.

Figure 4-3. I-90 Non-separated Concurrent Flow Lane near Seattle, Washington

The choice of pavement markings may also influence motorist behavior. Double yellow striped buffers of the type used in California are distinct from ordinary white lane striping, rendering it less likely for motorists to mistakenly cross the buffer. A single white solid stripe separator is at a disadvantage in this regard.

Adequate space for median shoulders on concurrent flow facilities is tremendously important. Many law enforcement agencies such as the California Highway Patrol regard a 4.3 m (14 ft) shoulder width as the bare minimum required, with 4.9 m (16 ft) preferable for vehicle apprehension. The absence of a center median shoulder has an especially adverse impact on the safety of enforcement activities since police are forced to

apprehend violators by taking them across potentially congested general-purpose lanes to the right shoulder of the freeway. Since the issuing of citations takes place away from the HOV lane, passing motorists will only see a routine pullover and will not associate the activity with HOV enforcement. The visibility of HOV enforcement is thus greatly reduced.

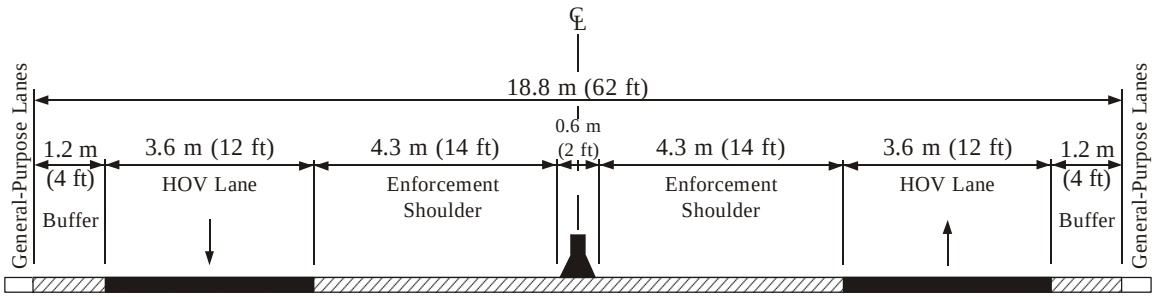
Figure 4-4. I-405 Buffer-Separated HOV Lane in Orange County, California

Figures 4-5 and 4-6 provide example cross sections for buffer-separated and non-separated concurrent flow HOV lanes. Where full 4.3 m (14 ft) median shoulders are not available, mainline enforcement areas should be considered at regular intervals, with typical spacing of 3.2 to 4.8 km (2 to 3 miles). A sufficient length should be provided to pull over a violator and, once cited, allow the violator to safely reenter the traffic stream. The minimum length required for this operation is approximately 400 m (1300 ft), excluding tapers. It should be noted that proper documentation and approval must be obtained for any non-standard features since it is likely that building any mainline enforcement areas will require an approved design exception. Figures 4-7 and 4-8 illustrate schematics for these types of enforcement areas on concurrent flow HOV lanes for various freeway median widths.

Additional safety features should be considered when designing for concurrent lane enforcement. As recommended in the Caltrans *HOV Guidelines for Planning, Design, and Operations*[5], such features include:

- Protective offset concrete barriers for the officers monitoring traffic;
- Median openings in, near, or at the enforcement area that allow the officer to observe both directions of the HOV lane operation;
- Removal of any barrier-top glare screen in the enforcement area; and
- Audible warning markers spaced 1.8 m (6 ft) apart and placed outside the lane striping, running parallel with the enforcement area boundary.

The enforcement area should not be signed or otherwise draw attention to its function, but it may require extra lighting. The median opening design is a particularly beneficial consideration for motorcycle officers who can maneuver within the median opening.



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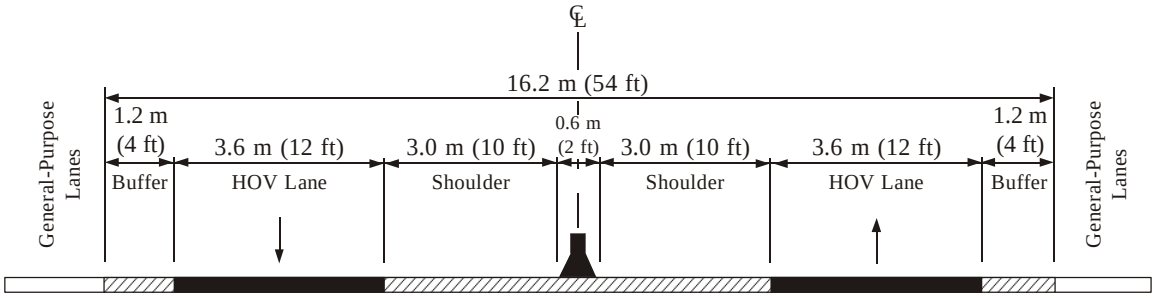

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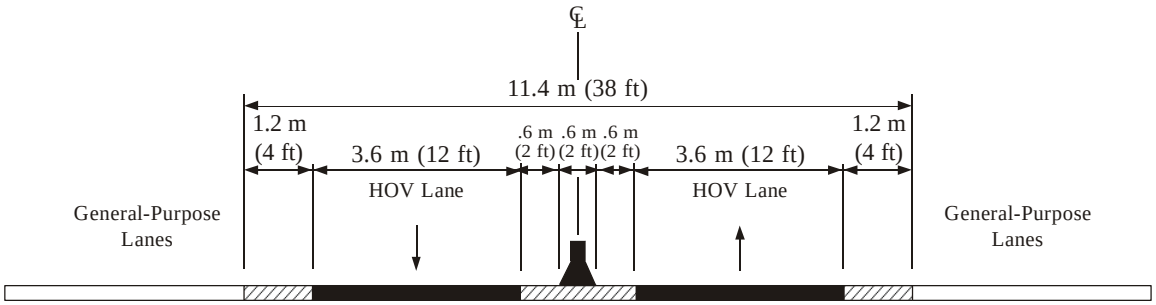
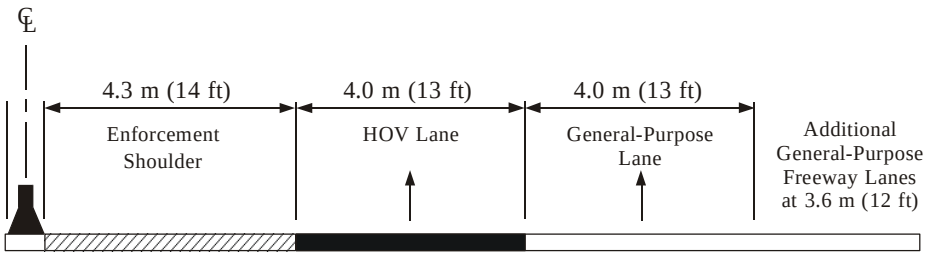


MINIMUM[2]

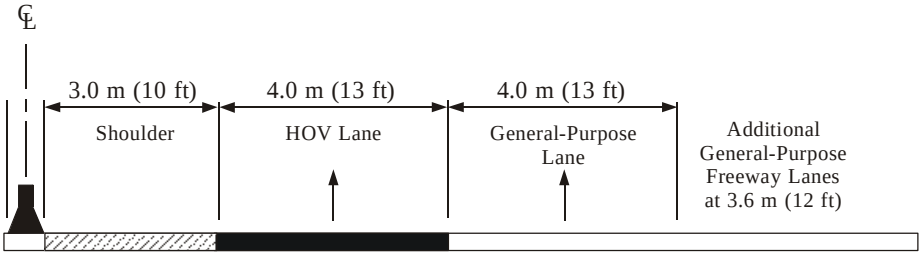
[1] Enforcement personnel should be consulted to determine how and where they intend to identify and issue citations to violators. This will affect the design. Directional or bi-directional enforcement areas that are barrier-protected may be incorporated into these cross sections.

[2] Operational treatments should be incorporated if the minimum design cross section is used. The minimum cross section should be used as an interim project or over short distances. Increased enforcement and incident management programs should be implemented to successfully operate the facility. The designer must also consider the design exception requirements.

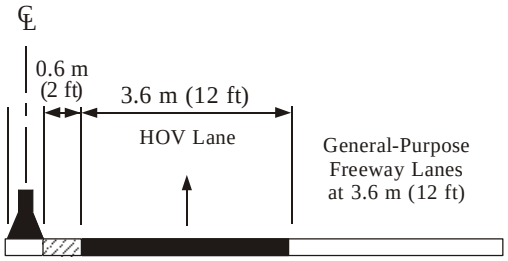
Figure 4-5. Examples of Cross Sections for Buffer-Separated Concurrent Flow HOV Facilities[2]



DESIRABLE[1] (WITH ENFORCEMENT SHOULDERS)



DESIRABLE[1]

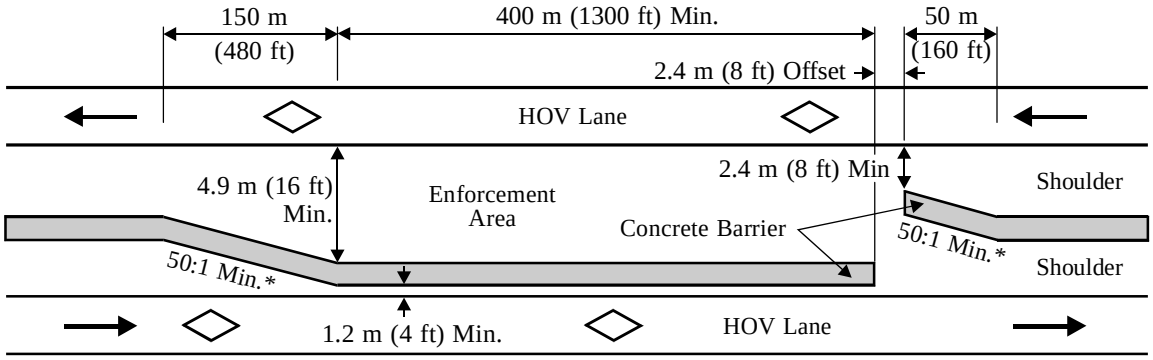


MINIMUM[1,2]

[1] This cross section has been used when the HOV lane will convert to general-purpose traffic use during non-peak periods.

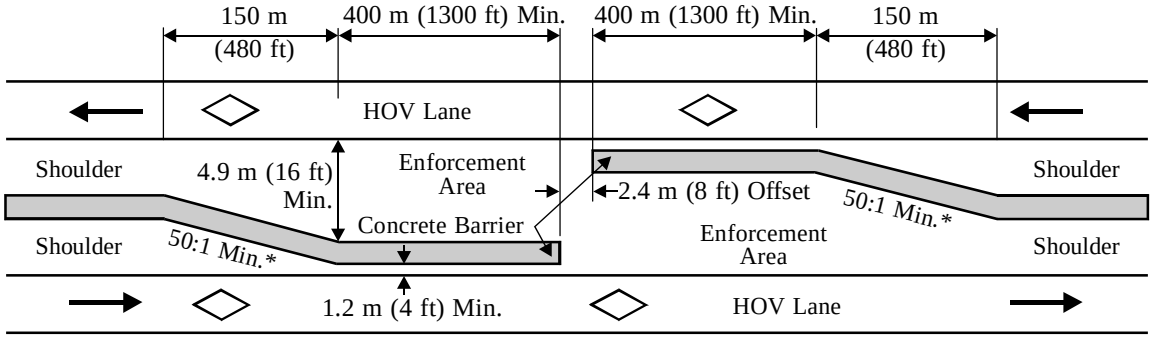
[2] Operational treatments should be incorporated if the minimum design cross section is used. The minimum cross section should be used as an interim project or over short distances. Increased enforcement and incident management programs should be implemented to successfully operate the facility. The designer must also consider the design exception requirements.

Figure 4-6. Examples of Cross Sections for Non-separated Concurrent Flow HOV Facilities[2]



*Minimum taper length based on design speed

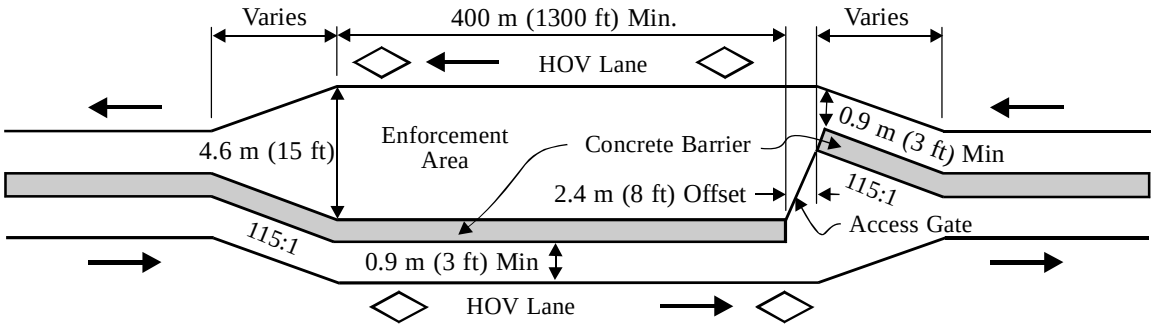
DIRECTIONAL ENFORCEMENT AREA



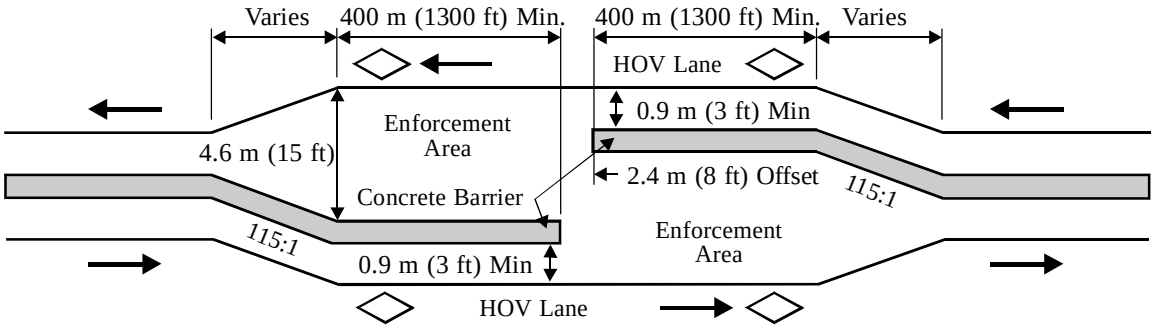
*Minimum taper length based on design speed

BI-DIRECTIONAL ENFORCEMENT AREA

Figure 4-7. Example Median Enforcement Area for Median Widths of 6.6–8.8 m (22–29 ft)[2]



DIRECTIONAL ENFORCEMENT AREA



BI-DIRECTIONAL ENFORCEMENT AREA

Figure 4-8. Example Median Enforcement Area for Median Widths Less than 6.6 m (22 ft)[2]

Figure 4-9 shows a bi-directional enforcement area on SR 57 in Orange County, California. This offset barrier configuration conforms to the design shown in Figure 4-7, with full 4.3 m (14 ft) median shoulders narrowing on the outer side of the barrier to 1.3 m (4 ft) near the median opening. The width of the enforcement area is 4.9 m (16 ft), and the enforcement area extends 370 m (1200 ft) on either side of the median opening.

Figure 4-9. Enforcement Area on SR 57 HOV Lane in Orange County, California

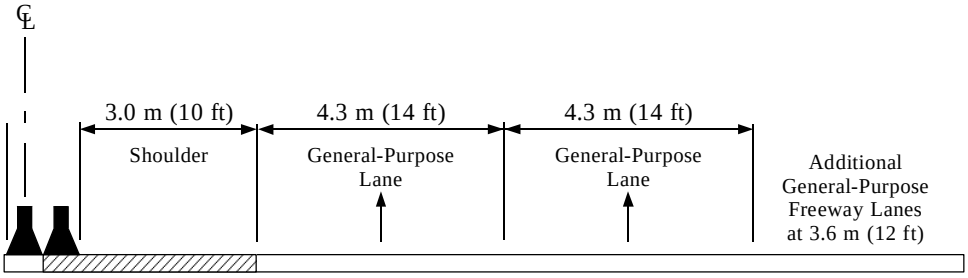
Contraflow HOV Lanes

Generally, two separation approaches are used for contraflow facilities. The first uses plastic pylons inserted into holes in the pavement to separate the traffic lanes, while the other uses a moveable barrier to create the contraflow HOV lane. This technique is used on the East R. L. Thornton Freeway (I-30 East) in Dallas, as seen in Figure 4-10. For enforcement on these types of lanes, personnel are typically positioned at the upstream

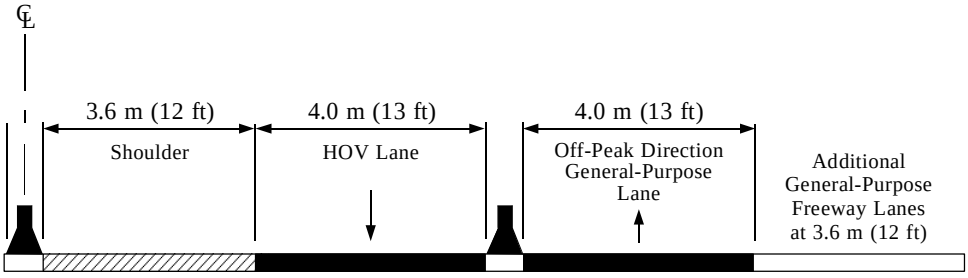
Figure 4-10. I-30 Movable Barrier Contraflow Facility in Dallas, Texas

entrance to the contraflow lane to monitor and enforce lane operations and prevent wrong-way maneuvers.

Contraflow operations typically include a single entrance area and a single exit although multiple access points may be provided. Figure 4-11 shows desirable cross sections for contraflow facilities that provide for a 3.6 m (12 ft) shoulder during operation of the lane. Since contraflow operation involves the "taking" of the inside general-purpose lane in the opposite direction of travel by placement of pylons or a moveable barrier, it is desirable for the width of these lanes to be 4.3 m (14 ft) to accommodate space to either side of the barrier during operation.



DESIRABLE[1] (NON-OPERATING) MOVEABLE BARRIER SEPARATED



DESIRABLE[1] (OPERATING) MOVEABLE BARRIER SEPARATED

[1] Enforcement of this facility is performed at the ends and access locations.

Figure 4-11. Example Cross Sections for Moveable Barrier Contraflow HOV Facilities[2]

Queue Bypass Lanes

In addition to the freeway HOV facilities in separate rights-of-way, there are special HOV priority treatments for HOVs at freeway ramp meters, toll plazas, and ferry landings in some areas. These types of treatments are frequently referred to as "queue bypass projects" since they allow HOVs to travel around single-occupant vehicles waiting in line at these facilities (see Figure 4-12).

A typical freeway metered entrance ramp will consist of one lane or two lanes. The two-lane metered ramp will taper to one lane before merging with the freeway mainline. HOV bypass lanes are generally constructed by widening existing ramps or redesignating one lane of existing multi-lane ramps. Adding an HOV bypass lane on a metered ramp will increase the ramp width to two or three lanes. HOV bypass lanes can be the right or left lane, depending on the geometric configuration of the ramp, and may also be physically separated from the general lanes. This eliminates the interaction between HOVs and general traffic, thereby enhancing safety. Additionally, it helps enforcement officers spot violators by increasing the visibility of the vehicles in the bypass lane. Figure 4-13 shows an example of a separated HOV bypass lane configuration. Minnesota specifies a raised median island to separate the HOV bypass lane from the metered general-purpose lanes. Among other benefits, this detail provides a better vantage point for motorcycle officers.

Figure 4-12. Ramp Meter Bypass in Milwaukee, Wisconsin

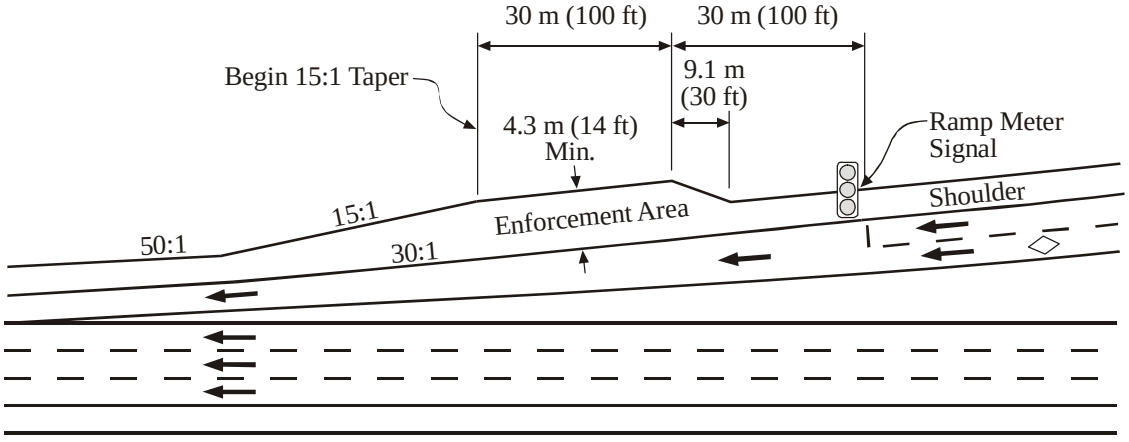


Figure 4-13. Enforcement Area for HOV Bypass Lane at Ramp Meter[2]

Dual-Facing Ramp Meter Indicators:

An optional ramp meter signal status indicator that faces the enforcement area may be placed at the HOV bypass to the ramp meter. This enables an enforcement officer to determine if vehicles are violating the ramp meter and allows the officer to simultaneously enforce both the ramp meter and the HOV bypass lane.

Enforcement has been one of the major problems associated with ramp metering and HOV bypasses. Violations mainly occur where there is a clear view of the ramp and, therefore, violators are able to tell if enforcement activities are taking place. In some cases, it may be desirable to provide screens for enforcement vehicles. This would reduce violations even when enforcement activities are not being conducted. When HOV bypass lanes are separated from the metered general-purpose lanes ("trapping" violators) or limited to buses only (making violators much easier to spot), violations are an inherently riskier affair. In these cases, periodic enforcement is often an effective deterrent to potential violators.

CHAPTER FIVE
ENFORCEMENT CONSIDERATIONS IN HOV FACILITY OPERATIONS

Chapter at a Glance

This chapter focuses on the role of enforcement as it pertains to HOV facility operations. The first section of this chapter identifies the relevant groups and agencies involved in HOV operations and the development of enforcement policies and programs. The next section discusses the components of an enforcement program that pertain to HOV facility operation. Throughout this chapter, examples from selected case studies will be used to illustrate the concepts presented.

Section headings in this chapter:

- Stakeholders Involved in Developing Enforcement Policies and Programs
- General Enforcement Strategies
- Enforcement Techniques
- Enforcement Programs and HOV Operations
- Case Study: Enforcement Operations

Stakeholders Involved in Developing Enforcement Policies and Programs

Representatives from a number of agencies and groups should be involved in the development of HOV enforcement policies and programs. The various groups to be included in the development of enforcement programs and their specific roles are highlighted in Table 5-1.

Enforcement agencies assume a primary role in HOV enforcement programs since they are responsible for day-to-day enforcement operations. As discussed further in Chapter Eight, a combination of state regulations and local ordinances determines which enforcement agency has primary responsibility for enforcement of freeway HOV facilities. Depending on the size and manpower demands of the HOV project, this lead agency may need to develop early agreements with other enforcement agencies to establish response and enforcement protocols across multiple jurisdictions. Any interagency agreements should incorporate adequate scope and flexibility to optimize coordination in staffing, patrol operational area, and scheduling.

Table 5-1. Stakeholders Involved in Developing Enforcement Policies and Programs.

Stakeholder	Potential Roles and Responsibility
State Department of Transportation	• Overall responsibility for freeway HOV facilities • Developing operation and enforcement plan • Operating facility • Staffing multi-agency team or committee
Transit Agency	• Overall project management or supporting role • Developing or assisting with operation and enforcement plan • Bus operations • Enforcement or assisting with enforcement
State Police and/or Highway Patrol	• Possible lead role in developing operation and enforcement plan • Usually responsible for enforcement of freeway HOV facilities • Coordination with judicial personnel
Local Police	• Assist with development of operation and enforcement plan • May assist with enforcement • Coordination with judicial personnel
State and Local Judicial Systems	• Participate in development of the enforcement program • Responsible for enforcing fines and citations for improper use of the HOV facilities
Local Municipalities	• Supporting role with freeway HOV facilities • Developing or assisting with operation and enforcement plan • Participate on multi-agency team
Rideshare Agency	• Assist with development of operation and enforcement plan • Participate on multi-agency team
Metropolitan Planning Organization	• Assist in facilitating meetings and multi-agency coordination • Assist with development of operation and enforcement plan • May have policies relating to HOV facility operation and enforcement
Federal Agencies—FHWA and FTA	• Provide guidance on federal funding for enforcement activities • Technical assistance on enforcement issues
Other Stakeholders Including Emergency Medical Services and Tow-Truck Operators	• Input on aspects of the operation and enforcement plan

General Enforcement Strategies

Enforcement strategies for HOV facilities can generally be categorized into the four basic approaches described below. All of these strategies may be appropriate for consideration with the various types of HOV projects, and the most effective approaches and techniques will vary somewhat for different types of facilities. To some extent, the level of relative priority assigned by the enforcement agency to the HOV enforcement program is usually indicated by the type of enforcement strategy selected.

Routine Enforcement

Routine enforcement represents the normal level of police patrols in an area, irrespective of the presence of an HOV facility. Under a routine enforcement approach, the existence of an HOV project does not significantly alter the enforcement agency's priorities, financing requirements, tactics, or objectives. Police officers assigned to patrol zones containing HOV facilities are typically permitted wide discretion in the degree to which they enforce HOV lane restrictions. The result is often an unequal or random distribution of enforcement effort. This inconsistency in enforcement can be reduced, provided that police management takes steps through policy pronouncements to inform its personnel of the importance of aggressive enforcement activity. Generally, routine enforcement may be an appropriate strategy if

- An HOV facility has become well established and the violation rate is at a low or locally accepted level;
- The design or operation of an HOV facility makes it relatively easy to monitor; or
- Resources are not available to fund other approaches, leaving routine enforcement as the only alternative available.

The Houston and Dallas HOV systems provide examples of the resource-constrained scenario. In both cities, enforcement of the HOV facilities is performed by officers of the respective transit agencies—Dallas Area Rapid Transit (DART) and the Metropolitan Transit Authority of Harris County (METRO). When the Dallas light rail operation came online in 1996, DART shifted its priorities from policing HOV operations to policing rail operations, often leaving only one officer on each lane. A similar reallocation of enforcement resources occurred in 2004, when Houston's light rail system became operational. In both cases, the scaled-down enforcement on the HOV facilities caused a predictable increase in violations. DART is currently staffing up their operations to provide for two officers on each HOV lane.

The initiative to provide an adequate level of enforcement to the HOV project may be absent within the structure of the enforcement agency due to concerns over unsafe vehicle movements associated with the HOV enforcement process (detection, apprehension, and issuance of the citation). A contributing factor to this

tendency may also be the relative exclusion of the enforcement agency from participation in the planning stages of the project, thereby removing a valuable source of information critical to the "enforceability" of the HOV project during its design phase. As mentioned in Chapter Three, the I-394 and I-35W HOV facilities in Minneapolis faced this circumstance. While the entrance and exit points of the I-394 barrier-separated section offered sufficient protection for conducting enforcement operations on a regular basis, the perceived difficulty and danger of enforcing the concurrent flow sections of the HOV lanes discouraged the Minnesota State Patrol from engaging in anything more than sporadic attempts to combat violators on these sections.

Special Enforcement

Special enforcement is characterized by continuing, systematic manpower allocations and enforcement tactics specifically dedicated to enforce HOV violations. A special enforcement strategy is appropriately employed when the need for HOV enforcement is great. Approaches may include assigning an enforcement vehicle specifically to an HOV lane, adding extra patrols in a corridor with an HOV facility, or locating enforcement personnel along a facility during all operating hours. Special enforcement activities may be accomplished by reallocating existing personnel, hiring additional enforcement during key operating periods, or utilizing existing personnel on an overtime basis.

As will be seen in Chapter Six, special enforcement is a common operating feature on most HOT lanes. An example of special enforcement on the HOV system in northern Virginia is presented at the end of this chapter.

Selective Enforcement

The overall purpose of a selective enforcement strategy is to induce a high level of motorist compliance by applying routine and special enforcement strategies in an unscheduled manner, thereby not allowing motorists to predict when enforcement will occur. Selective enforcement is usually applied periodically to specific problem areas where violations of the HOV facility have been observed. Selective enforcement may also be undertaken in response to a number of different events, such as opening a new HOV facility, increasing facility vehicle occupancy requirements, extending operating hours, or making other significant operating changes. Since the special enforcement activity in a selective enforcement program is of a temporary nature, the extra enforcement personnel are generally made available by a reassignment of manpower from other duties.

A high degree of systematic randomization in the scheduling of selective enforcement may enhance the effectiveness of this strategy, as suggested in an evaluation of enforcement efforts on the I-80 HOV lane in northern New Jersey. Part of the study compared the violation rates observed on the facility for several variations of special and selective enforcement. Beginning with five days per week of enforcement, enforcement levels were reduced to three days per week in October 1994. The enforcement program was modified in February 1995 to three random mornings and three random afternoons with four patrol cars. A further change was made in July 1995 to three patrol cars monitoring the lanes during four random AM and PM

periods. The resulting average violation rates were lowest for the case of six random peaks per week, as shown in Table 5-2.

Table 5-2. Violation Rates on I-80 in New Jersey[6, 7].

Enforcement Strategy	Percent Violations	
	I-80 EB	I-80 WB
Five days per week	6.9%	6.0%
Three days per week	9.7%	21.5%
Six random peaks per week (4 patrollers)	4.7%	5.6%
Eight random peaks per week (3 patrollers	7.5%	6.9%

The three day per week regime was least effective, especially for evening (westbound) operation since motorists were able to predict evening police presence based on what they observed on their morning commute.

Self-Enforcement

This strategy involves self-regulation by HOV lane users and motorists in the general-purpose lanes. Self-enforcement is usually used with other approaches, rather than as the only enforcement strategy. Seattle's HOV Lanes Education and Support (HERO) program provides the best example of a self-policing HOV enforcement effort. This approach has subsequently been used in other areas, including Houston, Texas, and the northern Virginia/Washington, D.C., region.

The Seattle, Washington, area's HOV Lanes Education and Support Program is exceptional in its scope and base of support. Begun in 1984, the HERO program is a cooperative effort involving the Washington State Department of Transportation (WSDOT), Washington State Patrol (WSP), and the transit agencies serving the Puget Sound region. Signs (see Figure 5-1) and other communication techniques provide HOV users and non-users with a telephone number they can call to report HOV lane violators. The individuals anonymously report the sighting of a violator and give the license number, time of day, location, and any other supporting information to the HERO telephone operator. Two dedicated full-time WSDOT staff members handle calls and create summaries of aggregated motorist reports. The vehicle data are checked for accuracy in the vehicle registration files, and if they are correct, an information brochure providing information on proper use of the HOV facility, along with a warning notification from the Washington State Department of Transportation, is mailed to the vehicle owner. Violators who are reported multiple times first receive a detailed warning from

Self-Enforcement (HERO) Programs:

- Reporting systems handled by live operators are preferred over automated systems.
- Staffing resources should be able to accommodate anticipated call volumes during peak congestion periods.
- Communication with enforcement personnel is crucial to program effectiveness. Citizen reports can provide valuable feedback to better assist enforcement efforts.

Figure 5-1. HERO Sign on HOV Facilities—Seattle, Washington

WSDOT that identifies the location and time of the observed violation. This is followed by a warning from the Washington State Highway Patrol if the violator is reported three or more times.

The tracking of repeat violators and the active participation by enforcement agencies in the notification process are some of the key features contributing to the success of the program. WSDOT staffers prepare monthly summaries of "violation hot spots" based on citizen reports. The Washington State Patrol receives these summaries on a regular basis and uses them to more efficiently deploy enforcement resources. In 2004, the HERO education program received nearly 36,000 citizen reports of HOV violations, an increase of 13 percent over 2003. Less than 3 percent of violators reported in 2003 were reported a second time, and fewer than 2 percent were reported three or more times[8].

The Virginia Department of Motor Vehicles (DMV) launched a peer enforcement program for the northern Virginia HOV lanes in 1989. Modeled after Seattle's HERO program, it allowed motorists to call a hotline when they witnessed another motorist violating the HOV restrictions. The first offense earned the violator a friendly letter from the DMV with information on HOV restrictions and other educational information. A second violation resulted in a somewhat more forceful letter, and the third violation yielded a letter warning the violator that they could be ticketed if they continued to violate the HOV restrictions.

For the first six months or so the program was very successful, with violation rates going from approximately 40 percent to around 10 percent[9]. However, violators quickly caught on to the fact that there were no teeth behind the warning program, and violations quickly returned to their previous level. After two years, the peer enforcement program was disbanded due to budget cuts.

In Texas, Houston's HERO program of self-enforcement has been operational in the Houston area for nearly 15 years. The program consists of a dedicated phone number that is available for motorists to call and report a violator on any of the HOV lanes. It is an automated system that requires that motorists leave a message about the reported violator. METRO transit police mail a letter to the reported violator warning them of the consequences of violating the HOV lane requirements.

Houston's program, while still operational, suffers from the same deficiency as Virginia's effort. Violators do not perceive the warning notices to be credible in terms of enforcement consequences. Anecdotal evidence suggests that the automated reporting system serves an unintended secondary role as a feedback mechanism for frustrated legitimate HOV lane users.

Enforcement Techniques

A variety of enforcement techniques can be used to monitor HOV facilities to enhance compliance. These techniques focus on providing surveillance of the lanes, detecting and apprehending violators, and issuing citations or warnings to violators. Brief descriptions of each technique are followed by a comparison of relative operational merits and drawbacks in Table 5-3.

Stationary patrols. Stationary patrols involve the assignment of enforcement personnel at specific locations along an HOV facility. These may be dedicated enforcement areas or locations that provide the necessary vantage points and space for enforcement personnel. This technique is normally associated with either special or selective enforcement strategies and would be most appropriately located at entry/exit points to the HOV lane or locations experiencing a high number of HOV violations. As discussed in Chapter Four, enforcement areas should provide adequate space and a safe environment for enforcement personnel to perform all necessary duties. These include monitoring the facility, pursuing a violator, and stopping the violator to issue a citation.

Roving enforcement patrols. This technique involves enforcement vehicles patrolling the length of the HOV facility. Marked or unmarked patrol cars or motorcycles may operate either on the HOV facility or on the adjacent freeway. Further, patrols may cover the total facility, or they may be assigned to specific segments or zones, provided that a safe area for apprehension and citation exists.

Team patrols. This technique uses various combinations of stationary and roving patrols working in unison to monitor an HOV facility and to apprehend violators. Potential combinations may include multiple stationary patrols, multiple roving patrols, or a combination of stationary and roving patrols. The team approach is generally utilized on HOV projects when it is impossible, or considered unsafe, for a single officer to detect and apprehend a violator. In this case, one officer detects the HOV violation and subsequently informs another officer stationed downstream for the purpose of apprehension.

Multipurpose patrols. This technique utilizes patrols or personnel that are assigned multiple functions, including HOV lane enforcement. Responsibilities of these groups may include incident detection and response, operation of the HOV facility, general policing, and enforcement.

Electronic monitoring. Electronic and other advanced technologies may be used to help monitor an HOV facility and to assist in detecting violators. Closed circuit television cameras (CCTV), infrared cameras, photographs of vehicles and license plates, and other technologies may help identify potential violators. As discussed in Chapter Nine, current technologies have yet to surmount the considerable difficulties inherent to vehicle occupancy detection, and no HOV facilities in the United States employ this technique. Electronic monitoring is gaining increasingly widespread use for HOT operations; this application is discussed further in Chapter Six and Chapter Nine.

Citations or warnings by mail. If the legal authority exists, enforcement personnel may be able to issue warnings or citations by mail, eliminating the necessity of stopping a vehicle violating the HOV requirement. The violators may be observed by police officers on the spot or with the aid of cameras and other advanced technologies. Another variant of this technique is the previously discussed HERO program, where warnings and/or program information is mailed to violators.

Currently, no provisions for issuing citations by mail are currently in effect with HOV facilities. In 1989, the Virginia Legislature authorized state police to record the license plate numbers of HOV lane violators and to issue tickets by mail.

Problems arose in the legal system, however, and many citations were not upheld. As a result, the Virginia State Patrol changed procedures to stop the vehicle and record information on the driver. The actual citation is then sent through the mail.

Table 5-3. Comparison of Selected Enforcement Techniques.

Enforcement Technique	Advantages	Disadvantages
Stationary Enforcement Patrols	• Time efficient (no pursuit required) • High degree of safety with sufficient lane cross sections • Highly visible enforcement presence • Effective for monitoring and surveillance	• Requires diversion of personnel or additional personnel • Limited locations • Enforcement locations may be circumvented by motorists on facilities with many access points
Roving Enforcement Patrols	• Operate anywhere on the HOV facility • Does not require reallocation of personnel	• Greater apprehension times • Disruptive if shoulder/refuge areas not available • Less favorable vantage point for observation
Team Patrols	• Divides the detection and apprehension tasks • Offers greater flexibility for facilities with non-optimal design elements	• Requires twice the personnel per apprehension • Not supported in jurisdictions where apprehending officer must also witness the violation
Electronic Monitoring	• Minimal or no enforcement presence • Unobtrusive	• Current technology is less reliable than visual inspection
Citations or Warnings by Mail	• Greater safety since violators do not have to be apprehended • Requires a smaller refuge area • Highly time efficient	• Currently not supported in law without apprehension of violator • Officer cannot conclusively verify occupancy—greater possibility of error

Enforcement Programs and HOV Operations

Enforcement is critical to the successful operation of an HOV facility. The role of an HOV lane enforcement program is to ensure that operating requirements, including vehicle occupancy levels, are maintained to protect eligible vehicles' travel time savings, to discourage unauthorized vehicles, and to maintain a safe operating environment. Visible and effective enforcement maintains the integrity of the HOV facility and can promote public acceptance.

An enforcement program can be considered successful if compliance rates on an HOV facility are within the established goals and if the enforcement function is accomplished in a safe and cost-effective manner. To accomplish these objectives, the most appropriate enforcement techniques should be used with the various types of HOV facilities. Although no one enforcement technique equates specifically to one type of HOV facility, some approaches may be more appropriate for

consideration with certain HOV projects. In addition, most areas use more than one technique.

Key General Practices for Effective Enforcement

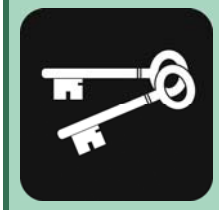
Irrespective of the particular strategies or techniques employed, certain general practices have been shown to enhance the effectiveness and safety of enforcement activities.

Maintain a visible enforcement presence. Enforcement efforts have greater deterrent effect if they are visible to other motorists. Police personnel should conduct apprehensions and issue citations in designated enforcement areas adjacent to the HOV lane. HOV violators should not be removed to other areas of the freeway for ticketing unless there is no room along the facility for safe conduct of these activities.

Use minimally intrusive enforcement techniques. Although visible enforcement is desirable, heavy enforcement can be disruptive to traffic since it usually induces rubbernecking. For example, the Minnesota State Patrol's attempts to provide effective enforcement on the I-394 concurrent flow HOV lane resulted in severe congestion on the general-purpose lanes due to onlooker delay. The induced congestion was so severe that the Minnesota Department of Transportation's (MnDOT) Traffic Management Center activated their changeable message signs to warn drivers of congestion ahead. More recently, enforcement efforts near Exit 166 on the I-95 HOV lane caused an 8-mile backup as motorists slowed and even stopped on the freeway to observe the more than one dozen Virginia State Patrol officers as they pulled over HOV violators.

The California Highway Patrol has been a leader in practicing non-intrusive enforcement techniques and recommends that officers

- Reduce the use of emergency lighting during traffic stops;
- Avoid multiple patrol vehicles at one location;
- Have no more than one car waiting to be ticketed at any time;
- Do not stand outside the vehicle; and
- For concurrent flow lanes, release violators cited in the median back into the HOV lane.



Non-intrusive Enforcement Practices:

Enforcement personnel should be trained in the use of non-intrusive enforcement practices, which minimize the adverse impacts on traffic resulting from enforcement activities.

Enforcement personnel should avoid such practices as:

- Partially blocking HOV lanes while observing or apprehending violators;
- "Ganging" multiple enforcement teams at the same location;
- Leaving flashers on, causing driver distraction; and
- Standing outside their vehicles near the HOV lane.

Failure to employ non-intrusive techniques has been amply shown in practice to cause significant drops in HOV lane traffic speeds and to create unnecessary congestion.

Enforcement Tactics by Facility Type

The approaches currently in use with different types of HOV facilities are summarized below, along with some of the issues that may need to be considered in developing enforcement programs for various types of HOV lanes. Table 5-4 highlights the enforcement strategies and techniques commonly found with various types of HOV facilities.

Table 5-4. Examples of Enforcement Techniques Commonly Found with Various Types of HOV Facilities[1, 2].

HOV Facility	Enforcement Strategies and Techniques
Barrier Separated	• Stationary patrol at beginning or end of lane • Team patrols • Multipurpose patrols • Self-enforcement
Concurrent Flow	• Stationary patrols at enforcement enclaves • Roving enforcement • Team patrols • Multipurpose patrols • Self-enforcement
Contraflow	• Stationary patrols at beginning or end • Multipurpose patrols • Self-enforcement
Queue Bypass	• Stationary patrols at ramp entrance • Self-enforcement

Barrier-Separated HOV Facilities

Barrier-separated HOV facilities are among the easiest to enforce due to limited ingress and egress and the physical separation from the general-purpose lanes. Stationary patrols, team patrols, and multipurpose patrols may all be appropriate for consideration with exclusive HOV lanes. Enforcement areas can be provided at direct access ramps, and at the beginning and end of a facility. Figure 5-2 illustrates a stationary enforcement area at an access ramp on the I-10 HOT lanes in Houston. The use of team enforcement, with one officer located at the beginning or mid-point of a facility radioing information on violators to an officer at the end of the facility where the apprehension takes place, can be an effective technique.

Figure 5-2. Low-Speed Enforcement Area along I-10 HOV Exit Ramp in Houston

Concurrent Flow HOV Facilities

These types of HOV lanes are the most difficult to enforce because violators are able to enter and exit at almost any time throughout the length of the facility. As a result, concurrent flow HOV lanes require extra consideration and increased enforcement. Without an effective enforcement plan, buffer-separated facilities may be susceptible to high violation rates. Selective enforcement using roving and team patrols, in combination with standard apprehension and citation procedures, are used with many concurrent flow facilities. Ensuring that safe and adequate enforcement areas are provided is also critical with the type of facility. Figure 5-3 shows an observation area on the Long Island Expressway. Officers can check occupancy in the adjacent HOV lane, safely protected by barriers, and launch pursuits after violators, who are subsequently apprehended in the median shoulder.

Figure 5-3. High-Speed Enforcement Area along I-495 on Long Island

Contraflow HOV Facilities

Contraflow HOV lanes are often easier to enforce because of limited access—often just a single entrance and exit—and because of limited vehicle eligibility criteria. Enforcement personnel are usually stationed at the beginning and/or end of a lane, and violators can be stopped at these points. Figure 5-4 shows an enforcement area at the entrance to the I-30 movable barrier contraflow lane in Dallas, Texas. To maintain safety for this type of operation, it is very important to stop and remove any errant motorists who inadvertently enter the facility. This necessitates continuous monitoring at the entrance and some means of redirecting ineligible users back into the general-purpose traffic stream. Enforcement of contraflow facilities can be further enhanced with the incorporation of a rejection lane at the entrance to the facility. The rejection lane enables enforcement personnel to apply stationary strategies and procedures to maintain compliance.

Figure 5-4. Enforcement Area on I-30 Contraflow Lane in Dallas, Texas

Queue Bypasses

Techniques for enforcing queue bypasses are limited to a stationary enforcement area. Violations mainly occur where there is a clear view of the ramp, and therefore, violators are able to tell if enforcement activities are taking place. Enforcement may be made more unobtrusive and effective by screening enforcement vehicles from the view of oncoming motorists.

Management of the Enforcement Plan

A detailed enforcement manual is highly recommended for effectively managing a complex HOV enforcement program. This manual should provide descriptions on

the HOV project, system operations, enforcement procedures, and reference information. A detailed enforcement manual will reduce the chances of misunderstandings among project personnel, enforcement officers in the field, and enforcement agency management personnel as to the functions and responsibilities of each group. Periodic reviews and updates of the manual should be conducted to reflect subsequent changes in enforcement practices, and incorporate lessons learned. Consideration may also be given to abbreviated versions of the manual that can be used to quickly orient newly reassigned field personnel.

Performance Monitoring

Performance monitoring programs provide the ability to determine if the goals and objectives of an enforcement program are being achieved. Such a monitoring program is required to determine compliance levels, provide a basis for fine-tuning enforcement operations, and identify problems that may need to be addressed. Evaluations may also be needed to meet federal or state requirements.

Basic enforcement data useful for performance monitoring and evaluation include violation rates and the number of citations issued. Beyond these measures, the agency responsible for funding or operating the enforcement program may want to consider the possible benefits that can be derived from an expanded monitoring effort. One of the prime benefits of a comprehensive monitoring program is that it can provide empirical support for operational or policy decisions. This is particularly valuable in the case where budgets for enforcement activities are constrained, and operating agencies must find the most efficient means to ensure effective enforcement along the HOV facility. Such a monitoring program should include data on manpower as well as tactics and strategies employed, including[4]

- Method of enforcement (officer, officer with video, etc.);
- When the enforcement commenced/ended;
- Where enforcement took place (direction and location);
- Number of police on duty (members supplied and man hours used);
- Summary of violations (number of warnings and citations issued);
- General notes regarding typical response by motoring public and challenges faced in carrying out this type of enforcement; and
- Results from court actions regarding dispute of HOV violations.

Besides the types of data collected, the frequency of collection efforts should be considered as well. Various factors will influence the intensity of monitoring efforts. For example, changes in particular quantitative, qualitative, or substantive aspects of the enforcement program may necessitate heightened monitoring before and after these events, in order to more quickly ascertain the effect on performance.

Procedures for establishing performance monitoring programs can be found in the *HOV Systems Manual* and the soon to be released *HOV Performance Monitoring, Evaluation, and Reporting Handbook*[10]. In addition, the *I-15 Congestion Pricing Project Enforcement Effectiveness and Violation Assessment Report*[11] and the *HOV Lane Violation Study*[12] offer comprehensive examples of enforcement data collection and analysis.

Communicating Enforcement Information to the Public

Public awareness is essential in any new enforcement program. As the level of planned enforcement for an HOV project increases, the need and importance of a public education program increases. The public awareness campaign should be a continuing effort that serves to aid enforcement. If the public is made to understand the HOV operating strategy and its restrictions, the tendency to violate may be reduced. Furthermore, enforcement agencies uniformly concur that a public awareness program that notifies the public of enforcement activities helps to increase the effectiveness of the enforcement effort.

Figure 5-5. HOV Requirements Road Sign on I-270

The primary message that should be transmitted with respect to HOV enforcement education should be a simple statement of what the law states and what is prohibited, what will be done if a violation of that law occurs, and what the consequences are if a violator is apprehended or cited. Other messages may be integrated into this, including an explanation of the purposes of enforcement and appeals for mutual cooperation for the public benefit. This information should be provided on an ongoing basis through signing along the facility, as well as in marketing brochures and materials. Figures 5-5 and 5-6 show examples of HOV signs indicating occupancy requirements and the posted fine for violations of these requirements.

Public perception toward enforcement can also influence proper use of an HOV facility. Visible enforcement can obviously keep violators from using the facility. It also builds a positive perception among non-users that the HOV requirements are being enforced and that the integrity of the facility is being maintained.

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Figure 5-6. California HOV Violation Fine Sign

Media Relations

HOV facilities are usually publicly funded and support public purposes. Well-placed and positive media stories represent a basic approach to getting key information to the public. This approach is often worth more than paid advertising. People read or watch the news more frequently and more closely than they do advertising, leading media experts to estimate the value of news stories at two or more times the value of equivalent advertising[1].

A major focus of media relations should be on soliciting the media for help. Press releases and press conferences, editorial board and assignment editor briefings, and media tours can all be used to heighten awareness and increase visibility of the enforcement program. Radio and television talk shows dealing with news, features, or special segments may also be appropriate communication mechanisms. Some areas have also had success working with the local traffic reporters.

A proactive program for dealing with media inquiries can benefit an enforcement program by promoting media perceptions of accessibility. Such perceptions on the part of the media make it more likely that the HOV facility operator and enforcement agencies will be given earlier opportunities for input on enforcement-related media coverage. The following activities may be appropriate to consider in such a media relations program[1]:

- A media calendar that tracks key events and opportunities to raise the visibility of HOV enforcement through the media;
- A regularly updated media packet that includes camera-ready art, fact sheets, and suggested contacts for interviews and feature stories;
- Specialized media packets for reporters who cover specific beats, such as transportation, public transit, science and technology, or lifestyle reporting;
- Training for key project and enforcement spokespersons that emphasizes the enforcement program message and provides tips for dealing with the media;
- Media protocol outlining procedures, designated spokespersons, and lines of reporting authority on a project; and
- Prepared responses for potentially controversial enforcement program elements or questions.

Case Study: Enforcement Operations

The I-95, I-395, I-66, and Dulles Toll Road HOV lanes serving northern Virginia are the focus of a six-year effort to substantially reduce HOV violations. Increasing congestion and complaints of widespread cheating prompted the Virginia Department of Transportation (VDOT) to convene an HOV Enforcement Task Force in 2003 to find and recommend solutions to improve enforcement. The Task Force includes members from VDOT, State Police, DMV, Department of Environmental Quality, Fairfax County, two northern Virginia transportation commissions, the Council of Government, the Metropolitan Washington Airports Authority, FHWA, and AAA Mid-Atlantic.

The HOV Task Force found rampant HOV violations during the morning peak period, especially within the first half hour of operation. The I-95 HOV lanes were the worst hit, with a 68 percent violation rate in 2002; I-395 had 38 percent for the same initial half hour. Violation rates for the entire peak period were 35 percent and 26 percent for I-95 and I-395, respectively. In response the problem, the HOV Task Force championed tough countermeasures[13], including

- Increase the $140,000 enforcement budget by an additional $250,000 ($390,000 total) for extra enforcement;
- Increase fines for HOV violations, up to $1000 for fourth and subsequent violations and assess 3 points on driving record for second and subsequent violations;
- Adopt a zero-tolerance enforcement policy toward early morning violators—strict enforcement of occupancy requirements commencing immediately at 6 AM, no exceptions; and
- Launch a "No Excuses" public information campaign.

The purpose of the "No Excuses" public information campaign was to notify the public of the change in enforcement policy on the HOV lanes, and explain the necessity and rationale for this change. News releases, press conferences, radio advertising, outreach to traffic reporters, and messages on VDOT's website were used in advance of the new policy, which took effect July 16, 2003. Overhead and portable message signs were used as well to alert motorists to the change.

Once the campaign began, special and selective enforcement was used during the morning peak periods to target problem locations, including I-95 at Newington and I-66 inside the Beltway. Over 18,000 citations had been issued in the 17 months until the next meeting of the HOV Task Force in January 2005. The HOV Task Force found that the stepped up enforcement had reduced overall violation rates during the morning periods somewhat (26 percent to 22 percent on I-395, and 35 percent to 21 percent on I-95) but had mixed results with respect to reducing the number of early morning violators (see Table 5-5)[14]. Stepped up enforcement will therefore continue for the foreseeable future.

Table 5-5. HOV Violation Rates in Northern Virginia[13, 14].

Location	Time	Percent Violators		
		2002	2003	2004
I-395	6:00–6:30	38	59	57
	6:00–9:00	26	21	22
I-95	6:00–6:30	68	52	54
	6:00–9:00	35	31	21
I-66 Inside the Beltway	6:30–7:00	55	34	N/A
	6:30–9:00	38	29	N/A
I-66 Outside the Beltway	5:30–6:00	30	95	N/A
	5:30–9:30	14	28	N/A
Dallas Toll Road	6:30–7:00	60	73	N/A
	6:30–9:00	28	55	N/A

N/A = not available

CHAPTER SIX
ENFORCEMENT CONSIDERATIONS FOR HOT FACILITIES

Chapter at a Glance

This chapter discusses the distinct features, challenges, and approaches to enforcement of high-occupancy toll facilities. The first section of this chapter provides an overview of HOT facilities, including a description of the key characteristics of this type of project, a summary of existing HOT facilities, and a brief discussion of core HOT operating concepts. The next section of this chapter presents the major stakeholders involved in HOT projects, highlighting the possible different roles that traditional stakeholders may assume in the context of HOT development. The next three sections of this chapter investigate the key enforcement concerns unique to the planning, design, and operational phases of a HOT project. The concluding sections of this chapter discuss the implementation approaches and issues encountered in converting HOV facilities in San Diego, Minneapolis, and Houston to HOT operations, and present a case study on the unique aspects of the SR 91 Express Lanes in Orange County, California.

Section headings in this chapter:

- Description of HOT Facilities
- Stakeholders Having Roles in HOT Development and Enforcement
- Enforcement Considerations in HOT Facility Planning
- Enforcement Considerations in HOT Facility Design
- Enforcement Considerations in HOT Facility Operations
- Conversion of HOV Facilities to HOT Facilities
- Case Study: HOT Lane Enforcement

Description of HOT Facilities

High-occupancy toll lanes are HOV lanes that allow lower-occupancy vehicles to have access to the facility for a toll. In order to make maximum effective use of the available space on HOV lanes, some communities have installed electronic tolling systems on one (two in the case of Houston, Texas) of their HOV facilities to allow them the flexibility of varying their eligibility and essentially "selling" unused capacity in the HOV lane. HOT lanes utilize traffic management techniques (pricing and occupancy requirements) in new ways, and in many jurisdictions HOT lanes may involve the introduction of tolls for the first time. These facts may require DOTs to establish new legal and institutional structures and operational capabilities before HOT lane projects can actually be implemented. They may also introduce non-traditional project financing and operational approaches. Most importantly, they introduce public relations challenges that have the potential to bring HOT lane initiatives to an abrupt halt at nearly any stage of their development.

How Are HOT Lanes Different from Traditional Highway and HOV Projects?

The FHWA *Guide for HOT Lane Development*[15] identifies several key features of HOT lanes:

- HOT lanes use market price and other management tools to provide dependable and superior travel conditions, particularly during highly congested peak travel periods.
- HOT lanes provide a new and desirable transportation option for motorists and transit users in congested travel corridors.
- HOT lanes generate revenues that might be used to pay for their implementation or to help underwrite other transportation improvements.
- HOT lanes require considerable attention to roadway management, including monitoring traffic operation and responding to incidents.
- HOT lanes offer new ways to apply traffic management and toll collection technologies.
- HOT lanes require ongoing marketing and pubic awareness outreach efforts.
- HOT lanes are likely to require interagency cooperation.

While an increasing number of state DOTs are studying the HOT lane concept as a strategy to improve urban highway service, currently, there are only five operating HOT facilities in the United States.

I-15 FasTrak—San Diego, California

The I-15 Express Lanes are an existing 13 km (8 mile), two-lane, barrier-separated reversible HOV facility in the median of I-15. Currently, access to the Express Lanes facility is available only at its north and south ends. The I-15 FasTrak program allows single occupancy vehicles to pay a variable toll ranging from $0.75 to $4.00 to use the HOT lanes, which are otherwise reserved for HOV2+ vehicles. In the event of severe traffic congestion, tolls may be raised up to $8.00. The San Diego Association of Governments (SANDAG) operates this facility, which is owned by Caltrans.

SR 91 Express Lanes—Orange County, California

The SR 91 Express Lanes are a 16 km (10 mile), four-lane, two-way HOT facility in the median of an existing highway. Toll rates on the Express Lanes vary from $1.10 to $7.75 by time of day and day of the week. All users of the facility must have a prepaid account and transponder to use the Express Lanes. HOV3+ vehicles ride for free except during evening peak periods in the eastbound direction, when they must pay a 50 percent discounted toll. The Orange County Transportation Authority (OCTA) owns and operates the SR 91 Express Lanes.

Katy Freeway QuickRide—Houston, Texas

The Katy Freeway HOT facility is a 21 km (13 mile), one-lane reversible HOV lane in the median of I-10 in Houston. The QuickRide program allows HOV2 vehicles to pay $2.00 per trip to use the facility during peak periods, while HOV3+ vehicles continue to use the facility at no cost. Customers must have a QuickRide account, transponder, and windshield tag to use the facility. Houston METRO, the transit authority in Harris County, manages the QuickRide program.

Northwest Freeway (US 290) QuickRide—Houston, Texas

This facility is a one-lane, barrier-separated, 25 km (15.5 mile), reversible HOV facility in its median of US 290. From 6:45 AM to 8:00 AM, when the facility serves inbound traffic, HOV3 vehicles may use the lane for free, but HOV2 vehicles must pay $2.00 to use the lane. HOV restrictions during the evening peak period are lower, enabling HOV2+ vehicles at no cost. This facility, like the Katy Freeway HOT lanes, is also operated by Houston METRO.

MnPASS I-394 Express Lane—Minneapolis

This 11-mile long facility combines a 5 km (3 mile) segment of two-lane, barrier-separated reversible HOV lanes with another 13 km (8 miles) of buffer-separated concurrent flow lanes. Single-occupancy vehicles having a MnPASS account and transponder may use the HOV2+ Express Lane for a fee. The fee varies dynamically and depends on traffic conditions and the trip entry and exit points along the facility. Peak period tolls average from $1 to $4, with a maximum of $8. The MnPASS I-394 Express Lane represents the first attempt anywhere to introduce tolling on a facility separated from the general-purpose lanes by only a double-white stripe buffer.

Operational Concepts for HOT Facilities

In the context of HOT lanes, the term "operating concept" refers to the process by which vehicles on the HOT facility are differentiated into toll and HOV users. Two types of operating concepts are currently being used on existing HOT facilities.

HOV-ineligibles tagged

Vehicles not meeting the eligibility/occupancy requirements for the HOT facility (those paying to use the facility) are the only vehicles required to have a toll transponder. At a stationary enforcement zone or through roving patrols the vehicle occupancy is first checked, and for vehicles not meeting occupancy requirements the toll payment must also be verified. Automated violation enforcement systems have thus far not been implemented under this scenario since not all vehicles are required to have transponders. All HOT facilities, with the exception of SR 91, utilize this operating strategy

Universal Tag

Under this operating concept, all vehicles in the HOT lane are required to have a toll transponder, including HOVs, and VES using photographic methods are used to enforce toll payment. Users in vehicles that meet the eligibility/occupancy requirements for the HOT facility (those that get a free or discounted trip) are required to access a special lane to receive a reduced (or zero) toll for the trip. The special lane could be an in-line pullout on the main lanes, or a pullout lane on a ramp or in a connecting park-and-ride facility. At this discount/credit lane the vehicle occupancy is visually verified. This scenario follows the model used on toll facilities with electronic toll collection. Currently, SR 91 in Orange County is the only HOT facility to employ this operating strategy.

Stakeholders Having Roles in HOT Development and Enforcement

The institutional arrangements supporting HOT projects conform to no set formula, reflecting the recent nature of these facilities (first authorized under the Intermodal Surface Transportation Efficiency Act of 1991)[16] and the multifarious approaches employed across the several projects implemented to date. Institutional structures will depend on a variety of factors and are likely to vary from project to project. Assuming prior implementation trends continue, many HOT lane applications may be expected to be developed from conversions of existing HOV lane facilities. When this is the case, existing HOV organizational arrangements are most likely to govern the operation of new HOT projects.

The operational requirements of HOT lanes will at the same time require changes to traditional stakeholder roles and the possible inclusion of new stakeholders. Readers who wish to learn more about some of the more significant changes to traditional institutional roles that arise from the planning, implementation, and operational requirements associated with HOT facilities should refer to the recent FHWA publication, *A Guide for HOT Lane Development*[15].

Table 6-1 lists the stakeholders having redefined or newly significant roles in the planning, design, and operation of HOT facilities.

Table 6-1. Stakeholders Involved in HOT Lane Development and Enforcement.

Stakeholder	Potential Roles and Responsibility
Federal Government, Federal Agencies	• Enacting legislation on HOT policies and appropriations for HOV facilities • Administration of value pricing programs and funding (FHWA) • Provide rules and guidance for HOT facilities and programs (FHWA, FTA)
State and Local Legislators	• Enacting statutes pertinent to HOT enforcement, including the designation of enforcement authority, disposition of HOT revenues, defining HOV regulations, violations, and the adjudication process and penalties.
State Department of Transportation	• Authority to contract multi-agency agreements for HOT operations • Lead agency for federal demonstration funds • Coordination with enforcement agencies
Transit Agency	• May have lead or assisting role in HOT operations • Lead agency for federal demonstration funds • Coordination with enforcement agencies
Toll Authorities	• Authority to implement and operate toll facilities • Project funding for HOT implementation • May have lead role in HOT operations • Coordination with enforcement agencies
Metropolitan Planning Organization	• Lead or assist in HOT planning and solicitation and disbursement of implementation funds • Assist in multi-agency coordination
Private Sector Concession Companies	• May have lead or assisting role in HOT operations • Funding for implementation and enforcement of HOT facilities • Coordination with enforcement agencies
State and Local Police	• Primary or contract enforcement role on HOT facilities • Guidance for enforcement planning in HOV to HOT conversions • Coordination with judicial personnel
State and Local Judicial Systems	• Responsible for enforcing fines and citations for improper use of the HOT facilities

Enforcement Considerations in HOT Facility Planning

Given the greater institutional and operational complexity associated with HOT projects, the planning process is necessarily more involved. The addition of a toll revenue element magnifies the importance of enforcement, which makes consideration of enforcement issues critically important in the planning stage. This section identifies the most important of these as they apply to HOT project development.

Identify and Involve Appropriate Entities

HOT projects require an unprecedented degree of multi-agency cooperation. Ownership and operating structures may vary widely and involve organizations ranging from for-profit, private sector developers to toll authorities, local planning organizations, transit agencies, and state departments of transportation. Early outreach to legislators is crucial to insuring that the requisite legal structures and authority are available to enforcement agencies. Depending on the size of the HOT project, planning should include early agreements between enforcement agencies to establish response and enforcement protocols across multiple jurisdictions. In the case where HOT lanes will be added to an existing HOV facility, enforcement agencies will bring invaluable operations experience to the planning table. This early involvement can be invaluable for resolving design issues for enforcement locations, investigation sites, and enforceable signing. As the planning process proceeds, outreach to members of the judicial system will be essential if they are to properly understand HOT enforcement and be responsible for upholding the fines and penalties.

Identify Preliminary Enforcement-Related Design and Operational Issues

Given the increasingly critical role of enforcement to the ultimate success of a HOT project, stakeholders should consider design and operation issues that have the potential to disproportionately impact enforcement effectiveness. Some key issues are identified and discussed below.

Choose an Operational Concept

The choice between "HOV-ineligibles tagged" and "universal tag" operating concepts is perhaps the most critical decision to be addressed in the planning of HOT facilities since it profoundly influences many aspects of HOT facility design and operations.

The "HOV-ineligibles tagged" concept, though the dominant choice for current HOT facilities, inherits many of the enforcement difficulties associated with traditional HOV facilities. Ultimately, manual verification by enforcement personnel is necessary to identify both occupancy and toll violations under an "HOV-ineligibles tagged" operating concept. As discussed in Chapter Eight, current rules of evidence for HOV violations impose a de facto requirement for officers to apprehend suspected violators, as opposed to serving citations by mail. The lack of a universal transponder requirement for HOT lane users therefore means that officers must also apprehend suspected toll violators, in order to verify the presence of a transponder in a low-occupancy vehicle.

A HOT facility under the "universal tag" operating concept is much more amenable to automated enforcement techniques. State-of-the-practice VES technologies used by toll authorities for toll evasion can be readily employed. The principal drawback to this operating concept derives from the requirement for HOV users to seek out their discount/credit by using a separate lane and a specially designated toll reader. In two cases where this operating concept has been suggested (Houston QuickRide and I-25 in Denver), there have been concerns and ultimately rejection of this approach because of the burden placed on HOVs to seek out their discount/credit,

sometimes to the detriment of existing travel time savings. It should be noted, however, that this issue is of greater contention in situations where existing HOV lanes are to be converted to HOT operation, and the impact to an established carpool user base must be considered. The "universal tag" operating concept may encounter greater support in the case of a new HOT facility, as was the case for the SR 91 Express Lanes in California. A "universal tag" operating concept also requires enabling legislation to mandate universal use of transponders on a HOT facility, which can impose delays for HOT projects on tight deadlines. For example, the 16-month implementation schedule for the I-394 HOT conversion project in Minneapolis effectively precluded consideration of the "universal tag" concept because project sponsors did not believe they would be able to secure legal authority to operate in this manner within the allotted project timeframe.

Estimate Costs and Funding

It is essential that realistic HOT enforcement cost estimates be considered early in the planning process since adequate HOT enforcement is an expensive proposition. Available information on annual HOT enforcement budgets indicate costs ranging from $2300 per lane per km up to $5600 per lane per km ($3700 to $9000 per lane/mile), as shown in Table 6-2.

Table 6-2. Annual Costs for HOT Enforcement.

HOT Facility	I-15	I-394	SR 91
Centerline Length	13 km (8 miles)	18 km (11 miles)	16 km (10 miles)
Number of Lanes	2	2	4
Budget Year	2001	2005	2005
Annual Enforcement Costs	$60,000	$200,000	$360,000
Costs per Lane per km (per Lane/Mile)	$2300 ($3700)	$5500 ($8900)	$5600 ($9000)
Source of Enforcement Funds	Toll revenues	Toll revenues	FHWA demonstration funds (first year only)

Note that much of the disparity in cost arises from the number of man-hours devoted to enforcement. Costs for I-15 are based on one officer providing 3 four-hour shifts per week, while I-394 enforcement costs reflect 12 four-hour shifts per week. The SR 91 Express Lanes funds 14 eight-hour shifts per week, with two officers present during morning and evening peak periods. Comparable costs for well-funded HOV enforcement programs are typically much lower although enforcement budgets for HOV facilities can, in rare cases, be just as large as those for HOT facilities. The 2004 budget of $390,000 for enforcing the I-95/I-395 and I-66/I-267 HOV lanes in northern Virginia equates to $1700 per lane per km ($2800 per lane/mile) for the 113 km (70 miles) along these facilities. The 2003–2004 enforcement budget for the 28.8 km (18 mile) Nassau County section of the Long Island Expressway HOV lanes was $308,000, or $5300 per lane per km ($8600 per lane/mile).

While enforcement costs for HOT facilities are typically higher than HOV facilities, additional funding sources are available to HOT projects in the form of federal

demonstration funds and revenue from toll operations. Sections 1604(a) and 1604(b) of the Safe Accountable Flexible and Efficient Transportation Equity Act: A Legacy for Users of 2005[17] extend the federal funding for value pricing projects and create a new Express Lanes Demonstration Program.

As discussed further in Chapter Eight, HOT lanes also benefit from state legislation which permits the financing of enforcement efforts through toll revenue generated by these facilities. Legislation in California[18], Utah[19], and Colorado[20] allows revenues from toll operations on HOT facilities to reimburse state agencies for enforcement operations along the corridors served by these facilities.

Define Enforcement Objectives

As is the case for HOV enforcement, a low level of HOT violations is essential for the long-term success of the facility. Effective enforcement has economic value to the extent that it helps maintain the base of toll users. In contrast, ineffective enforcement can discourage toll-paying commuters if these users perceive that violators are at low risk of incurring penalties for their actions. A related benefit accrues to HOT facility revenue if low-occupancy violators are persuaded by enforcement efforts to become paying toll customers so that they may travel legitimately on the HOT lanes.

Given the greater benefits of effective enforcement, and the more serious consequences of ineffective enforcement, low target violation rates should be considered when planning HOT facilities. Few sources of data are available to formulate a relative baseline for acceptably low violation rates because the number of operating HOT facilities is small and limited thus far to barrier-separated facilities. The recent opening of the I-394 HOT lanes in Minneapolis should eventually provide useful data on violation rates for buffer-separated facilities, however.

The *I-15 Congestion Pricing Project, Phase II Year 3 Enforcement Effectiveness and Violation Assessment Report* reported violation rates in the 3 to 5 percent range for elevated levels of selective enforcement (two to five days per week) on this barrier-separated HOT facility[11]. This level of violations was considered "adequate" by the researchers, which suggests that a target violation rate of 5 percent is appropriate for barrier-separated HOT facilities using an "HOV-ineligibles tagged" operating concept. Violation rates on SR 91 in Orange County represent perhaps the lowest achievable for a barrier-separated HOT facility—less than 2 percent. It should be noted, however, that such a low violation rate is due to the unique operating characteristics of the facility. First, the facility has no entrance or egress points other than at the beginning and end of the two-way facility. The facility also uses a "universal tag" operating strategy and relies heavily on automated photo enforcement. Lastly, the resources allocated to enforcement are large ($360,000), funding 24-hour dedicated special enforcement by California Highway Patrol (CHP) officers.

The changes wrought to federal law in 2005 by the Safe Accountable Flexible and Efficient Transportation Equity Act: A Legacy for Users impose specific performance objectives for HOT facilities[21]. Under SAFETEA-LU, agencies responsible for HOT facilities must establish, manage, and support an enforcement

program that ensures the operating performance of these facilities is not degraded, where

- The operation of a HOT facility shall be considered to be degraded if vehicles operating on the facility are failing to maintain a minimum average operating speed 90 percent of the time over a consecutive 180-day period during morning or evening weekday peak hour periods (or both); and

- Minimum average operating speed is defined as 45 miles per hour, in the case of an HOV facility with a speed limit of 50 miles per hour or greater, or not more than 10 miles per hour below the speed limit, in the case of an HOV facility with a speed limit of less than 50 miles per hour.

Agencies are further required to limit or discontinue the use of the facility by toll SOVs if the presence of these vehicles has degraded the operation of the facility.

Enforcement Considerations in HOT Facility Design

As nearly all existing freeway HOT lanes have resulted from conversions of prior HOV facilities, HOT projects have used traditional highway design standards and HOV guidelines maintained by AASHTO, state DOTs, and local governments. The HOV design recommendations for enforcement features, as described in Chapter Four, are directly applicable to HOT lanes. This section of the chapter focuses on design elements and recommendations that can have a substantial influence on HOT enforcement effectiveness.

General Design Elements for HOT Enforcement

General priorities for enforcement design elements are largely comparable to those of HOV lanes, which are discussed in Chapter Four. Some differences do exist, however, and are discussed below.

Location of Enforcement and Observation Areas

Effective observation and enforcement locations on HOT facilities are dictated by several factors, the most important being

- The type of facility (barrier or buffer separated),

- The type of HOT operating concept, and

- The capabilities of the technologies used to assist enforcement officers.

For a barrier-separated facility using a "universal tag" operating concept, HOV traffic may be segregated into a special lane at the tolling area to bypass the ETC readers. Officers in this case need only observe traffic in the special lane for occupancy violations, with toll violations in the non-HOV lane being handled by automatic photo or video enforcement. Such a system is used for the SR 91

Express Lanes. Spotters situated alongside the HOV special lane in the tolling area observe vehicle occupancy and radio information on violators to CHP officers located downstream.

Enforcement and Observation Areas:

- Effective locations are determined by facility type, HOT operating concept, and enforcement technologies employed.
- Choose locations downstream of tolling areas for barrier-separated facilities.
- For "HOV-ineligibles tagged" barrier-separated HOT facilities, use ETC-actuated beacons to provide toll verification to officers.
- Consider mobile AVI reader technology and mobile patrols for buffer-separated facilities.

For barrier-separated facilities using an "HOV-ineligibles tagged" operating concept, the presence of toll and HOV traffic on HOT lanes requires enforcement officers to differentiate not only between HOV and non-HOV vehicles, but also between legitimate (toll-paying) and illegitimate low-occupancy vehicles. In this case, it is advantageous to locate some observation and/or enforcement areas slightly downstream of tolling areas on the facility so that officers can observe transponder status (as shown by a roadside indicator beacon) as well as vehicle occupancy in the tolling zone. This approach is used on I-15 in San Diego as the exclusive means of toll verification and is one of three means of toll verification currently in use on I-394 in Minneapolis. Both the I-15 FasTrak and the barrier-separated portion of the MnPASS I-394 Express Lanes employ an indicator beacon mounted near or on the tolling gantry structure, which is actuated by the ETC reader. The beacon indicates that a vehicle passing through the zone has a valid transponder placed properly in the vehicle. If the light does not flash, the officer, sitting downstream from the toll zone, visually determines how many people are in the vehicle and issues a citation if there are too few occupants. The barrier-separated HOT lanes on US 290 in Houston necessarily use a different approach. When these lanes were converted to HOT operation, no provision was made for observation or enforcement locations near tolling zones. Enforcement is exclusively conducted at certain entrance and exit points along the facility. Stand-alone AVI readers are used at these locations to detect the presence of valid toll transponders.

Buffer-separated HOT facilities preclude many of the approaches described above since toll evaders can potentially enter and exit at will along the length of the facility by illegally crossing the buffer. There are thus no optimal stationary locations for toll enforcement as would exist for barrier-separated facilities. This disadvantage may be overcome though appropriate mobile ETC technology, as demonstrated by the enforcement system used on the buffer-separated portion of the I-394 Express Lanes. Utilizing AVI readers mounted in roving law enforcement vehicles and toll transponders that store a limited transaction history, the MnPASS system permits officers to identify violators at any point along the HOT facility. The versatility of the MnPASS mobile AVI reader system is one reason why this system is preferred by the enforcement officers.

While the number of operating HOT facilities is yet small, data are emerging to support the conjectures of police officers in the field, namely that violations relating to toll evasion are a potentially significant problem for enforcement if an "HOV-ineligibles tagged" operating concept is used. In Houston, data collected as part of the FHWA Value Pricing Project on the I-10 and US 290 QuickRide program indicated that up to 45 percent of violations were committed by ostensible QuickRide participants. These violations were determined to be equally attributable

to the practice of "masking" toll transponders, using an invalid transponder, or using a faulty transponder. It is therefore recommended that enforcement areas on HOT facilities, in the absence of other effective countermeasures, should preferentially be placed downstream within sight distance of a toll area, and that the toll reader be equipped with some type of indicator beacon. Other transponder verification technologies, as mentioned above and described in Chapter Nine, should also be considered for implementation.

HOT facilities using a "universal tag" operating concept are largely immune to the above concerns since nearly all toll violations are handled automatically through VES. Only vehicles entering either an HOV toll bypass lane or an HOV "credit" lane need to be visually inspected for the proper minimum number of occupants. Observation locations should therefore be situated alongside or slightly downstream from these "HOV-only" lanes so as to provide optimum interior views of vehicles. If the observation location is to be separate from the apprehension area, further improvements such as a raised platform for better viewing angle can be employed. As is the case for HOV facilities, visual confirmation of occupancy will be more accurate under low-speed conditions.

Facility Ingress and Egress Locations and Spacing

The toll aspect of HOT lanes favors more limited access locations. As with HOV lanes, this can be accomplished by using a painted stripe or buffer zone, or a physical barrier. Physical barriers are preferred for permanent HOT lane installations because they provide better access control and are more effective at reducing violations and maintaining premium traffic service[15]. Since there are often significant speed differentials between the general-purpose lanes and HOT lanes, physical barriers also help maintain safety by preventing potential violators from crossing the buffer into the HOT lanes and disrupting the traffic flows.

For effective tolling, a vehicle must periodically be "captive" in the HOT lane for a sufficient distance so as to guarantee that it passes through a tolling zone. Access points and tolling zones should be considered together; judicious placement can help reduce the temptation for vehicles to "dodge" tolls (i.e., exiting before the toll zone and re-entering downstream). Nearly all HOT facilities have been converted from barrier-separated HOV lanes and have thus inherited the limited access features of this type of facility. The MnPASS I-394 Express Lanes facility is a notable exception in that an 8-mile section was converted from continuous access, concurrent flow operation to that of limited access, buffer-separated operation.

In its decision to endorse restricted access on the concurrent flow section of the Express Lanes in Minneapolis, the I-394 Community Task Force[22] pointed out that recent trends in HOV lane design in California, Atlanta, and Seattle are similar in their access treatments to the I-394 design concept. Pre-defined, limited access points are considered a better design for managing traffic access and upholding safety than the open, random access previously allowed.

Facility Access Locations:

- The tolling aspect of HOT facilities requires a limited number of access locations.
- Pre-defined, limited access points are a better design for managing traffic access and upholding safety.

Adequate Signage

Accurate, informative signs explaining the operational procedures of HOT lane facilities, such as toll information, are important for safety and enforcement. Informed drivers are less likely to commit unsafe last-minute maneuvers or inadvertently violate the HOT lane. Good signage is particularly important when variable tolls are involved. These can involve either time-of-day tolls or a dynamic pricing system that changes price according to the level of congestion in the parallel general-purpose lanes and the availability of excess capacity on the HOT lane(s). Signage for HOT lanes should generally adhere to the standards prescribed for HOV facilities in the federal *Manual on Uniform Traffic Control Devices*, Section 2B-49 and 50.

Figure 6-1. DMS Toll Sign before Entrance to FasTrak SR 91

Toll signs should be situated far enough before HOT lane access points so that drivers can decide, in light of the toll, whether to enter the HOT lane (see Figure 6-1).

For HOT lanes that toll as a function of distance traveled, the toll rates from point to point should be displayed to help the driver decide whether to enter the HOT lanes. Similar signage, visible to vehicles already in the HOT lane, could be used so that drivers of these vehicles could make a comparable choice to continue in or exit from the HOT lane. Such information is provided by the overhead DMS signs used for the MnPass Express Lanes, as shown in Figure 6-2. These signs are located above the buffer-separated concurrent flow lane before HOT lane access points and are visible to drivers in both the mixed flow and HOT lanes.

Figure 6-2. DMS Toll Sign Indicating Segment Pricing—MnPass I-394

Enforcement Considerations in HOT Facility Operations

Enforcement programs play an expanded role in HOT operations, due to the increased complexity of the enforcement task and the inherently greater importance of enforcement to the continuing success of a HOT facility. HOT lanes in particular depend on public acceptance of the tolling concept, and effective enforcement provides visible means of promoting the fairness and integrity of the facility. This section of the chapter discusses additional operational issues pertinent to HOT enforcement.

Role of Technology

Police personnel must deal with two major types of violations on HOT facilities—those involving a violation of minimum occupancy requirements and the related problem of toll evasion. Given the limitations of automated technologies and the

difficulties of verifying the number of occupants in a vehicle, the enforcement of occupancy requirements requires routine visual inspection. Toll evasion presents a complementary problem for enforcement personnel, in that visual inspection cannot conclusively verify toll payment, but the problem is readily amenable to technological countermeasures.

Since HOT lanes depend heavily on ETC technology, they can potentially exploit the latest advances in automated toll enforcement. The degree to which toll enforcement can be automated is critically limited by the type of operating concept used on the HOT facility. As previously stated, "universal tag" facilities such as SR 91 in Orange County can utilize photo or video enforcement systems and mailed citations as the principle enforcement mechanism since all vehicles (including HOV) must have toll transponders to use this type of facility. "HOV-ineligibles tagged" facilities are constrained in their ability to employ automated techniques and instead utilize technologies to assist manual enforcement methods. As discussed more fully in Chapter Nine, facilities such as I-394 in Minneapolis and US 290 in Houston have implemented AVI-based systems that provide information on toll transponder status to enforcement officers.

Citations and Fines

Violations on most HOT facilities are handled under existing laws regulating HOV lane usage, rather than being classified as toll evasion. This has to do with the fact that most HOT lanes have been implemented as conversions from existing HOV facilities and have inherited the citation and fine structure from the latter. It is important in implementing a HOT conversion that existing fines be reviewed and, if necessary, updated. The concept of HOT lanes—selling "unused" capacity in the HOV lanes—means that the potential negative impact of uncontrolled violators on HOT revenue, person-movement capacity, and public approval can be large. Penalties for violations must be adequate to discourage the willful violator such that reliance on dedicated enforcement officers can be minimized. Currently, aggregate penalties on HOT/HOV projects in the United States vary from $45 to $351 for the first offense. Some states, such as California and Virginia, have graduated fines for repeat offenders up to $1039, while other states assess license points for HOV offenses. Fines and other legal and judicial aspects of HOV violations are discussed more fully in Chapter Eight.

The one HOT facility which treats occupancy and toll violations separately is SR 91 in Orange County. This facility is unique in that it was originally a privately operated toll facility. Although the SR 91 Express Lanes initially allowed HOV3+ carpools to travel for free, this policy was changed to a 50 percent reduced toll after a few years of operation. Limited free HOV use of the facility resumed only after it was purchased in 2003 by the Orange County Transportation Authority. During the most heavily congested directional peak (eastbound PM), HOVs must still pay a 50 percent reduced toll. At the tolling zone, HOV vehicles are separated from general toll traffic into their own lane. Spotters at the tolling zone count occupants in these vehicles and relay information on HOV violators to downstream CHP officers. Suspected violators are apprehended, and confirmed violators are issued a moving violation for improper HOV lane use, a $351 fine.

Toll violations processing is conducted by the toll operator, as prescribed under Section 40252 of the California Vehicle Code (CVC). Non-HOV traffic is monitored automatically by a VES employing AVI readers and photo license plate monitoring. Violators who are not customers of any partnering toll authorities are issued a notice charging them with the toll plus a $20 processing fee. A second notice is sent and another $35 fee charged if the first notice remains unpaid after 30 days. If the violator still does not pay, the unpaid balance is sent to a collection agency, which further escalates the charges with each successive notice to the limit provided by law. Section 40258 of the California Vehicle Code prescribes a maximum fine for toll evasion of $100, $250, and $500 for first, second, and subsequent violations in a 12-month period, respectively. Unlike HOV violations, adjudication of toll violations in California is strictly a civil administrative matter and carries no insurance or license demerit points. However, Section 40267 of the CVC allows the toll facility operator to pursue additional civil remedies if a violator is delinquent in paying the civil penalty. Delinquent toll evasion penalties can be converted to civil judgments against the violator and may be recovered through seizure of assets, liens against property, and wage garnishment. The violator in this case would be liable for the penalty as well as all legal and collection costs incurred by the operating agency. Furthermore, violators can have their vehicle registration placed on hold for non-payment of assessed fines.

Performance Monitoring

A systematic monitoring program is required to determine compliance levels and provide a basis for fine-tuning HOT operations and enforcement requirements. While the information gathered by such a monitoring program may not differ substantially from that discussed for HOV facilities in Chapter Five, the importance of performance monitoring to continuing enforcement operations can arguably be seen as greater in the context of HOT facilities. Here, each violation has a direct economic impact on the HOT facility in the form of lost revenue from toll evasion. Since all HOT facilities utilize toll revenue to some extent for funding enforcement activities, excessive violations can financially impair enforcement efforts when greater expenditures in this area are most needed. The potential consequences of high violation rates are more acute for HOT facilities that depend exclusively on contracts with local law enforcement or state highway patrols, such as I-15 in San Diego and SR 91 in Orange County. Accurate and frequent monitoring of compliance data such as violation rates and adjudication outcomes are therefore of great benefit for future planning and for identifying resource requirements for ongoing enforcement and future HOT projects.

Performance monitoring has acquired critical importance with recent changes to federal law[21]. State agencies that allow exceptions to HOV requirements must certify to the secretary of transportation that they have established a program to monitor, assess, and report on the operation of the facility and the impact of HOT vehicles and other low-emission and energy-efficient vehicles. Information from these reports must be used to determine if the HOT facilities are operating at or above new minimum standards, as mentioned earlier in the facility planning section of this chapter. Agencies are required to limit or discontinue the exceptions if the performance of these facilities becomes seriously degraded.

Conversion of HOV Facilities to HOT Facilities

General recommendations addressing conversion issues for HOV facilities are practically synonymous with those from the preceding discussions in this chapter since nearly all HOT facilities in existence are conversions. The focus of this section, therefore, is an individual examination of each converted HOT project. Each case study example in this section highlights the enforcement features and enforcement-related implementation issues encountered during the conversion process.

I-15 FasTrak—San Diego, California

The I-15 Express Lanes are a 13 km (8 mile) two-lane, barrier-separated reversible HOV facility in the median of I-15. Access to the Express Lanes facility is available only at its north and south ends during morning and evening peak traffic periods. The I-15 Express Lanes employ variable pricing based on time of day. Single-occupant vehicles with a FasTrak transponder are charged $0.75 to $4.00 per trip to use the express lanes, which are free for HOV2+ vehicles. The San Diego Association of Governments operates this Caltrans-owned facility.

Figure 6-3. Cross Section View—I-15

Enforcement Design Elements

Full 3.6 m (12 ft) left and right shoulders are provided along the length of the facility, as seen in Figure 6-3. Periodic 3 m (10 ft) openings in the concrete barrier allow CHP motorcycle patrols to have intermediate access to the facility from the general-purpose lanes. The exposed barrier ends are protected by crash absorption cushions, as shown in Figure 6-4.

Enforcement Strategies

Selective enforcement is provided by CHP under a $60,000 yearly contract. This supports 12 four-hour shifts per month (three peak periods per week), one officer per shift.

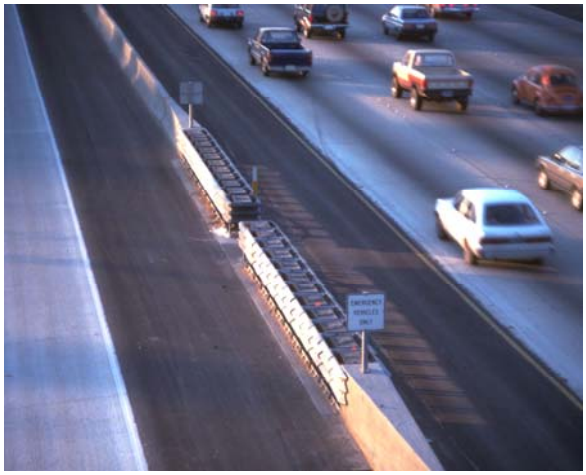


Figure 6-4. Motorcycle Access Points between General-Purpose and HOT Lane—I-15

Enforcement Tactics and Procedures

Stationary patrols, with an officer located in the tolling zone, are used as well as roving patrols. CHP uses motorcycles or police cruisers although motorcycles are preferred. The officer visually inspects vehicles for occupancy while observing a beacon controlled by the toll reader. SOVs with a valid toll transponder will illuminate the green beacon (as shown in Figures 6-5 and 6-6); otherwise, an HOV violation has occurred (a $351 fine). Motorists masking tags are also in violation of

Figure 6-5. Indicator Beacons Mounted on Tolling Gantry—I-15

Figure 6-6. Close-Up of Gantry-Mounted Indicator Beacons—I-15

California law, which requires SOVs to display transponders on the I-15 Express Lanes.

Enforcement-Related Performance Monitoring

Manual counts for occupancy and occupancy violations are performed on a quarterly basis. Violation rates are approximately 5 percent.

Implementation-Related Activities and Issues

The I-15 Express Lanes were implemented in 1996. SANDAG contracted with CHP for enforcement services on the I-15 Express Lanes for a total of $300,000 for the period December 1996 through December 1999. Under the SANDAG-CHP agreements, levels of CHP patrol vehicle and motorcycle enforcement of the I-15 Express Lanes vary by month. The enforcement levels include five days per week, three days per week, and two days per week. Higher levels of enforcement were timed to follow or coincide with program milestones.

Occupancy data were collected two days per month, from December 1996 through December 1998. Monthly CHP citation data from 1994 through 1998 were also used. An analysis of the occupancy and citation data determined that varying levels of selective enforcement did not have much effect on violations (although violations during implementation were much lower than pre-project levels), but citations increased with higher levels of enforcement.

Motorcycle-based enforcement has been judged superior to that of car-based enforcement for the project. Motorcycle units are able to maneuver better than cars within the barrier-separated Express Lanes facility. Patrol cars provide stationary enforcement but have less ability to enter and exit the facility at intermediate points and instead need to drive the length of the facility to cruise or pursue a potential violator.

For the first two years, the tolling zone had an extra lane for SOVs to aid occupancy enforcement. SOV users complained about the amount of weaving required to merge in and out of the extra lane; that and potential safety concerns led to the elimination of the SOV lane. Video monitoring was attempted in the initial stages of the project for occupancy detection but was abandoned in 1998. Operators using the system could not reliably distinguish SOV violators on the videotapes and found it difficult to discern the number of vehicle occupants, especially for those in back seats.

MnPASS I-394 Express Lane—Minneapolis, Minnesota

This newly implemented 18 km (11 mile) facility combines a 5 km (3 mile) segment of two-lane, barrier-separated reversible HOV lanes with another 13 km (8 miles) of limited-access concurrent flow lanes. Lane separation on the concurrent flow segment consists of a 0.6 m (2 ft) double white stripe for restricted access portions (see Figure 6-7) and a single 0.2 m (8 inch) dashed stripe at access points (shown in Figure 6-8). Single-occupancy vehicles having a MnPASS account and transponder may use the HOV2+ Express Lane for a fee. The fee varies dynamically and depends on traffic conditions and the trip entry and exit points along the facility. Peak period tolls average from $1 to $4, with a maximum of $8.

Figure 6-7. Double White Striping at Restricted Access Sections—I-394

Enforcement Design Elements

The median shoulder on the concurrent flow segment is narrow, restricted to as little as 2.2 m (7 ft) in places, while somewhat wider shoulders are located along the barrier-separated segment (See Figure 6-9). Stationary patrols can be used at the beginning and end of the barrier-separated segment since sufficient shoulder space is available there; otherwise, enforcement is restricted to roving patrols.

Enforcement Strategies

Selective enforcement is used, with a $200,000 startup budget supporting 12 four-hour peak periods per week. Enforcement is performed jointly by the Minnesota State Patrol (lead enforcement agency), the Cities of Minneapolis and Golden Valley, and the Metro Transit Police, subject to contractual arrangements.

Enforcement Tactics and Procedures

Roving patrols use special enforcement transponders to verify toll payment by SOVs. The officer follows an SOV through a toll zone and determines if the SOV has a MnPASS account. If the officer's vehicle passes through the toll zone within four seconds of the passage of the SOV, the system will cause the enforcement transponder in the trailing officer's vehicle to beep three times; otherwise, the SOV is a violator. HOV violations are a $130 fine, with fine proceeds going to the state.

Figure 6-8. Dashed Striping at Access Locations to HOT Lane—I-394

Figure 6-9. Cross Section of Barrier-Separated HOT Lanes—I-394

Enforcement beacons are mounted on overpasses situated near a tolling zone and will flash if a vehicle passing through the zone has a valid transponder placed properly in the vehicle. If the beacon does not flash, a downstream observing officer counts occupants in the passing vehicle and issues a citation if the vehicle does not have at least two occupants.

Mobile transponder readers are devices installed in enforcement vehicles that allow an officer to either park anywhere on the shoulder of the road and read the transponders of passing vehicles or to travel adjacent to a vehicle in the HOT lanes and read the transponder. The mobile readers utilize side-mounted antenna and are used to detect transponders on the left of the monitoring vehicle. The transponder reader provides the officer with the last date and time the transponder was read and the transponder's account status (valid or not valid) via a personal data assistant (PDA) display located in the vehicle cabin. If this information does not confirm that the SOV is properly using the lanes, there is a violation.

Enforcement-Related Performance Monitoring

Information on monthly citations and violation rates is recorded, but no analysis of violation rates has been performed yet (HOT operations commenced in late May of 2005). Early qualitative assessments by enforcement personnel indicate violation rates have decreased from earlier levels.

Implementation-Related Activities and Issues

The I-394 Community Task Force is a 22-person group drawn from elected officials and public and private organizations. This task force is currently developing the enforcement plan and enforcement manuals for the facility.

Comments by enforcement personnel indicate that the beeping enforcement transponders and enforcement beacons are not as effective as had been hoped. Officers have mild difficulties matching an individual vehicle to the corresponding status of the beacon (on or off), particularly along the two-lane reversible section of the facility since one beacon is used to indicate transponder status in either lane.

The mobile enforcement reader is favored by officers because it can provide them with positive confirmation of toll transactions. An upgrade to this system is being planned that will give officers the ability to monitor transponders on either side of the enforcement vehicle. This feature is necessary in the two-lane reversible section of the facility, where currently officers can only read transponders if they are traveling in the right lane.

I-10 and US 290 QuickRide—Houston, Texas

These facilities are both one-lane, reversible, barrier-separated HOT lanes in the medians of the I-10 and US 290 freeways in Houston, Texas. The respective lengths of the facilities are 21 km (13 miles) for I-10 and 25 km (15.5 miles) for US 290, and both facilities operate in the morning between 5:00 AM and 11:00 AM, and in the afternoon between 2:00 PM and 8:00 PM. During peak periods, the minimum occupancy requirement to use the lanes increases from HOV2+ to HOV3+. HOV lane buy-in is available under the QuickRide program, where for a $2.00 per trip fee, HOV2 vehicles may use the I-10 (Katy Freeway) lanes during both morning and evening peaks. QuickRide is only available during the morning peak period on US 290 (Northwest Freeway) because HOV restrictions during the evening peak period are lower. Customers must have a QuickRide account, transponder, and windshield tag. Houston METRO, the transit authority in Harris County, manages the QuickRide program.

Figure 6-10. Cross Section View—I-10

The exclusion of single-occupant vehicles from the lane makes the QuickRide lanes unique among other HOT lane facilities. The decision by QuickRide operators to disallow single-occupant drivers to use the lane—even if willing to pay the toll—reflected the I-10 corridor's high travel demand and its limited capacity (one reversible lane), as well as SOV use restrictions tied to the HOV lanes' original construction financing from the FTA.

Enforcement Design Elements

Both facilities had originally been designed as transitways, and no provisions had been made for incorporating dedicated enforcement areas along the facilities. Additionally, limited right-of-way resulted in a narrow facility cross section of 6 m (20 ft) (seen in Figure 6-10) so that enforcement is only possible at entrances and exits to the facilities

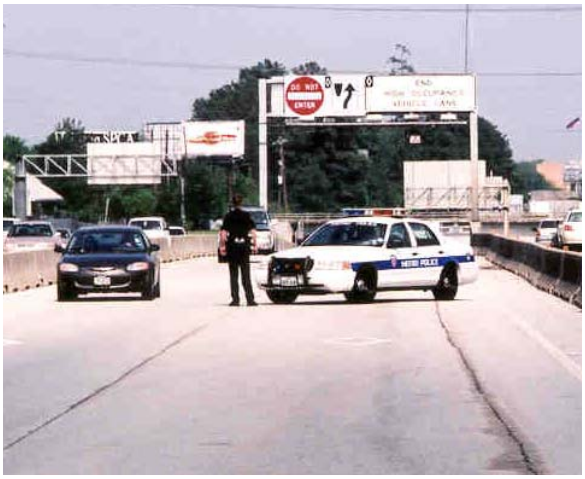


Figure 6-11. Enforcement Area at Entrance—I-10

Enforcement Strategies

METRO has its own police force, which provides enforcement for the HOT lanes. This force must also serve METRO's transit facilities and the rest of the 193 lane-km (120 lane-miles) Houston HOV system. Selective enforcement is used, averaging one to two peak periods per week with one officer and occasional task forces involving multiple officers. METRO had annually spent between $30,000 and $40,000 to enforce the I-10 and US 290 HOT lanes. Since late 2004, METRO has had to redirect resources to enforcement of the new light rail system and has considerably scaled down enforcement on HOV and HOT lanes.

Enforcement Tactics and Procedures

Stationary patrols are used at entrances and exits, primarily near the inbound termini to the facilities (see Figure 6-11). METRO officers count vehicle occupants and verify that two-person vehicles have the required transponder and QuickRide identification hang-tag. Violators are subject to a fine of up to $200, the proceeds of which revert to the City of Houston.

Four HOT access ramps along US 290 are each equipped with a stand-alone roadside AVI system, which is designed to monitor HOV traffic and indicate (via a green beacon) the presence of a valid QuickRide transponder in passing vehicles. In addition, PDA-based handheld AVI readers provide apprehending officers with the ability to scan transponders for validity and proper functioning.

A HERO program of self-enforcement has been operational in the Houston area for over 10 years. The program consists of a dedicated phone number that is available for motorists to call and report a violator on any of the HOV lanes. It is an automated system that requires motorists to leave a message about the reported violator. METRO transit police mail a letter to the reported violator warning them of the consequences of violating the HOV lane requirements.

Enforcement-Related Performance Monitoring

Occupancy counts on the HOT facilities are reported quarterly. Information on the disposition of citations is available and has been recently reported as part of a FHWA Value Pricing Project. Data on violation rates observed in February and April 2003 found these rates to be excessively high—between 55 percent and 65 percent of the users on the Katy and Northwest HOV lanes were not in compliance with either minimum vehicle occupancy or QuickRide program requirements during peak periods.

Implementation-Related Activities and Issues

Part of a recently completed FHWA Value Pricing Project study examined enforcement issues on the Katy and Northwest HOT lanes in detail and determined that the system for enforcing compliance had not been effective:

- Under the current system, HOV2 violators during the QuickRide periods are impossible to detect with certainty. The limited deployment of AVI enforcement technology is not able to verify toll transactions
- Transponder verification and billing at the point of enforcement is not presently used; toll evasion is evident.
- Reconstruction of I-10 has additionally compromised enforcement on HOT lane in this corridor since the existing enforcement areas have not been available on a consistent basis.
- Judicial support for citations is weak, with 64 percent of court cases being dismissed. Even those who are ticketed may not pay a fine.

Several temporary and long-term improvement measures were implemented over the course of the study to reduce violations, among them:

- Increased enforcement presence along the Katy and Northwest HOV lanes during QuickRide hours, with enforcement areas staffed daily during peak periods;
- Standardized policing procedures to improve efficiency of operations;
- Posted signs communicating maximum $200 fine;
- Public outreach in the form of friendly reminder letters to QuickRide enrollees and to non-enrollees who were using the facilities (1500 letters were sent that described the QuickRide operation, including hours of operation, requirements to comply, and information on the process for enrollment); and
- Development and implementation of AVI systems to verify that HOV2 vehicles carried properly registered QuickRide transponders.

Implementation of the above measures demonstrated that violation rates can be significantly reduced by both increasing law enforcement coverage and employing technology to assist officers in verifying QuickRide accounts. Violation rates were halved to between 29 and 33 percent.

Unfortunately, many of the improvement measures implemented in the study have not been continued since HOV enforcement is no longer a core function for the METRO police force. As of November 2004, changes in the METRO organizational structure resulted in the HOV enforcement section being assimilated into other traffic management functions. This change was made to ensure sufficient resources for other priority efforts, particularly rail safety and security. As a result, HOV enforcement does not have the same emphasis, level of dedicated staff resources, or level of officer experience as it has in previous years.

Case Study: HOT Lane Enforcement

SR 91 Express Lanes—Orange County, California

The SR 91 Express Lanes are a 16 km (10 mile) HOT facility in the median of an existing highway. The section of SR 91 containing the express lanes is located between the SR 91/SR 55 junction in Anaheim and the Orange/Riverside County Line. The project provides two extra lanes in each direction, separated from the adjacent freeway by a "soft" barrier consisting of a double-yellow stripe painted buffer with pylons. Toll rates on the Express Lanes vary from $1.10 to $7.75 by time of day and day of the week. All users of the facility must have a prepaid account and transponder to use the Express Lanes. HOV2+ vehicles ride for free except Monday through Friday 4:00 PM to 6:00 PM in the eastbound direction, when they must pay a 50 percent discounted toll. The Orange County Transportation Authority owns and operates the SR 91 Express Lanes.

Figure 6-12. Cross Section View—SR 91

Enforcement Design Elements

The Express Lanes have only minimal 1.2 m (4 ft) median shoulders along most of their length (see Figure 6-12). Bi-directional enforcement areas with offset median barriers are provided at periodic intervals along the facility (see Figure 6-13). At these areas, HOT and general-purpose lanes are shifted to accommodate a widening of the median to 7 m (23 ft).

Figure 6-13. Bi-directional Enforcement Area—SR 91

Enforcement Strategies

Special enforcement is provided by CHP, with a yearly contract enforcement cost of approximately $360,000. This enables 24-hour enforcement of the facility. Two officers assist with enforcement during peak hours. One officer is present during off-peak hours, and enforcement is shared with the adjacent free lanes at night

Enforcement Tactics and Procedures

HOV3+ vehicle occupancy is verified by a spotter adjacent to a dedicated carpool-only lane within the tolling zone (see Figures 6-14 and 6-15). The spotters are aided in identifying and reporting suspect violating vehicles by photographic license recording methods. Descriptions of suspected violators are radioed to California Highway Patrol officers downstream.

All non-carpool traffic toll violations are handled automatically by video and license plate recognition (see Figure 6-16). License plates of suspected violators are compared against a customer database and against databases of other toll authorities. Toll violators that cannot be identified as customers in any partnering toll authorities are identified through Department of Motor Vehicle records. Written notices are sent to toll violators, charging them the toll plus a $20 processing fee. A second notice is sent and another $35 fee charged if the first notice remains unpaid after 30 days. If the violator still does not pay, the unpaid balance is sent to a collection agency, which further escalates the charges with each successive notice to the limit provided by law. If the fine is not paid, a hold can be placed on the vehicle's registration. Violation rates are under 2 percent.

Repeat toll violators who remain delinquent in paying tolls and penalties are tracked by the operating agency. CHP becomes involved in collection efforts only if a violator appears on a "top 10" list. Habitual violators earn this distinction by accruing unpaid charges/penalties typically in excess of $20,000. In this case, the Customer Service Assistance patrol watches for the appearance of the egregious violator and notifies CHP, who then apprehend the violator, issue a citation for toll violation, and order the violator off the road.

Figure 6-14. Carpool-Only Lane at Toll Plaza—SR 91

Figure 6-15. Observation Area Adjacent to Carpool Lane—SR 91

Figure 6-16. VES Camera Mounted on Toll Plaza Gantry—SR 91

CHAPTER SEVEN ENFORCEMENT CONSIDERATIONS FOR EXEMPT VEHICLES ON HOV FACILITIES

Chapter at a Glance

This chapter discusses enforcement considerations pertaining to some of the exempt vehicle classes permitted on HOV facilities, particularly the class of low-emission vehicles and of law enforcement and emergency services vehicles. The first section of this chapter surveys the regulatory and legislative treatments regarding HOV exemptions for these vehicles at the federal and state level. Current guidance for exempt vehicles, based on review of existing and proposed policies, as well as recommendations from recent study efforts, is presented in the following section. The last section of this chapter discusses the Virginia HOV Enforcement Task Force findings and recommendations regarding exempt vehicle usage on HOV facilities in northern Virginia.

Section headings in this chapter:

- Federal and State Rules for Exempt Vehicle Classes
- Enforcement Considerations for Exempt Vehicle Classes
- Case Study: Exempt Vehicles

Federal and State Rules for Exempt Vehicle Classes

Exempt vehicles are those that qualify to use HOV facilities without regard to minimum occupancy requirements. The reasons for granting minimum occupancy exemptions may be related to overall HOV goals and objectives, or may be motivated by the desire to recognize or advance a public benefit. Law enforcement and emergency vehicles, for example, provide valuable benefits to communities, and most state and local policies allow marked (rooftop emergency lights and sirens) on-duty law enforcement and emergency vehicles to use HOV lanes without meeting the occupancy requirements. Federal legislation allows states to authorize HOV occupancy exemptions for certain low-emission vehicles as a means of encouraging the purchase and use of these vehicles and improving air quality. This section of the chapter discusses two general classes of exempt vehicles and their eligibility status on HOV facilities, namely low-emission vehicles and law enforcement and emergency vehicles. Particular emphasis is placed on the category of low-emission passenger vehicles, reflecting current interest and proposed legislation regarding exemptions for these types of vehicles. Many of the topics in this chapter are drawn

from the recent publication, *Potential Impact of Exempt Vehicles on HOV Lanes*[23], which provides a more comprehensive resource for the interested reader. The implications of exempt vehicle eligibility on enforcement is presented in the next section.

Low-Emission Vehicles

Federal Rules for Low-Emission Vehicles

Low-emission vehicles first gained exemptions from HOV minimum occupancy requirements in the 1990s. The 1990 Clean Air Act Amendments, as codified in Section 40 of the Code of Federal Regulations (CFR) Part 88, authorized fleet vehicle inherently low-emission vehicles to use HOV facilities without meeting vehicle occupancy requirements as one way of encouraging the purchase and use of these vehicles. The Transportation Equity Act for the 21st Century (TEA-21) allowed states to expand this authorization to include individually owned ILEVs. This provision has recently been extended until September 30, 2009, with the passage of the Safe Accountable Flexible and Efficient Transportation Equity Act: A Legacy for Users[24] in 2005.

ILEVs:

- Vehicles must be manufactured to use a dedicated non-gasoline clean fuel.
- EPA-certified clean fuels include compressed natural gas, liquid natural gas, hydrogen, ethane, methane, or liquified petroleum gas.
- Clean fuel aftermarket conversion vehicles do not qualify.

ILEVs are a subcategory of clean-fuel vehicles that have essentially no fuel vapor emissions and are powered by a single dedicated gaseous fuel. Vehicles that can operate on more than one fuel and/or an alcohol fuel cannot be classified as an ILEV vehicle; moreover, no clean fuel aftermarket conversion vehicles can comply with the EPA's ILEV certification requirements. The ILEV emission standards are part of the EPA Tier I standards, with EPA Tier II standards being phased in from 2004 through 2007[25].

Hybrid vehicles, such as the Toyota Prius and Honda Civic hybrid, utilize both electric motors and smaller displacement gasoline engines. It should be emphasized that none of the hybrid-electric vehicles that have been certified by the EPA qualify as ILEVs because their engines use conventional gasoline. With the passage of SAFETEA-LU, however, certain types of hybrids may now qualify for the HOV minimum occupancy exemption.

SAFETEA-LU creates a new class of low-emission vehicles. A low-emission and energy-efficient vehicle is defined as a vehicle that meets EPA's Tier II standards for light-duty vehicles and either

- Is certified by the Environmental Protection Agency, in consultation with the manufacturer, to have achieved not less than a 50 percent increase in city fuel economy or not less than a 25 percent increase in combined city-highway fuel economy relative to a comparable vehicle that is an internal combustion gasoline fueled vehicle; or
- Qualifies as an alternative fuel vehicle.

SAFETEA-LU provides responsible state and local agencies with the option of allowing low-emission and energy-efficient vehicles to use HOV facilities under specific conditions. Under this definition, fuel-efficient hybrids meeting Tier II emission standards could be exempted from HOV occupancy requirements at the discretion of state agencies. SAFETEA-LU contains language outlining the provisions that must be followed to ensure that these vehicles do not seriously degrade operation of an HOV lane. Under SAFETEA-LU, a state may revoke low-emission vehicle access to HOV lanes if the state determines such action is necessary.

Low-Emission and Energy-Efficient Vehicles:

- Newly defined class under SAFETEA-LU
- Includes gas/electric hybrids meeting EPA Tier II emission standards and having not less than a 50 percent increase in city fuel economy or not less than a 25 percent increase in combined city-highway fuel economy relative to a comparable vehicle that is an internal combustion gasoline fueled vehicle
- Includes alternative fuel vehicles meeting EPA Tier II emission standards

State Rules for Low-Emission Vehicles

Eight states currently have legislation allowing ILEVs or other low-emission vehicles to use HOV lanes without meeting minimum occupancy requirements; these states include Arizona, California, Colorado, Florida, Georgia, Texas, Utah, and Virginia. With the exception of Texas, all such legislation has also been implemented. Although the terminology differs, most descriptions of ILEVs and low-emission vehicles in the legislation either reference federal guidelines or appear to be in keeping with federal requirements.

Subsequent legislation in five states—Arizona, California, Colorado, Florida, and Georgia—added hybrids to the list of vehicles allowed to use HOV lanes without meeting minimum occupancy levels if allowed or approved by federal law or federal agency regulations. As of late 2005, following the passage of SAFETEA-LU, California now permits certain fuel-efficient hybrids to use the HOV lanes. Virginia has allowed hybrid vehicles to access HOV lanes since 2000, although this policy is expected to be revised with the 2006 legislative session to conform to new federal rules for hybrid vehicles.

The main elements of the legislation in the eight states are surveyed below. The survey includes elements pertaining to the types of vehicles allowed to use the HOV lanes; the termination date of the exemption; the requirements for stickers, decals, or special license plates; and the types of violations and fines.

Arizona allows alternative fuel vehicles to use HOV lanes without meeting minimum occupancy requirements[26]. Hybrid vehicles are also permitted to use the HOV lanes regardless of vehicle occupancy, but only with federal government approval (which has not been granted). Hybrid vehicles that would qualify for AFV plates must be fuel-efficient, factory-manufactured vehicles conforming to the EPA ULEV emission standard.

Section 28-2416 of the Arizona Revised Statutes specifies the verification requirements for an AFV, including the requirement that it meet federal LEV, ILEV, or ZLEV

Arizona Legislation on LEV HOV Exemptions:

- Only non-gasoline alternative fuel vehicles meeting ILEV, ultra-low-emission vehicle (ULEV), or ZLEV standards
- Appears to meet EPA guidelines
- Proposed exemptions for hybrid vehicles only with federal approval
- $350 civil penalty for misuse of AFV license plates
- Special license plate required:

emission standards. Both AFV and hybrids (if approved by the federal government) must display a diamond-shaped sticker or AFV special license plates.

Signs are to be set along HOV corridors indicating AFVs can use the HOV lanes; these signs should match the design of the AFV stickers and plates. This section also sets a civil penalty of $350 for any person found to be using AFV stickers or plates on a vehicle which is neither an AFV nor a hybrid vehicle.

California permits certain low-emission vehicles to use HOV facilities without meeting minimum occupancy requirements. According to the California Vehicle Code, Sections 21655.9 and 5205.5, new vehicles meeting the state's super-ultra-low-emission vehicle (SULEV) standards and the federal ILEV standards qualify for HOV exemptions. Vehicles manufactured before 2004 need only meet California ULEV and ILEV standards to qualify for the exemption, while hybrids and other vehicles powered by fuel other than compressed natural gas or propane (LPG) do not qualify for the HOV exemption. The exemption from minimum occupancy requirements expires January 1, 2008.

Section 5205.5 permits hybrid vehicles to use the HOV lanes without regard to occupancy, as long as they meet the state's advanced technology partial zero-emission vehicle (AT PZEV) standard for criteria pollutant emissions and have a 45 mpg or greater fuel economy highway rating. Hybrid or alternative fuel vehicles manufactured no later than 2004 also qualify for the exemption if they achieve 45 mpg or greater fuel economy and satisfy the California ULEV, SULEV, or partial zero-emission vehicle (PZEV) standards.

Qualifying vehicles are required to be registered with the DMV and display California Clean Air Vehicle decals on their vehicles. Three decals are required and must be located on the rear bumper and both rear quarter panels of the vehicle. The California Highway Patrol, in consultation with Caltrans, determines the design, location and number of these identification decals. Section 5205.5 restricts the total number of decals that can be issued at 75,000. This section also authorizes Caltrans to determine if the traffic flow on HOV facilities has eroded and halt the issuance of exemption decals only after the Department of Motor Vehicles has issued 50,000 such decals. Caltrans can also deny exemptions to hybrid vehicles if the level of service on an HOV facility or a portion of an HOV facility falls below a level of service C, but only during peak congestion periods.

Violations for HOV occupancy are subject to a minimum fine of $351 for a first offense. Second offenses within one year and third offenses within two years are subject to minimum fines of $526 and $876, respectively. The misuse of clean air vehicle decals is also a misdemeanor

California Legislation on LEV HOV Exemptions:

- Exemptions for fuel-efficient vehicles (at least 45 mpg) meeting both ILEV and California SULEV standards
- Exemptions for fuel-efficient hybrid and AF vehicles satisfying either California AT PZEV standards, or California ULEV, SULEV, and PZEV standards
- Meets EPA guidelines
- Existing exemptions expire 2008
- Special decals required:

Colorado permits ILEVs to use HOV lanes in the state without meeting the minimum occupancy requirements[27]. This HOV exemption will also apply to hybrid vehicles only if it does not affect the receipt of federal funds and does not violate any federal laws or regulations. Since federal law does not currently allow hybrids in HOV lanes (per TEA-21), this provision has not been implemented in Colorado.

Qualifying vehicles are required to display Colorado Department of Transportation (CDOT) developed 4-inch circular bright orange stickers to the front windshield, the front driver's side view mirror, or the front bumper. Violations of this identification requirement are a traffic infraction subject to fines of $65 and $125 for first and subsequent offenses within a 12-month period. The HOV exemption for ILEVs may be restricted or eliminated if these vehicles are found to negatively impact level of service (LOS) in the HOV lane or if the use of the HOV lanes by ILEVs is determined to jeopardize federal highway funds to the state.

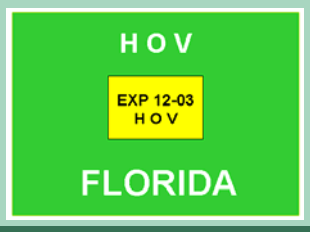
Florida allows ILEVs that are certified and labeled in accordance with federal regulations to use HOV lanes without meeting minimum occupancy levels[28]. ILEV owners must apply to a county tax collector office on an annual basis for a decal and a registration certificate if they wish to use their vehicles on the HOV lane. Hybrid vehicles will also be exempt from minimum occupancy requirements if approved by the federal government. Such hybrids must meet or exceed California standards for low-emission vehicles. Violations of the identification requirements for ILEVs are considered traffic infractions.

Colorado Legislation on LEV HOV Exemptions:

- Only vehicles meeting EPA ILEV standards
- ILEV exemptions subject to cancellation if HOV LOS degraded
- Proposed exemptions for hybrid vehicles will not be implemented unless FHWA approves
- Violations of ILEV regulations are traffic infractions carrying a $65 and $125 fine for first and second offenses within a 12-month period
- Special stickers required:

Florida Legislation on LEV HOV Exemptions:

- Only vehicles meeting EPA ILEV standards
- Meets EPA guidelines
- Hybrid exemptions depend on federal government approval
- Violations are traffic infractions
- Special decal and certificate required:



Georgia Legislation on LEV HOV Exemptions:

- Only AFVs meeting EPA ILEV standards
- Meets EPA guidelines
- Proposed exemptions for hybrid vehicles will require special license plate
- Hybrid exemptions will not be implemented unless U.S. DOT or the U.S. Congress approves
- Violations of HOV regulations are misdemeanors carrying a fine up to $176 and one point for fourth and subsequent offenses
- Special license plate required:

Texas Legislation on LEV HOV Exemptions:

- Only vehicles meeting EPA ILEV standards
- Special sticker required
- Meets EPA guidelines
- ILEV exemptions have not been implemented

Utah Legislation on LEV HOV Exemptions:

- Only "clean fuels special group" vehicles
- Meets EPA guidelines
- HOV violations are Class C misdemeanors carrying a fine of $138
- Special license plate required:

Georgia allows alternative fuel vehicles meeting the EPA ILEV standards to use HOV lanes without meeting occupancy requirements[29]. Exemptions for hybrid vehicles will not be implemented unless approved by either federal legislative action or regulatory action by the U.S. Department of Transportation; at this time hybrid vehicles do not qualify for the occupancy exemption.

To use the HOV lanes, owners of alternatively fueled vehicles must obtain an alternative fuel license plate by completing a vehicle request form, stating the type of fuel used to propel the vehicle[30]. Violators of ILEV regulations are subject to the same graduated misdemeanor fines for general HOV lane violations. Fines begin at $101 for the first offense, graduating to a $176 fine plus one point on a person's driver's license for fourth and subsequent offenses in a 12-month period.

Texas Senate Bill 5, approved in 2001[31] and incorporated into Section 431.073(d) of the Texas Transportation Code, allows vehicles displaying a low-emission vehicle insignia to use HOV lanes without meeting occupancy requirements. Vehicles eligible for the insignia must meet federal ILEV or ULEV emissions standards. This provision is set to expire August 31, 2008; however, this provision was never implemented due to changing priorities in the state.

Utah allows vehicles with clean fuel special group license plates to use HOV lanes without meeting minimum occupancy requirements[32]. To quality for a clean fuel license plate, a vehicle must meet the appropriate EPA standards. The clean fuel plate must be renewed annually. The Utah Code lists a violation of HOV lane regulations as a Class C misdemeanor, punishable by a $138 fine.

Virginia legislation establishes a clean special fuel license plate for special fuel vehicles[33]. The legislation defines clean special fuel to mean 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 includes compressed natural gas (CNG), liquefied natural gas (LNG), liquefied petroleum gas (LPG), hydrogen, hythane (a combination of CNG and hydrogen), and electricity. The legislation does not specifically mention the EPA ILEV requirements. In 2000, the Virginia Department of Motor Vehicles, after prompting from state legislators, allowed hybrid vehicles to obtain clean special fuel license plates. All vehicles using gasoline/electric hybrid technology qualify for these plates.

Virginia allows vehicles with clean special fuel license plates to use the HOV lanes in Virginia without meeting the minimum occupancy requirements[34]. To obtain the special plates, a vehicle owner must submit an application and documentation to the Virginia DMV headquarters Special License Plate and Consignment Center.

The penalty for use of the HOV lane by an unauthorized vehicle is a non-moving traffic infraction, subject to a fine of $50 plus $39 in court costs. However, fines for HOV violations in the northern Virginia area served by the I-95, I-395, I-66, and Dulles Toll Road HOV lanes are significantly higher for repeat offenses. Fines of $200 and $500 are mandated for second and third offenses within five years, while the fourth and subsequent offenses carry a $1000 fine; additional court costs of $39 also apply. Violations of the HOV regulations in northern Virginia count as moving violations, and three license demerit points are assessed for each violation subsequent to a second offense within five years.

Table 7–1 provides a summary of active state legislation regarding HOV eligibility rules for low-emission vehicles. The table also lists any fees related to applying for and maintaining HOV exemption status for a low-emission vehicle.

Virginia Legislation on LEV HOV Exemptions:

- Only "clean special fuel" vehicles
- Qualifying vehicles initially included only non-gasoline vehicles (EPA compliant)
- Fuel-efficient hybrids were added in 2000—Virginia is unique in having implemented HOV exemptions for hybrids
- Exemptions expire July 1, 2006
- Hybrid exemptions do not conform to EPA and current FHWA guidelines
- Stiff fines up to $1039 and license demerits for multiple HOV violations in the northern Virginia area
- Special license plate required:

Table 7-1. Summary of State Low-Emission Vehicle HOV Eligibility Rules[35].

State	Eligible Non-gasoline Vehicles	Eligible Gas/Electric Hybrid Vehicles	Identification Requirement	Fee(s)	Type of Violation	Fine Amount(s)
Arizona	EPA ILEV/ULEV/SULEV	EPA LEEEV (1)	License plate	$8 one time fee $9.75 annual fee	Misuse of AFV plates	$350
California (Pre-2004 Vehicles)	CARB ULEV/ZEV	CARB ULEV/SULEV/PZEV & 45+ Highway mpg (2)	Stickers/decals	$8 one time fee	Unauthorized use of HOV lane	$351/$526/$876
California (2004+ Vehicles)	CARB SULEV/ZEV	CARB AT SULEV & 45+ Highway mpg (2)				
Colorado	EPA ILEV	EPA LEEEV (1)	Stickers/decals	none	Unidentified ILEV	$65/$125
Florida	EPA ILEV	EPA LEEEV (1)	Sticker/decal	$5 annual fee		Moving violation, no points
Georgia	AFV meeting EPA ILEV	EPA LEEEV (1)	License plate	$20 annual fee	Unauthorized use of HOV lane	$101/176 for 4+ violations
Utah	AFV meeting EPA ILEV	None	License plate	$10 one time fee $85 annual fee	Unauthorized use of HOV lane	$138
Virginia (Northern)	"Clean Special Fuel"	Propelled by energy source with lower emissions than gasoline (3)	License plate	$10 annual fee	Unauthorized use of HOV lane	$89/239/539/1039
Virginia (Rest of State)						$50

Notes:

(1) Original state legislation depended on U.S. DOT/EPA approval. Hybrid eligibility will depend on legislative adoption of SAFETEA-LU rules.

(2) Meets or exceeds requirements outlined in SAFETEA-LU.

(3) Does not conform to requirements outlined in SAFETEA-LU; however, state adoption of these rules is anticipated with the 2006 legislative session.

CARB = California Air Resources Board
ZEV = Zero-emission vehicle

Law Enforcement and Emergency Vehicles

Law enforcement and emergency vehicles enjoy explicit exemptions from HOV minimum occupancy requirements under certain conditions. The HOV program guidance provided by FHWA states that vehicles operated by federal, state, or local law enforcement personnel may be permitted to use HOV lanes as long as they are clearly marked law enforcement vehicles equipped with rooftop emergency lights and a siren. Officially marked emergency services vehicles, such as ambulances, fire and tow trucks, and emergency medical services vehicles, are also allowed to use HOV lanes in areas throughout the country without meeting the minimum occupancy requirements. FHWA guidelines do not include an HOV exemption for unmarked agency vehicles or the personal vehicles of enforcement or emergency services personnel.

Enforcement Considerations for Exempt Vehicle Classes

The challenges posed by exempt vehicles to HOV lane enforcement are more peripheral in nature than those presented by non-exempt vehicles. With the exceptions of Virginia and California, most states report having few registered ILEV or low-emission vehicles. For the comparatively few states that track ILEV or low-emission vehicle usage on HOV facilities, an even smaller number of such vehicles actually operate on the HOV lanes. Enforcement personnel do not usually need to perform the difficult task of verifying the number of occupants in low-emission vehicles, instead relying on external identification insignia. Law enforcement and emergency vehicles are likewise constrained in number, thus mitigating their potential impact to HOV operations. However, there is evidence to suggest that the exemption for law enforcement vehicles has been misconstrued to apply more to the driver of the vehicle being a law enforcement officer, rather than a verification of the vehicle markings or type of vehicle being driven.

Concern: HOV Exemptions for Law Enforcement Vehicles:

Evidence suggests that the exemption for law enforcement vehicles has been misconstrued to apply more to the driver of the vehicle being a law enforcement officer, rather than a verification of the vehicle markings or type of vehicle being driven.

Enforcement Considerations for Low-Emission Vehicles

The presence of exempt low-emission vehicles on HOV facilities increases the complexity of the enforcement task. Officers must understand the policies regarding exempt vehicle usage of the HOV lanes and be familiar with the means of identification for these vehicles. A number of other issues may need to be considered in enforcing HOV exemptions. These issues include determining the type of citation for violating the requirements, clearly communicating the rules and regulations on HOV access by these types of vehicles, outreach to the judicial system to help ensure that citations will be upheld, and adding and funding extra enforcement personnel if required. Finally, the fact that the exemption for low-emission vehicles may be terminated at some point in the future should be communicated to commuters, travelers, and the public.

Develop highly visible identifiers. The identification insignia for low-emission vehicles should be distinctive and clearly visible to facilitate visual acquisition and recognition by enforcement personnel. Agencies responsible for enforcement of HOV facilities should play an active role in the design and selection process:

- Special stickers or decals should be large enough to permit identification at a distance and should be located on areas of the vehicle that can be readily seen by an observing officer.

- Special license plates for low-emission vehicles should incorporate distinctive elements such as graphic insignia and a designated prefix or suffix in the plate number.

- Signs should be posted along the HOV facility indicating permission for low-emission vehicles not meeting occupancy requirements to use the HOV lanes. These signs should incorporate the same design used in the low-emission vehicle identification stickers and plates so that enforcement personnel and motorists may more easily recognize these identifiers.

Determine type of citation and fine. The type of citation and the fine associated with violating the HOV exemption will need to be determined. Lawmakers should consider whether violations of the regulations for low-emission vehicles on HOV facilities should be treated differently from violations of HOV occupancy restrictions. Specific violations may be considered for the failure of a low-emission vehicle to display the appropriate identifiers, and the misuse of low-emission vehicle stickers, decals, or license plates by owners of ineligible vehicles.

Clearly communicate regulations and fines. The regulations for use of the HOV facilities by low-emission vehicles and the penalties for violating these regulations should be clearly communicated to commuters and travelers in the corridors and the general public. A variety of methods can be used to communicate the regulations and penalties. These methods include press releases, news stories, public service announcements, and websites. In addition, corridor signage should be updated to include this new information.

Outreach to the judicial system. Experience with regular HOV enforcement efforts shows that ensuring that the judicial system is aware of and understands the regulations and fines is important to upholding citations. Extra outreach may be needed with judges and other groups to explain the exemption regulations and the fines and citations associated with violating the regulations.

Provide extra enforcement. Extra enforcement may be needed with HOV exemptions. Approaches to consider include extra enforcement after the introduction of the exemption policies and periodic spot enforcement activities. Funding for extra enforcement personnel may be an issue in many areas. Many of these issues are discussed in greater detail in Chapter Eight.

Communicate potential that exemption may be terminated. Numerous methods are available for communicating the possibility that access to HOV lanes by environmentally friendly vehicles or other exempt vehicles may be terminated in the future or in real time as operating conditions warrant. Potential communication

methods should be targeted to the public at large, to travelers in corridors with HOV lanes, and to owners of the exempt vehicles. Press releases, news stories, public service announcements, and websites can be used to communicate with the general public. Drive time radio updates, highway advisory radio (HAR), stories in neighborhood newspapers, billboards, bus signs, and other techniques may be appropriate.

Enforcement Considerations for Law Enforcement and Emergency Vehicles

Generally, HOV lane use by law enforcement and emergency vehicles that are clearly marked and equipped with rooftop emergency lights and a siren is relatively low. However, law enforcement and emergency personnel traveling alone in their personal vehicles or in an unmarked agency vehicle when not on duty may be an issue in some areas of the country. This issue has been identified as a problem with the HOV lanes in northern Virginia by the HOV Enforcement Task Force, which attributed this activity not only to law enforcement personnel, but also to many federal employees in enforcement roles. It has also been identified as a concern on the Gowanus Expressway HOV lane in New York. Observations from the I-10 and US 290 HOV lanes in Houston indicate that personal or unmarked vehicles of law enforcement personnel may account for some 2 percent of the HOV lane volumes in the morning peak period (6:30 AM to 8:00 AM)[36]. The recommendations of the northern Virginia HOV Enforcement Task Force with regard to law enforcement and emergency vehicles are discussed in the case study at the end of this chapter. In contrast to the multi-agency efforts in Virginia, neither New York nor Texas appear to have addressed this issue in a formal policy capacity.

Other issues to consider in enforcing HOV exemptions for law enforcement and emergency vehicles include establishing policies and guidelines on use of HOV lanes by law enforcement and emergency vehicles, clearly communicating those policies, and monitoring use to ensure that enforcement personnel follow the regulations and issue tickets to violators.

Establish policies and guidelines on use of HOV lanes by law enforcement and emergency vehicles. It is important to ensure that current state policies and guidelines clearly articulate the types of law enforcement and emergency vehicles that can use an HOV lane without meeting the occupancy requirements. If no policies or guidelines exist, they should be developed by the HOV operating agency, usually the state department of transportation, in cooperation with law enforcement, emergency service, and other appropriate agencies. Recommended elements of such policies or guidelines include

- A policy stipulating that law enforcement officers using personal vehicles on the HOV lanes, as well as personnel using HOV lanes while driving unmarked government vehicles, should observe vehicle occupancy requirements (specific exceptions to this policy should be clearly noted);
- Guidelines that identify the required vehicle markings for eligible law enforcement and emergency service vehicles; and

- Standard procedures to safely accommodate law enforcement vehicles in emergency status (flashing lights and sirens) while using an HOV lane.

Clearly communicate policies and guidelines. The policies and guidelines should be clearly communicated to the agencies responsible for law enforcement and emergency services, policy makers, and the public. A number of approaches may be used to communicate these policies, including letters or directives from top law enforcement personnel to their staff, information on agency websites, newsletters, bulletins, and outreach through police unions and professional organizations. The guidelines should also be clearly communicated to HOV lane enforcement personnel in standard operating procedures. Enforcement efforts should be monitored to ensure the policies or guidelines are being implemented.

Case Study: Exempt Vehicles

The I-95, I-395, I-66, and Dulles Toll Road HOV lanes serving northern Virginia present a particularly relevant example of the enforcement issues associated with exempt vehicles. With its close proximity to the nation's capital, counties in northern Virginia have some of the highest per capita numbers of law enforcement personnel, many of whom commute to the Washington, D.C., metropolitan area. The number of hybrid vehicles using HOV lanes in northern Virginia has grown dramatically following VDOT's decision to waive the HOV minimum occupancy restriction for these vehicles. HOV lanes in northern Virginia now report the highest percentage of low-emission vehicle use in the nation. This section of the chapter will examine the challenges to HOV enforcement in northern Virginia and the steps taken by Virginia authorities to address them.

Northern Virginia's HOV system is one of the most successful in the nation. The I-95/I-395 corridor stretches from the Potomac River almost 50 miles south to the Fredericksburg area, and the HOV lanes along this route serve over 30,000 commuters every morning. The I-66/Dulles Toll Road corridor carries traffic west from the Potomac to Dulles Airport and southwest to the Manassas area. For a typical morning peak period (6:30 AM to 9:30 AM), the HOV lanes on these corridors carry over 52,000 people. Over the past several years, usage of HOV lanes in northern Virginia by low-occupancy vehicles had risen to the point where the I-95 HOV lanes were exceeding their maximum capacity. The resulting breakdown in LOS and complaints of widespread cheating prompted VDOT to convene an HOV Enforcement Task Force in 2003 to find and recommend solutions to improve enforcement. The Task

Adaptive Regional or Corridor-Level Regulation of Exempt Vehicles:

Some states limit the number of hybrid registrations based on a statewide assessment of excess capacity on the HOV system, but many find that hybrid vehicles concentrate and degrade the LOS on specific HOV corridors, while excess capacity still exists statewide.

This is true in Virginia, where the majority of registered clean special fuel vehicles are located in northern Virginia, while relatively few such registrations occur in the rest of the state.

Despite the fact that on a statewide basis Virginia still has excess capacity on its HOV system, the HOV lanes in northern Virginia are facing congestion resulting from the hybrid exemption.

Regional or corridor-specific policies, as enacted in Virginia and California, enable facility operators to better protect service levels on the HOV lanes in the face of an increasing numbers of exempt vehicles.

Force includes members from VDOT, State Police, DMV, Department of Environmental Quality, Fairfax County, two northern Virginia transportation commissions, Council of Government, Metropolitan Washington Airports Authority, FHWA, and AAA Mid-Atlantic.

In its findings pertaining to exempt vehicle use on the HOV lanes, the HOV Task Force reported that by October 2004, clean special fuel vehicles accounted for up to 17 percent of the vehicles in the HOV lanes on I-95 during the 6:00 AM to 9:00 AM period in the northbound direction, a significant increase from the 12 percent observed in 2003. Clean special fuel license plates issued in Virginia had increased dramatically, from only 78 through 1999, to 5943 as of October 2004. Nearly 95 percent of these plates were issued to hybrid vehicles, while 93 percent of all clean special fuel plates been issued to vehicles in the counties of northern Virginia served by the I-95, I-395, I-66, and Dulles Toll Road HOV lanes.

The task force also found that off-duty law enforcement and emergency personnel, as well as many federal employees who consider themselves law enforcement personnel, use the HOV lanes to travel to and from work in their personal vehicles. The exact number of these individuals has not been documented, however.

In its 2003 and 2005 reports, the Virginia HOV Enforcement Task Force recommended the following policies be implemented for exempt vehicles[13, 14]:

- The number of clean special fuel plate vehicles should be restricted. This can be effected by several means in the short term, including the adoption of stricter criteria such as the California SULEV standard for eligible hybrid vehicles, requiring annual renewals of clean special fuels registrations and not extending the clean special fuel HOV exemption past its current expiration date of July 1, 2006. Longer term policy options include
  - Increasing occupancy levels for hybrid vehicles;
  - Increasing the issuance fee for clean special fuel vehicle license plates from $10 per year to at least $500 per year and sharing these revenues with law enforcement and VDOT for enforcement and facility maintenance efforts;
  - Limiting the hours that vehicles registered with clean special fuel vehicles license plates can enter HOV lanes exempt from occupancy requirements; and
  - Capping the number of clean special fuel vehicle license plates that can be issued and using a lottery process to assign the limited number of registrations available.
- The policies regarding usage of the HOV lanes by law enforcement and emergency personnel must be clarified. The Virginia secretaries of transportation and public safety should issue a joint letter to all enforcement and emergency agencies emphasizing that law enforcement and emergency personnel cannot legally commute in the HOV lanes in their personal vehicles without meeting the required

occupancy level. The statutory exemptions for law enforcement vehicles should be better defined and clarified because the current Code of Virginia does not provide a specific definition for such vehicles.

CHAPTER EIGHT
LEGISLATIVE AND JUDICIAL ISSUES IN HOV AND HOT ENFORCEMENT

Chapter at a Glance

This chapter discusses the relevant legislative and judicial issues affecting enforcement along HOV and HOT facilities. The first section of this chapter identifies the relevant entities having roles in the legal and judicial aspects of HOV/HOT enforcement. The next section of the chapter discusses the main legislative issues affecting enforcement and supplies pertinent examples of federal, state, and local legislation. Comprehensive surveys of state laws are provided in this chapter for topics such as vehicle eligibility requirements, jurisdiction of enforcement agencies, and HOV penalties and fines. The final section of the chapter discusses salient issues related to the adjudication of HOV violations.

Section headings in this chapter:

- Stakeholders Involved with Legal and Judicial Issues in HOV Enforcement
- Legislative Issues in HOV and HOT Enforcement
- Judicial Issues in HOV and HOT Enforcement

Stakeholders Involved with Legal and Judicial Issues in HOV Enforcement

The various stakeholders having significant roles in the legislative and judicial processes are highlighted in Table 8-1. Many of these stakeholders share a common trait in that they have the power to set policies governing HOV lanes, whether this be in the form of laws, administrative rules, or legal precedents.

Table 8-1. Stakeholders Concerned with Legal and Judicial Issues in HOV Enforcement.

Stakeholder	Potential Roles and Responsibility
United States Congress	• Enacting federal legislation on permitted user classes and appropriations for HOV facilities
State Legislators	• Enacting statutes pertinent to HOV enforcement, including the designation of enforcement authority, enforcement appropriations, defining HOV regulations, violations, and the adjudication process and penalties
County and Municipal Legislators	• May be responsible for enacting regional or local laws pertaining to HOV enforcement, including the designation of enforcement authority, enforcement appropriations, defining HOV regulations, violations, and the adjudication process and penalties
State Department of Transportation	• Coordination with enforcement agencies • Provide guidance to legislative bodies on HOV enforcement issues
Transit Agency	• May be responsible for enforcement of HOV facilities • Coordination with enforcement agencies • Coordination with judicial personnel
State Police	• Often primarily responsible for enforcement of HOV facilities • Coordination with judicial personnel
Local Police	• Lead or assisting role in enforcement of HOV facilities • Coordination with judicial personnel
Federal Agencies—FHWA, FTA, EPA	• Provide rules and guidance on permitted user and vehicle classes
State and Local Judicial Systems	• Responsible for enforcing fines and citations for improper use of the HOV facilities
Metropolitan Planning Organization	• Assist in facilitating meetings and multi-agency coordination • May have policies relating to HOV facility operation and enforcement

Legislative Issues in HOV and HOT Enforcement

As rulemaking bodies, legislatures have, within their respective scopes, ultimate say in how HOV and HOT facilities are enforced. This section of the chapter discusses the principal areas of legislation most pertinent to enforcement, including the authority and jurisdiction of enforcement agencies, vehicle eligibility on HOV/HOT facilities, standards of evidence for violations, provisions for funding of enforcement operations, and the nature and severity of penalties for HOV/HOT violations.

Authorization and Allocation of Powers

HOV Facilities

The authorization and allocation of powers for enforcement of freeway HOV facilities is handled through a combination of state regulations and local ordinances, so long as those laws do not conflict with any federal regulations governing the operation of federal-aid highways. Most commonly, such legislation designates primary responsibility for HOV enforcement to the state patrol or state police. For example, the California Highway Patrol has full responsibility and primary jurisdiction for the administration and enforcement of the laws on all California toll highways, freeways, and most associated transit-related facilities[37], including those laws pertaining to HOV and toll/HOT operation[38]. However, city police are also authorized to perform incidental enforcement of HOV facilities and in fact have primary jurisdiction in cities having a population greater than 2 million or an area of more than 300 square miles[37].

Some states may instead assign primary HOV enforcement responsibilities to local or regional agencies. In New York, Nassau and Suffolk County police provide primary enforcement of the I-495 HOV lanes[3], while in Hawaii, the Honolulu County Police Department is the lead agency for enforcement on HOV facilities in the metropolitan area[39].

Other agencies with the power to enforce HOV requirements may include transit authorities. In Texas, certain transit authorities are allowed to commission and hire peace officers, who are responsible for enforcing traffic laws within the transit authority system[40, 41]. Additionally, if a transit authority serves an area in which the principal municipality has more than 1.5 million residents, sworn peace officers of the authority are granted the more general powers of peace officers[42]. However, it is important to note that the municipalities in which transit peace officers have this authority do not typically rely on the transit peace officers for all primary control on state highways within the municipal boundaries.

HOT Facilities

HOT facilities generally require some form of dedicated enforcement, which can often be financed through toll revenue. In addition, HOT facilities may also be operated by private entities. Most state legislation authorizing HOT facilities includes provisions by which the facility operator can enter into contractual arrangements with various state or local enforcement agencies.

California legislation is relatively explicit with regard to the general terms required in contract enforcement arrangements. The California Streets and Highways Code authorizes the California Department of Transportation and the California Highway Patrol to enter into agreements with private entities for maintenance and police services on existing transportation toll demonstration projects[43]. Other sections of the code deal with arrangements for enforcement on specific HOT facilities. Sections 149.1 and 149.4 of the code[44] provides guidelines to the San Diego Association of Governments for enforcement operations on the I-15 Express Lanes such as

- Specifying exceptions to HOV minimum occupancy requirements for vehicles paying a toll,

- Developing clear and precise procedures for enforcement by CHP of laws prohibiting the unauthorized use of the HOV lanes, and

- Reimbursing CHP and other state agencies for services performed during implementation and operation of the facility.

Similar legislative provisions are specified for potential HOT lane facilities in Alameda County[45] and Santa Clara County[46].

Minnesota does not assign primary jurisdiction for enforcement of HOV/HOT lanes to any particular agency. The Minnesota State Patrol, as well as county and municipal enforcement agencies, has authority to enforce traffic laws on trunk roadways and toll facilities[47, 48]. For HOT lane operations on I-394, MnDOT is empowered to enter into contracts with enforcement agencies[49], in which an agreement may provide for the exercise of powers by one or more of the participating governmental units on behalf of the other participating units[50]. In the case of the joint exercise of police power, an officer acting pursuant to that agreement has the full and complete authority of a peace officer as though appointed by both governmental units and licensed by the state of Minnesota[51].

Table 8-2 provides a list of the agencies responsible for enforcement on the various HOV and HOT facilities in the United States.

Table 8-2. Authorized Enforcement Agencies for HOV Facilities[52].

Location	Routes	Peak Eligibility Requirements	Enforcement Agency
Phoenix, AZ	I-10, SR 202, I-17	HOV2+	State police
California	Many	HOV2+ on most facilities HOV3+ on I-80, I-10 SOV (toll) or HOV2+ on I-15 HOV3+ (reduced toll) on SR 91	California Highway Patrol
Hartford, CT	I-84, I-91	HOV2+	State police
Denver, CO	I-25	HOV2+	Colorado Highway Patrol, Denver and Adams County Police
Ft. Lauderdale, Miami, FL	I-95	HOV2+	Florida Highway Patrol
Atlanta, GA	I-20, I-75, I-85	HOV2+	State police, local police, state transportation departments, certified police officers
Honolulu, HI	H-1, H-2, Moanaloa Freeway, Kalanianaole Highway, Kahekili Highway	HOV2+	Honolulu Police Department
Montgomery County, MD	I-270	HOV2+	Maryland State Police
Boston, MA	I-93	HOV2+	State police
Minneapolis, MN	I-35W, I-394	SOV (toll) and HOV2+	Minnesota State Patrol, Minneapolis, Golden Valley, and Transit Police
Charlotte, NC	I-77	HOV2+	State and local police
Pittsburgh, PA	I-279/579	HOV2+	State police
Nassau and Suffolk Counties, NY	I-495	HOV2+	Nassau and Suffolk County Police
Nashville, TN	I-40, I-65	HOV2+	Metropolitan National Police
Dallas, TX	I-35E, I- 635, US 67, I-30	HOV2+	Dallas Area Rapid Transit
Houston, TX	I-10, I-45, US 59, US 290	HOV2 (toll) and HOV3+ on I-10 during AM and PM peaks HOV2 (toll) and HOV3+ on US 290 during AM peak	Houston METRO
Salt Lake City, UT	I-15	HOV2+	Utah Highway Patrol
Norfolk, Virginia Beach, VA	I-64, I-564, SR 44	HOV2+	Virginia State Patrol
Northern Virginia, VA	I-66, I-95, I-395, SR 267	HOV3+ on I-95/395 HOV2+ on I-66, SR 267	Virginia State Patrol
Seattle, WA	I-5, I-90, I-405, SR 167, SR 520	HOV2+	Washington State Patrol

Authorized User Classes

Title 23 of the United States Code[53] directs state departments of transportation or other responsible local agencies to establish minimum occupancy requirements for vehicles operating in HOV lanes and defines exceptions to these requirements for certain classes of vehicles. As amended in 2005 by the Safe Accountable Flexible and Efficient Transportation Equity Act: A Legacy for Users[24], operating agencies are required to restrict the use of the HOV lanes to vehicles with at least two occupants. Motorcycles are also permitted, subject to safety restrictions that may be imposed by the operating agency. SAFETEA-LU also allows operating agencies to designate exceptions to the minimum occupancy rules for certain classes of vehicles, such as

- Low-emission and energy-efficient vehicles,
- "Deadheading" designated public transit vehicles, and
- Single-occupant vehicles paying a toll.

The decision to permit exemptions for toll or low-emission vehicles imposes significant new enforcement and performance monitoring responsibilities on the operating agency. As specified under SAFETEA-LU, operating agencies permitting these exemptions on HOV facilities are required to

- Establish, manage, and support a performance monitoring, evaluation, and reporting program for the facility that provides for continuous monitoring, assessment, and reporting on the impacts that the vehicles may have on the operation of the facility and adjacent highways;
- Establish, manage, and support an enforcement program so as to insure that the operational performance of the facility is not degraded; and
- Restrict or eliminate exceptions for these vehicle classes if specific performance criteria are not met.

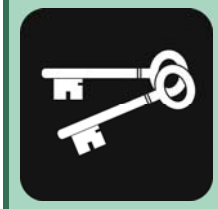
Further information about the specific provisions of SAFETEA-LU pertaining to HOT facilities is provided in Chapter Six, while a discussion of enforcement issues associated with low-emission vehicles may be found in Chapter Seven.

Most state legislation regarding vehicle occupancy requirements on HOV facilities either references federal guidelines or appears to be in keeping with federal requirements. A current listing of minimum vehicle occupancy requirements is provided in Table 8-2. Specific state legislative treatments for low-emission vehicles are discussed in Chapter Seven.

Admissible Evidence for Violations

The standard of evidence for proof of an HOV violation depends on whether the violation is civil or criminal in nature. Non-criminal violations may be subject to administrative legal procedures, where the state's burden of proof may be only a "preponderance of the evidence," in contrast to "beyond a reasonable doubt" for

criminal procedures. Preponderance of evidence means evidence which is of greater weight, or more convincing, than that which is offered by the opposing party. This approach is most effective when supported by legislation establishing prima facie evidence for HOV violations. This is legal evidence adequate to establish a fact or raise a presumption of fact unless refuted. In regard to prima facie evidence, it is up to the defendant to refute the evidence. The establishment of prima facie evidence through legislative enactment benefits the enforcement officer by putting the burden of proof on the defendant and not the officer.



Legislation Concerning Evidence for HOV Violations:

- If not already enacted, consider decriminalization of HOV violations to ease prosecutorial evidentiary burdens and facilitate adjudication.
- Consider additional legislative language to expand the definition of prima facie evidence for HOV violations if viable technologies for automated enforcement emerge.
- For HOT lanes, consider legislation requiring the display of toll transponders or other readily visible identifier.

Many, if not all, states use civil administrative procedures to deal with HOV violations, and some states have additionally passed legislation pertaining to prima facie evidence of HOV violations as a means of enabling "ticket by mail" enforcement programs. Under such a program, the enforcement officer is not required to apprehend a violator; instead, visual observation of the moving vehicle constitutes the evidence for occupancy violations, and a complaint or citation is issued by mail to the registered owner of the vehicle. In this case, a potential area of prima facie evidence (assuming appropriate legislative statutes/ordinances have been passed) could be that the registered owner of a vehicle violating the HOV facility is the same person driving the vehicle at the time of the violation. The fact that a vehicle was violating the HOV restrictions could be enough proven fact to establish the registered owner as the person operating the vehicle. This presumption makes the registered owner responsible, and it is then up to the owner of the vehicle (defendant) to refute this connection if it is not valid.

Hawaii legislation currently provides an option for enforcement officers to issue citations by mail without apprehending the violator. The statute requires an officer exercising this option to be clearly visible to motorists; the officer, upon observation of an HOV violator, records information displayed on the vehicle that may identify its registered owner and cause a summons or citation to be sent by certified or registered mail to that owner[54]. The standard of proof to be applied by the court shall be whether a preponderance of the evidence proves that the traffic infraction was committed[55]. Georgia legislation allows a broad range of prima facie evidence as proof of an HOV violation. Direct observation by an officer, or video surveillance, either by magnetic imaging or photographic copy, of the offense, together with proof that the defendant was at the time of such violation the registered owner of the vehicle, constitutes evidence as a rebuttable presumption that such registered owner of the vehicle was the person committing the violation[56].

This presumption may be overcome by sworn testimony of the owner of the vehicle that he or she was not the operator of the vehicle at the time the alleged offense occurred.

While decriminalization and legislation pertaining to prima facie evidence of vehicle occupancy violations have facilitated adjudication, they have thus far proved inadequate to permit further streamlining of the HOV enforcement process by techniques such as ticket by mail and automatic photo/video enforcement. Without apprehension of the motorist and an inspection of the vehicle by an enforcement officer, the prosecution of HOV violations is vulnerable to challenges by defendants. The chief difficulty undermining remote inspection of vehicles mirrors those problems discussed in Chapter Nine, namely the inability of officers and imaging devices to reliably detect rear occupants and small children. Virginia's experience with mailed citations is instructive in this case.

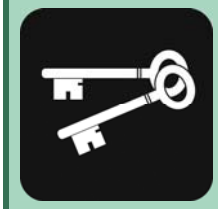
HOV violations in Virginia were originally considered a moving violation and carried a three-demerit point penalty against the driver's record at DMV. When the state undertook a demonstration project of "ticket by mail" in 1989, the point penalty was eliminated and only fines were assessed. State legislation was changed to hold the registered owner of a vehicle presumptively responsible for an HOV violation involving that vehicle. Prima facie evidence for this presumption consists of proof that the vehicle described in the violation summons was operated in violation of HOV regulations, together with proof that the defendant was at the time of such violation the registered owner of the vehicle. The statute provides that this presumption shall be rebutted if the registered owner of the vehicle testifies in open court under oath that he was not the operator of the vehicle at the time of the violation[57]. Initially, the ticket by mail program was effective, resulting in an 85 percent conviction rate while allowing officers to apprehend more violators[58]. However, legal challenges based on insufficient proof of violation became increasingly successful, and many citations were not upheld. As a result, the Virginia State Patrol changed procedures to stop the vehicle and record information on the driver. Ticketing by mail has effectively been discontinued in Virginia although the state patrol still uses the mail to send completed citations to violators since this practice spares officers from having to complete and issue the citation during the stop.

Toll violations on HOT lanes share many of the same evidentiary requirements as HOV violations, in that vehicle occupancy must be verified to determine if the vehicle is exempt from the toll. All currently operating and planned HOT facilities utilize electronic toll collection technologies, where a radio frequency transponder is used to identify a toll user for billing purposes. As discussed in Chapter Nine, this method of toll collection is vulnerable to several evasion methods if the use of a toll transponder is not mandated for all users (HOV as well as toll) of the HOT facility. The difficulty in proving toll violations on HOT facilities can be ameliorated by legislation pertaining to the display of transponders. For example, the California Vehicle Code allows operators of toll facilities to require that transponders be located so that they are visible for the purpose of enforcement at all times. This requirement may be imposed even if the operator offers free travel or non-toll accounts to certain classes of users[59].

Funding and Revenue

Funding for continuing enforcement efforts on HOV facilities is limited to that which is available through normal or special legislative appropriations and interagency agreements although the level of funding from these sources may

sometimes be substantial. Funding for enforcement efforts by the Virginia State Patrol on the HOV facilities in northern Virginia currently reflects an additional $250,000 over the 2002 annual budget of $140,000. The 2003–2004 annual budget for Nassau County police enforcement of the Long Island Expressway HOV lanes was similarly large at $308,000. Well-financed enforcement programs such as these are often exceptions, however, and many HOV facilities must make do with budgets that support little more than routine enforcement.



Legislation Concerning Funding and Revenue:

- For HOV lanes, consider legislation that permits a portion of HOV fine revenue to be allocated toward continuing HOV enforcement efforts.
- For HOT lanes, ensure that authorizing legislation for these facilities contains provisions for reimbursement of enforcement costs from toll revenue.

Independent continuing sources of revenue, such as the revenue from the collection of HOV fines, are not directly available to enforcement agencies although there has been a recent legislative effort to make this source available. A 2004 bill in the Washington State Senate attempted to channel a portion of fine revenue from HOV violations back to the Washington State Patrol as a means of providing funding for expanded enforcement operations. Senate Bill 5936 would have increased the fine for HOV violations by $100, of which $50 would be provided to a new fund for HOV lane enforcement and education[60]. This bill was not ratified, however.

HOT lanes, unlike HOV lanes, do benefit from legislation that permits the financing of enforcement efforts through toll revenue generated by these facilities. Legislation in California[61] and Utah[62] stipulates that revenues from toll operations on HOT facilities shall be used in part to reimburse state agencies for enforcement operations along the corridors served by these facilities, while Colorado legislation[20] limits reimbursement for law enforcement services to the available toll revenue left over after paying capital and (non-enforcement) operating costs for the facility.

As discussed previously in Chapter Six, HOV and HOT facilities are also eligible for pre-implementation and implementation funds. Under the Value Pricing Pilot Program, $9 million is available to state agencies for implementing variable toll pricing projects, beginning with the 2006 fiscal year ($8 million for the 2005 fiscal year) and continuing through 2009. The VPPP is funded by contract authority and remains available for four years. Funds available for the Value Pricing Pilot Program can be used to support pre-project study activities and to pay for enforcement planning and implementation costs.

Citations and Fines

Table 8-3 summarizes the results of a survey of state and local statutes pertaining to HOV violations and penalties. This table identifies several characteristics of the various legislations described below:

- **Controlling legislation.** This indicates if the legislation governing HOV violations has been enacted on the local/municipal or the state level.

- **Type of violation.** Some states have enacted penalties specifically for buffer violations such as entering or exiting a buffer-separated facility at non-designated locations. These provisions are noted in addition to the more common violation of improper lane use by non-eligible vehicles.

- **Fine amount(s).** This indicates the monetary penalties for an HOV lane violation. Where available, information on total penalties (fine, surcharges, court costs, etc.) is provided. States having an escalating fine structure for repeat offenders are also noted.

- **License penalties.** This identifies any additional penalties such as demerit points on insurance or driving record.

Legislation Concerning HOV Violations:

- Consider enacting state laws that explicitly categorize HOV violations so as to facilitate consistent enforcement and adjudication.
- Consider enacting specific laws for buffer violations on HOV facilities.

Controlling Legislation

Nearly all the states shown in Table 8-3 have enacted legislation specifically pertaining to unauthorized use of an HOV lane. States such as Arizona[63], California[64], Florida[65], Georgia[66], Hawaii[67], Minnesota[68], Tennessee[69], Utah[70], Virginia[71], and Washington[72] define a violator to be any person who operates a vehicle on an HOV lane with less than the required minimum number of occupants. Other states do not have statutes explicitly dealing with HOV violations, and enforcement officers instead charge violators under more general state motor vehicle laws. For example, in New York State, Nassau and Suffolk County police charge unauthorized users on the Long Island Expressway HOV lanes with failure to observe posted highway signs or markings[73]. HOV enforcement personnel in Houston, Texas, rely on similar laws to ticket violators where the HOV lane system operates beyond the Houston city limits[74]; otherwise enforcement is handled under a City of Houston ordinance[75].

Type of Violation

On buffer-separated or non-separated HOV facilities, enforcement personnel must concern themselves with an additional type of HOV violation. Motorists who violate the buffer or double lines indicating prohibited access to the HOV lane pose a serious safety hazard to traffic in the HOV and general-purpose lanes. Due to the great number of buffer-separated facilities operating in California, the state has passed legislation specifically prohibiting such unsafe movements on HOV facilities[76]. Other states treat such buffer violations in similar fashion to New York, where officers charge violators with an unsafe lane change[77].

Table 8-3. Citations and Fines for HOV Violations in Selected States[78].

State	Controlling Legislation	Type of Violation	Fine Amount(s)	License Penalties
Arizona	State	Unauthorized use	$354(2)	Moving violation, three points
California	State	Unauthorized use	$351/526/876(2)	Moving violation, no points
		Buffer violation	$351/526/876(2)	Moving violation, one point
Colorado	State	Unauthorized use	$65/65/125	Non-moving violation, no points
Florida	State	Unauthorized use	$78(2)	Moving violation, no points
Georgia	State	Unauthorized use	$101/126/176(2)	Moving violation, one point for fourth and subsequent offenses in 12 months
Hawaii	State	Unauthorized use	$102/177/227(2)	Moving violation, points imposed by insurance company
Maryland	State	Unauthorized use (1)	$50	Moving violation, one point (two points if contributing to an accident)
Massachusetts	State	Unauthorized use (1)	$50	Moving violation, one point
Minnesota	State	Unauthorized use	$130	Moving violation, points imposed by insurance company
New York	State	Unauthorized use (1)	$150	Moving violation, two points
		Buffer violation (1)	$150	Moving violation, two points
North Carolina	State	Unauthorized use	Up to $100	Moving violation, two points
Pennsylvania	State	Unauthorized use (1)	$105(2)	No points
Tennessee	State	Unauthorized use	$60(2)	Non-moving violation, no points
Texas (Houston)	Municipal	Unauthorized use	Up to $200	Non-moving violation, no points
Texas (Dallas)	Municipal	Unauthorized use	$251(2)	Moving violation, insurance may increase
Utah	State	Unauthorized use	$138(2)	Moving violation, no points
Virginia (Northern)	State	Unauthorized use	$50/200/500/1000(2)	For Planning District 8: moving violation, three points for third and subsequent offenses in five years
Virginia (Rest of state)	State	Unauthorized use	$50	Elsewhere in the state: Non-moving violation, no points
Washington	State	Unauthorized use	$101(2)	Moving violation, zero or one point, depending on insurance policy

Notes:

(1) HOV violations are actually cited under failure to obey traffic signs, markings, or traffic control devices.

(2) Includes penalty assessments, surcharges, and court costs in addition to base fine.

Fines for HOV Violations:

- Enact uniform state rules for HOV penalties to reduce inconsistent judicial fine assessments, and to facilitate public awareness of fine amounts.
- Set fine amounts to levels that constitute a credible deterrent to potential violators.
- Enact escalating fine structures with substantial penalties for repeat offenders.
- Consider multi-year periods for the tracking of repeat offenders to maximize effectiveness of an escalating fine structure.

Fine Amount(s)

Fines constitute the chief deterrent against HOV violators. The general experience with fines for non-compliance with HOV facility operating requirements is that higher fines equate to lower violations[52]. Fine assessments for HOV violations vary widely among the various states, as may be readily seen in Table 8-3. Some of the more noteworthy approaches to HOV fines are discussed below.

Only California, Colorado[79], Georgia[80], Hawaii[81], and Virginia[82] have instituted escalating fine structures for repeat HOV violators. The fine amounts listed for four of these states in Table 8-3 represent the *minimum* penalties for violating HOV regulations. Hawaii is the exception among this group; its legislation permits consideration of non-specified mitigating circumstances in the determination of HOV fines[83].

The high value of minimum HOV fines in California is set statewide by the Judicial Council of California in its Uniform Bail and Penalty Schedules[84], and the fine amounts shown in Table 8-3 are the total cost of a ticket. These costs result from the imposition of substantial penalty assessments in addition to the base or statutory fine. For example, the total fine is the sum of

- The base fine for a first ($100), second ($150), and third or more ($250) HOV violation within a 12-month period;
- A state penalty assessment equal to 100 percent of the base fine;
- A county penalty assessment equal to 70 percent of the base fine;
- A penalty assessment to support DNA identification and recordkeeping, equal to 10 percent of the base fine;
- A court penalty assessment equal to 50 percent of the base fine;
- A general surcharge equal to 20 percent of the base fine; and
- A $1 fee assessed in all counties with night courts.

Thus, a first offense for an HOV violation results in a $100 base fine, plus $251 in penalty assessments and surcharges, for a total cost of $351. Other states having substantial penalty assessments in proportion to the base fine include Arizona (77 percent on a $200 fine), Utah (176 percent on a $50 fine), and Washington (173 percent on a $37 fine).

Virginia's structure of escalating fines is also notable in that HOV violations are tracked for a five-year period from the first such violation. By contrast, California, Colorado, Georgia, and Hawaii only count repeat offenses for a one-year period from the first violation. Virginia's legislative provisions for escalating fines and point assessments on HOV violations are not applicable statewide, but only to the northern Virginia region. Outside this area, HOV violations are a flat $50 fine plus $39 in court costs. This fact is not as anomalous as it initially appears, however, because nearly all state HOV facilities (specifically I-95, I-395, I-66, and the Dulles Toll Road) are located in northern Virginia.

License Penalties

Next to the potential cost of a ticket, the possible imposition of demerits on a driving record provides the greatest deterrent to potential HOV violators. Demerits or "points" provide an additional weapon with which to combat persistent, repeat violators since the higher insurance premiums and the possible loss of driving privileges resulting from multiple point assessments can impose substantial costs and inconvenience. Alternatively, a system of points can allow for lower fines while still providing a deterrent effect, especially if the assessed points persist for at least a few years on a violator's driving record.

Of the states listed in Table 8-3, slightly over half assess points for HOV violations. Some states, such as California and Maryland, assess points based on the severity of the particular violation. California legislation does not impose points for violating minimum occupancy requirements but does impose one point for buffer violations since the latter type of violation is considered hazardous driving behavior. Maryland legislation doubles the normal one-point assessment for an HOV violation if the violation contributes to a traffic accident. Other states assess points based on the number of repeat violations. Georgia assesses one point for the fourth and subsequent HOV violations committed within a one-year period. Virginia legislation is more severe, with HOV violators in northern Virginia being docked three points for a third and subsequent offenses within a five-year period. The point penalties for HOV violations in Virginia are, in fact, the highest in the nation when considered in light of the fact that Virginia drivers with more than six points on their license records are subject to having their licenses suspended.

License Penalties:

- Consider changes to motor vehicle codes that would categorize HOV violations as moving violations.
- Consider implementing demerit points for HOV violations to deter repeat violators.

Judicial Issues in HOV and HOT Enforcement

Judicial Support for Citations and Fine Structure

A good enforcement program can be undermined by the judicial branch of government if the judicial branch does not uphold the citations issued by the enforcement agency. If police officers continually find their citations being overturned in traffic court, they may be inclined to issue fewer citations for the offense in question. Knowledgeable motorists may also become aware of certain traffic citations that are not being upheld by the traffic court system, particularly if publicized in the news media.

An HOV project is susceptible to misinterpretation by the judicial branch. The HOV project oftentimes incorporates a traffic scheme and traffic regulations that are unique to the area. Incomplete judicial understanding of the HOV project could result in judicial overrulings of the HOV citations. Additionally, because of the unique traffic scheme associated with HOV projects, traffic court judges can be more sympathetic to an alleged "confused and unsuspecting" motorist cited for an HOV violation.

Recent studies of the Houston and Atlanta HOV systems reveal some of the above difficulties. In Houston, fines for HOV violations can be up to $200, but judges have wide latitude in setting fine amounts, resulting in inconsistent fines. The average fine is only $140, and fines of as little as $20 have been assessed for HOV violations. In a 2003 enforcement report prepared as part of the HOV Strategic Implementation Plan for the Atlanta Region, Georgia Department of Transportation (GDOT) staff, HOV enforcement officers, and researchers found that the judicial branch was not consistently enforcing legislative policies and laws, therefore limiting the effectiveness of those policies. In the area of judicial support for HOV enforcement, the team recommended

- Working more actively with municipal and county probate judges who hear HOV violation cases to better uphold HOV violation citations, including the use of special presentations, focus-group meetings, or education seminars for judges who are involved with HOV enforcement violations; and

- Restructuring the system of fines for HOV violations and increasing the level of the fines, modifying existing state legislation as necessary.

Scheduling Support

In addition to judicial unfamiliarity with HOV laws, the time spent by officers supplying witness testimony against defendants poses another difficulty for enforcement. These extra hours can increase the expense of enforcement as well as divert manpower, and it is in the best interest for enforcement and judicial agencies to closely coordinate the scheduling of testimony to minimize this time.

The consequences of poor scheduling support can also have a great impact on conviction percentages, as may be seen in the case of legal proceedings against HOV violators in Houston. A judicial liaison for the Houston Metropolitan Transportation Authority has identified a pattern of defendants "gaming" the legal system, whereby defendants are able to successively obtain continuances at each court appearance. The result of this series of continuances is to greatly increase the time and associated pay required to have the citing officer present for the proceedings. If the officer ultimately fails to appear at a rescheduled hearing, the case is dropped. An examination of judicial records for HOV violations between October 2001 and October 2003 revealed that, of 4863 cases that went to court, 65 percent of these cases were dismissed. Seventy percent of these dismissed cases (46 percent of all court cases) were dismissed due to the failure of the citing officer to attend the hearing. For cases where the officer was able to attend, 98 percent of defendants plead guilty or no contest, with the remaining 2 percent being found guilty 96 percent of the time.

Communication between Enforcement and Judicial Agencies

It is important that judges develop an appreciation for the objectives of the HOV project and the enforcement approach needed to achieve the objectives. Briefings for traffic court judges regarding an HOV facility and its associated traffic regulations can be an important consideration influencing court attitudes. Judicial appreciation of the merits of the HOV facility helps toward developing the proper judicial support for the project. Specifically, the judges should be informed of[4]

- The objectives of the HOV facility project;
- The traffic regulations applied to achieve the objectives;
- The enforcement approach;
- Previous court rulings, if any, on similar projects; and
- The legal basis for the restrictions and enforcement procedure.

Efforts to improve judicial awareness of HOV enforcement issues should commence as early as the planning phase of an HOV or HOT project and should be intensified in advance of operational changes to the facility.

CHAPTER NINE
ENFORCEMENT TECHNOLOGIES

Chapter at a Glance

This chapter reviews existing and newly emerging technologies applicable to HOV enforcement, beginning with a discussion of the different requirements posed by HOV and HOT facilities. The first section offers general guidelines for technologies appropriate to HOV facilities and discusses the additional technologies that should be considered for enforcement of HOT facilities. The next section discusses the various technologies available for HOV and HOT enforcement. These include occupancy enforcement technologies, as well as recent developments in occupancy verification systems. Technological implementations for HOT along HOT facilities in two cities (Houston, Texas, and Minneapolis, Minnesota) are examined in this section as well.

Section headings in this chapter:

- General Technology Guidelines for HOV and HOT Facilities
- Technologies for Vehicle Occupancy Detection
- Technologies for Toll Transponder Verification

General Technology Guidelines for HOV and HOT Facilities

Most enforcement technologies developed specifically for HOV facilities have focused on vehicle occupancy detection and eligibility verification. Similar to license plate recognition systems, a vehicle occupancy detection system utilizes one or more cameras and illumination sources to collect images from the interior of passing vehicles. Systems range in complexity from operator-monitored video cameras though automated processing of infrared composite images. To date, none of these systems are in regular use since they have either proved themselves inadequate for the task or have yet to progress past the point of limited field tests. No automated occupancy verification system has been able to demonstrate comparable accuracy (low false alarm rate) and reliability to other existing automated systems now in widespread use (e.g., LPR and ETC).

Difficulties of HOT Enforcement:

- The mixed toll and carpool vehicle traffic on HOT lanes compounds difficulties already inherent to HOV enforcement.
- In the absence of a universal transponder requirement, automated toll enforcement systems cannot be used.
- Enforcement personnel must therefore verify both vehicle occupancy and proper toll payment by these vehicles.

The presence of mixed toll and carpool vehicle traffic on HOT lanes adds an additional challenge to effective enforcement. Regular toll lanes are amenable to

Proactive Policies for Toll System Management:

- Consider proactive, automatic replacement of toll transponders on a periodic basis to minimize the number of failed transponders in circulation.
- Agreements should be made between toll authorities to facilitate interoperability of transponders among toll facilities. This could reduce frustration and confusion on the part of motorists and enforcement personnel.

automated enforcement techniques, such as LPR in combination with AVI. However, usage of toll transponders on HOT lanes is not required for HOVs, while additional verification of vehicle occupancy is needed. Enforcement personnel must not only identify low-occupancy vehicles, but also verify proper toll payment by these vehicles. In contrast to the difficulties and complexities associated with vehicle occupancy detection technologies, relatively straightforward approaches are available for addressing the problem of toll verification. These approaches commonly involve communicating AVI toll or transponder information to enforcement personnel, allowing them to more fully concentrate on counting vehicle occupants.

Transponder Verification for HOT Facilities

Transponder verification refers here to any technologies or methods by which enforcement personnel can receive real-time information on the status of in-vehicle AVI transponders. A transponder verification system ideally should address the most common methods used to evade tolling on HOT facilities, among them:

- **No transponder**. While an enforcement officer can often verify the presence of a transponder by visual inspection, this process may be difficult in poor visibility conditions. The frequency of low-occupancy vehicle buy-ins on HOT facilities is greatest in the morning and evening peak periods, which may occur in darkness during winter months. Inclement weather, road and vehicle glare, and non-optimal vantage points also have significant potential for degrading visibility of transponders. Scofflaws may feel more confident in their ability to evade detection by enforcement personnel under these conditions.

- **Malfunctioning transponder.** This form of toll evasion can arise when physical damage or age degrades the performance of the transponder to the point where it can no longer be read by the AVI system. Active transponders use a non-user-serviceable battery to provide higher signal levels than passive reflector transponders, and this battery typically fails after a few years. Physical damage can render both types of transponder inoperable. Only close inspection of the transponder can reveal whether a transponder is malfunctioning, so a verification system would require some type of handheld or in-vehicle reader device to detect this case.

- **Invalid transponder.** Some HOT facilities are located in areas served by multiple toll authorities, and if the transponders issued by these agencies are not interoperable with the ETC system used on the HOT facility, a motorist may avoid the toll on the HOT facility and possibly evade detection by using an improper transponder. This is an ongoing concern for the Metropolitan Transit Authority of Harris County, which operates the QuickRide program on the I-10 and US 290 HOT

lanes in Houston. Based on data collected in October 2003, approximately 15 percent of all violators are able to evade tolls by using a transponder issued by the Harris County Toll Road Authority (HCTRA) in place of the one issued by METRO. Unless a HCTRA transponder is registered with METRO, it will not be recognized by the QuickRide billing system. It is also impossible to visually differentiate HCTRA and METRO transponders from one another except under close visual inspection. This presents an opportunity for violators to evade detection by METRO enforcement personnel.

- **Masked transponder.** This form of toll evasion presents possibly the greatest challenge to a transponder verification system. HOT programs, such as I-15 FasTrak in San Diego, and I-10 and US 290 QuickRide in Houston, provide enrollees with a foil-lined pouch which may be used to shield the transponder from detection by the ETC system. This pouch allows enrollees to avoid being charged when they operate a vehicle as a carpool instead of a low-occupancy vehicle on the HOT lanes. The pouch can be misused, however, if the AVI billing reader is not located within sight of an enforcement or observation area. Violators may then temporarily mask their transponders as they pass under the reader and still have time to replace the transponder in the windshield before they pass an enforcement area.

Technological countermeasures exist for all of the above forms of toll evasion on HOT facilities. As may be expected, the most comprehensive measures have the greatest capability for detection, but even relatively simple systems can effectively combat some forms of toll evasion.

Indicator Beacon

One approach to transponder verification involves an AVI-activated overhead beacon mounted on the toll reader gantry to indicate when a toll transponder passes under the reader. This system is utilized on I-15 in San Diego and I-394 in Minneapolis. Under this approach, enforcement personnel must be within the line of sight of the tolling zone in order to see both the overhead beacon and the triggering vehicle. However, this line of sight requirement provides opportunity to motorists who, in the absence of enforcement agents near the tolling zone, will be tempted to shield their transponders. Also, most ETC systems do not process billing transactions in real time, so this approach cannot determine if a transponder is linked to a valid toll account; it merely indicates that a readable transponder is present in the vehicle. One drawback to this approach is the difficulty of matching an individual vehicle to its corresponding beacon status (on or off), particularly at high speeds. It requires the proper combination of speed and angle of observation to produce a reliable assessment of both occupancy and transponder status. Multi-lane HOT facilities present further complications in this regard—for the I-15 FasTrak facility, an enforcement officer must verify vehicle occupancy and transponder presence for two lanes of traffic at highway speeds.

If facility geometry precludes siting the enforcement area near the tolling zone, then an additional AVI reader and indicator beacon may be installed in a suitable location near the enforcement area. More sophisticated transponder verification systems can use the transponder identification to determine if that transponder is associated with

a valid ETC account. The indicator beacon will then only be activated if a valid transponder (i.e., one belonging to an account holder) is detected. This approach is used on the US 290 HOT lanes in Houston, where additional roadside AVI readers in the enforcement areas compare transponders in real time to an on-board database of valid QuickRide accounts.

While such a stand-alone reader will be able to detect an active transponder, it probably will not be able to confirm whether this transponder has been captured by readers in the tolling zone, especially if the enforcement reader is not able to communicate with the ETC system. However, as noted above, most ETC systems do not process toll transactions in real time. They are therefore not capable of supporting the multiple queries to billing records that an enforcement reader would generate, and it is also unlikely that these ETC systems possess the high-speed bi-directional communications capability that such account queries would require.

Handheld and In-Vehicle Systems

Compact and portable transponder verification systems are available in either handheld configurations or installed within the vehicle used by enforcement personnel. Such systems enable enforcement officers to examine toll transponders from vehicles at any point along the facility and to verify the transponder of a suspected violator. Handheld devices, such as those developed for the US 290 HOT lane in Houston, may use a rugged PDA integrated with a low power AVI reader. These devices are suitable in situations where a suspected violator has been pulled over by an enforcement officer. In a stopped vehicle situation, the officer has the opportunity for close inspection of the transponder, and if the handheld reader permits manual input of transponder identification (IDs), an officer may determine if a transponder is malfunctioning. In-vehicle transponder verification systems, such as the one used on I-394 in Minneapolis, enable enforcement officers to verify transponders while driving alongside or behind vehicles in the HOT lanes.

As with roadside AVI readers, the capabilities of portable devices rise with the degree of on-board processing power and the networking or communications abilities of the device. Continuing advances in both computing power and wireless communication technologies bode well for the future developments in transponder verification.

Technologies for Vehicle Occupancy Detection

Three main technologies for vehicle occupancy detection have been developed and tested over nearly two decades. Since vehicle occupancy detection systems are not currently employed on HOV or HOT facilities, this section surveys the various development efforts conducted in this area. Table 9-1 compares the principle benefits and drawbacks inherent to each technology.

Table 9-1. Comparison of Technologies for Vehicle Occupancy Detection.

Technology	Benefits	Drawbacks
Video	• Commercially available systems	• Poor resolution • Inferior to visual inspection • Cannot operate autonomously • Unusable in low lighting
Infrared	• Usable under all lighting conditions	• Not developed past custom prototype • Cannot penetrate metallic window tint • Cannot operate autonomously • Cannot distinguish human skin from other objects of similar temperature • Expensive
Multi-band Infrared	• Can distinguish unique infrared (IR) signature of human skin • Usable under all lighting conditions • Can potentially operate autonomously	• Not developed past custom prototypes • Cannot penetrate metallic window tint • Extremely expensive

Video Systems

Video systems have been deployed in the past for vehicle occupancy verification. While video continues to serve a useful role in HOV facility monitoring, it has not proven adequate for the task of vehicle occupancy verification. The collective experience from several studies and implementation projects has concluded that video methods are not as reliable as live visual inspection. Further details of these projects are provided below.

Los Angeles and Orange County, California

The use of video in HOV lane surveillance and enforcement was tested by Caltrans in 1990[85]. Multiple cameras were used to obtain three or four different views into vehicle cabins, and displayed on split-screen monitors. The study concluded that video cameras operating alone cannot identify the number of vehicle occupants with enough certainty to support citations for HOV lane restrictions. Over one-fifth (21 percent) of vehicles identified by videotape reviewers as violators actually had the proper number of occupants. The high false alarm rate was primarily due to the inability of the cameras to capture small children or sleeping adults in the rear seat of vehicles and was made worse by poor light conditions, glare, and tinted windows.

Dallas, Texas

In 1995, The Dallas Area Rapid Transit and the Texas Department of Transportation (TxDOT) tested the use of real-time video and license plate reading for HOV lane enforcement on the I-30 HOV lanes in Dallas, Texas. The high-occupancy vehicle enforcement and review (HOVER) system employed three-way views of vehicle cabins and license plate recognition to record occupancy and vehicle identification. Enforcement agents reviewed the archived images to identify HOV violators. An effectiveness study of

the HOVER system revealed that the video and LPR implementation failed to achieve the necessary image quality and accuracy for effective enforcement screening[86].

San Diego, California

In another application of video enforcement, the I-15 Congestion Pricing Project initially used gantry-mounted video cameras to provide a record of SOV violators on the carpool-only lanes of the Express Lanes facility. Operators were required to review the videotape and provide a count of SOVs using the Express Lanes. Problems with the video system, however, led to its elimination in 1998. In their 2001 report on enforcement effectiveness, San Diego State University researchers reported that the operators could not reliably distinguish SOV violators on the videotapes and found it difficult to discern the number of vehicle occupants, especially for those in back seats.[11]

Infrared and Multi-band Infrared Systems

No occupancy detection systems based on infrared imaging have ever been implemented on HOV facilities although a few recent field tests have been conducted. The primary potential benefit offered by infrared systems is the ability to operate in darkness as well as daylight. Infrared systems operating in sufficiently long wavelengths can utilize camera illumination that is outside the visible light range and that consequently would minimize driver distraction. Infrared systems otherwise suffer from many of the same shortcomings as conventional video, especially with respect to heat-blocking or metallic vehicle window tint. Infrared systems are also substantially more expensive than conventional video systems, with costs for a single infrared camera starting in the mid four figures.

Atlanta, Georgia

Georgia Tech Research Institute (GTRI) developed a roadside infrared vehicle monitoring system for the Georgia Department of Transportation in 1998[87]. Designed for counting the number of occupants in vehicles passing by at highway speeds, the prototype consists of a computer-assisted infrared imaging system, utilizing a single near-infrared camera illuminated by an infrared light source. The system is contained in a roadside-mounted camera/processing unit that captures side views of passing vehicles; both the camera and illumination are triggered by radar. A field test of the prototype demonstrated its ability to capture images of vehicles at speeds up to 80 mph. A qualitative assessment of system accuracy involved a real-time comparison with visual observation. Researchers found that the system was superior to visual inspection at identifying rear passenger occupants. GDOT ultimately declined further development, and to date, no further work has been undertaken.

Minneapolis, Minnesota

In 1998, the Minnesota Department of Transportation and researchers from Honeywell and the University of Minnesota developed a machine vision system for vehicle occupancy detection, utilizing a pair of synchronized near-infrared cameras to capture dual-band near-infrared images[88]. The system exploits the infrared reflection

characteristics of human skin. By imaging two infrared bands and generating a differential image (the difference in brightness between corresponding pixels of the two images), the system can isolate the signature of human skin from that of other materials in the vehicle cabin. In operation, the synchronized IR cameras take snapshots of the road scene when triggered by vehicle-detection radar. An image processing and classification system subsequently extracts and counts the number of larger regions of skin in the differential image to estimate the number of vehicle occupants.

Researchers conducted a field test of the system in February 2000[89]. Vehicles containing one or two front seat occupants were driven at 50 mph under both daylight and nighttime conditions. The prototype captured images through the windshield, and the resulting automated occupancy counts were compared to those obtained by visual inspection. Researchers reported 100 percent correct identification of the number of occupants by the system for a randomly selected subset of 100 images. No further development has occurred since the limited field test.

Leeds, United Kingdom

In 2003, the U.K. Department of the Environment, Transport, and the Regions funded a three-year research project to develop an automated vehicle occupancy camera detection system began in Leeds, United Kingdom. The resulting Cyclops system uses visible and near-infrared (NIR) wavelengths to count vehicle occupants through the front windshield of oncoming vehicles at highway speeds. Like the Minnesota effort, Cyclops exploits the near-infrared absorption properties of human skin; a combination of the visible and NIR images yields a skin signature that contrasts with its surroundings and can be recognized immediately by processing software. Software algorithms then filter the detected skin regions to remove any non-facial features in the scene, and enumerate the isolated "faces." The occupancy count is overlaid on the final image, along with time stamp and location information.

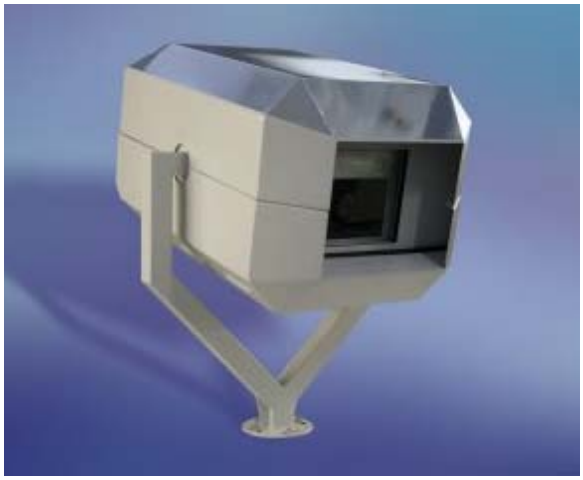


Figure 9-1. Cyclops Vehicle Occupancy System[90]

Tests of the Cyclops system on the United Kingdom's first HOV lane (on A467 in Leeds) were conducted in 2005; results indicated a 95 percent success rate in detecting real people and rejecting decoy information such as hands or dummies[91]. Trials are currently underway near Edinburgh, Scotland; if successful, the Cyclops system will be used to automatically discriminate high- and low-occupancy vehicles for differential tolling. The trials come before the introduction next year of automatic electronic tolling on the Forth Road Bridge in 2007. That system, while charging peak and off-peak tolls, will also give discounts based on the number of occupants in the vehicle. The Forth Estuary Transport Authority is jointly funding the test with the Scottish government. The cost of a Cyclops installation providing single-lane coverage is estimated to be $165,000.

Technologies for Toll Transponder Verification

Transponder verification systems have been deployed so far on three HOT facilities: I-15 in San Diego, US 290 in Houston, and I-394 in Minneapolis. This section of the chapter discusses the various capabilities of the Houston and Minneapolis transponder verification systems and summarizes the effectiveness of each system in addressing the primary types of toll violations.

The capabilities of the Houston and Minneapolis transponder verification systems are summarized in Table 9-2 below. The multiple strategies employed in both systems (roadside and portable technologies) provide both systems with robust transponder detection capabilities.

Table 9-2. Capabilities of Transponder Verification Systems.

Violator Category	US 290 in Houston	I-394 in Minneapolis
No Transponder	Yes	Yes
Malfunctioning Transponder	Yes	Yes
Invalid Transponder	Yes	Yes
Masked Transponder	No	Yes

Houston, Texas—US 290 HOT Lanes

As part of a three-year FHWA Value Pricing Study, Transcore developed a transponder verification system that utilizes both roadside and PDA-based handheld AVI readers. Each stand-alone roadside AVI system is designed to monitor HOV traffic and indicate the presence of a valid QuickRide transponder in vehicles using the HOT lane. The roadside system has two different configurations. One configuration is designed for fixed installations on overhead gantry structures. The other configuration utilizes a mobile equipment trailer mounting with a telescoping boom for the AVI antenna (see Figure 9-2). System power in both configurations is provided by batteries that are charged by photovoltaic panels.

Figure 9-2. Enforcement Reader at Entrance Ramp—US 290

The handheld AVI systems are intended to provide METRO enforcement officers with an additional means of verifying valid QuickRide transponders and identifying faulty transponders. Each handheld system consists of an Intermec Series 750 handheld computer, with the AVI reader integrated into a pistol-grip cradle for the Intermec 750 (see Figure 9-3).

In operation, the roadside system captures transponder reads from oncoming vehicles and compares the transponder IDs to a stored list of valid QuickRide IDs. If a match to a valid ID is found, a large green light-emitting diode (LED) beacon is activated. The valid transponder list stored by the roadside system may be updated remotely since the roadside system is Internet-enabled through an on-board cellular modem. WiFi

communications capabilities permit the roadside system to communicate with the handheld system as well. The roadside system is also capable of storing captured transponder IDs and transmitting them wirelessly to offsite locations for monitoring and data collection purposes.

Figure 9-3. Handheld AVI Enforcement Reader—US 290

The handheld transponder verification system can read transponders over an approximate range of 3 ft and is suitable for scanning stopped vehicles in the enforcement area. Transponder verification is performed when an enforcement officer places the handheld reader near a vehicle's transponder and activates the AVI reader. As with the roadside system, captured transponder IDs are compared to a list of valid transponders. The liquid crystal display (LCD) screen of the handheld displays appropriate status messages that include the transponder ID and whether or not the transponder is valid. An error message is displayed if the transponder cannot be successfully read. Malfunctioning transponders can be checked for validity by manually entering transponder serial numbers. Updates of the valid QuickRide transponder list can be performed via secure wireless communication with any of the roadside systems.

Minneapolis, Minnesota—I-394 Express Lanes

The Raytheon ETC system used for the I-394 Express Lanes in Minneapolis incorporates three enforcement aids for police officers: an enforcement beacon, an enforcement transponder, and a mobile enforcement reader. Each of these offers distinctive capabilities for transponder verification.

The beacon option consists of an amber signal located at a toll site that flashes whenever the ETC system detects the passage of a MnPass transponder in the Express Lanes (see Figure 9-4).

Figure 9-4. Close-Up of Enforcement Beacon—I-394

The enforcement transponder option adds another level of sophistication. This special transponder, affixed to the windshield of an enforcement vehicle, provides a positive indication that the subject vehicle being followed has a MnPass transponder (see Figure 9-5). An audible signal is emitted by the device when a valid MnPass transponder is detected.

The mobile reader is another enforcement-vehicle-mounted system that takes advantage of the read-write transponder technology used for the MnPass ETC system. Each read of a MnPass transponder by the ETC system is logged on the transponder itself, and the last three logged reads can be viewed by the mobile readers. This allows enforcement personnel to determine whether

Figure 9-5. Enforcement Transponder on Windshield—I-394

Figure 9-6. Mobile Enforcement Reader Antenna—I-394

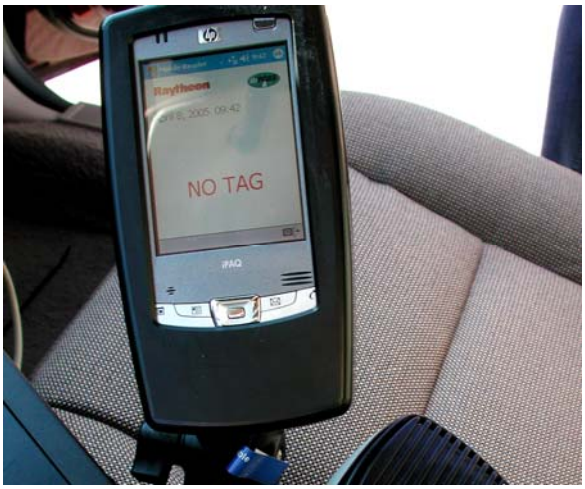


Figure 9-7. Mobile Enforcement Reader Display—I-394

a toll has been paid since an absence of tolling reads will indicate if the transponder has been masked.

The mobile readers utilize side-mounted antenna (see Figure 9-6) and are used to detect transponders on the left of the monitoring vehicle. It allows an officer to either park anywhere on the shoulder of the road and read the transponders of passing vehicles or to travel adjacent to a vehicle in the HOT lanes and read the transponder. The mobile reader compares a captured transponder ID to a list of valid MnPass customers; the on-board database of valid MnPass users is updated daily through wireless high-speed data communication link with the patrol vehicle.

The status of the transponder is displayed on a PDA-type display (see Figure 9-7), which provides the officer with the last date and time the transponder was read and the transponder's account status.

APPENDIX A
GLOSSARY

Alternative Fuel Vehicle (AFV): A vehicle that runs primarily on a fuel other than gasoline or diesel.

At-Grade Access: Ingress/egress between an HOV facility and the adjacent general-purpose lanes that occurs with a direct merging maneuver.

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.

Barrier-Separated HOV Facility: A roadway or lane 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. The facility may have one or two reversible lanes or be bi-directional.

Buffer-Separated HOV Lane: An HOV lane that is separated from general-purpose lanes by a buffer such as painted striping or plastic pylons/posts.

Busway: A preferential roadway designed exclusively for use by buses.

Carpool: A passenger vehicle carrying a designated number of people (at least two, including the driver).

Clean Air Act Amendments (CAAA): Federal legislation designed to reduce exposure to pollutants generated by industry and transportation. Areas that do not meet air quality standards are classified by the severity of their air quality problems and required to reduce emissions.

Clean Fuel: Any fuel or power source that enables a vehicle to emit less pollution and meet low-emission vehicle or better emissions standards when running on that fuel.

Concurrent Flow HOV Facility, Buffer Separated: 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. Synonym: congestion-relief tolling.

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.

Contiguous Access: Access treatment in which the HOV lane is separated from the general-purpose lanes by painted skip striping only. Vehicles carrying the required number of occupants are permitted to enter or leave the HOV lane anywhere along its length (also called continuous or unrestricted access).

Continuous Access: See Contiguous Access.

Corridor: A broad geographical band that identifies a general directional flow of traffic. It may encompass streets, highways, and transit route alignments.

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.

Delineation: Painted striping or other demarcation used to indicate a separation of elements such as lanes and shoulders on a roadway.

Department of Transportation (DOT): State agency responsible for administering federal and state highway funds.

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.

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): Electronic system that collects vehicle tolls by means of transponders and credit-card accounts, reducing or eliminating the need for vehicles to stop at tollbooths.

Eligibility: Limiting lane use to specific types of users, such as HOVs, motorcycles, low-emission vehicles, or trucks. For most typical HOV lane settings, eligibility requirements would be used during selected hours or at specific access ramps.

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 implementing and maintaining rules and regulations to preserve the integrity of HOV and HOT facilities.

Express Lanes: A lane or set of lanes physically separated or barriered from the general-purpose capacity provided within major roadway corridors. Express lane access is managed by limiting the number of entranced and exit points to the facility. Express lanes may be operated as reversible flow facilities or bi-directional facilities.

Federal Highway Administration (FHWA): Part of the U.S. Department of Transportation. FHWA is responsible for administering all federal-aid highway programs.

Federal Tier 1 and Tier 2 Programs: A set of emission reduction regulations, including vehicle emission standards, established by the U.S. EPA under the 1990 Clean Air Act Amendments. "Tier 1" vehicle emission standards were phased in beginning in 1994. Over the 2004–2007 period, more stringent "Tier 2" standards will replace Tier 1 standards.

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.

General-Purpose Lane: Lane on a freeway or expressway that is open to all motor vehicles.

Grade Separation: The vertical separation of an intersecting roadway or transportation facility.

High-Occupancy Toll (HOT) Lane: Managed, limited-access, and normally barrier-separated highway lane that provides free or reduced cost access to HOVs, and also makes excess capacity available to other vehicles not meeting occupancy requirements at a market price.

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 high-occupancy vehicles and certain other qualifying vehicles such as emergency vehicles or motorcycles.

Inherently Low-Emission Vehicle (ILEV): Alternative fueled clean air vehicles. Related terms include Zero-Emission Vehicle (ZEV), Ultra-Low-Emission Vehicle (ULEV), and Super-Ultra-Low-Emission Vehicle (SULEV) powered by alternative fuels.

Ingress/Egress: The provision of access to/from an HOV or park-and-ride facility.

Intelligent Transportation Systems (ITS): Advanced technologies and communication systems that can be used to remotely operate, monitor, and manage an HOV or HOT facility to better assure safety, operations, and improved responsiveness to incidents.

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.

Interoperability: The ability to provide reciprocal privileges for users of electronic toll collection systems on other facilities equipped with ETC systems.

Law Enforcement Vehicle: Vehicle that is primarily operated by a civilian or military police officer or sheriff or enforcement agencies of the federal government, by state highway patrols, or by municipal law enforcement.

Level of Service (LOS): Also knows as "traffic service," a qualitative measure describing operational conditions within a traffic stream. LOS assesses conditions in terms of speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety. Six levels of service are defined by letter designations from A to F, with LOS A representing the best operating conditions and LOS F the worst.

Limited Access: Access management used to restrict entry to a facility based upon facility congestion levels or operational condition, such as the presence of an accident or maintenance activities. Access may be restricted by 1) metering signals or 2) limiting the number of entrances and exits. Some restricted access lanes include HOV priority.

Low-Emission Vehicle (LEV): A specific category of vehicle emission standard, established by the U.S. EPA and also by the state of California (the federal and California LEV standards differ). Also, a generic term for any vehicle that is certified to a standard at least as stringent as the specific LEV standard.

Mainlane: See General-Purpose Lane.

Mode: Means of travel.

Metropolitan Planning Organization (MPO): Federally mandated regional organization responsible for comprehensive transportation planning and programming for an urbanized area. Work products include the Transportation Plan, the Transportation Improvement Program, and the Unified Planning Work Program.

Mileage-Based Fee: A vehicular toll based on the vehicle miles traveled (VMT) in the jurisdiction.

Mixed Flow Lane: See General-Purpose Lane.

Non-separated HOV Lane: An HOV lane containing no buffer or barrier separation with the adjacent general-purpose lanes.

Open Road Tolling: Fully automated electronic tolling in an open road environment allowing vehicles to travel at normal speeds when passing through toll collection points.

Paratransit Vehicle: Any form of intra-urban 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.

Partial Zero-Emission Vehicle (PZEV): A specific category of vehicle emission standard under California's LEV program. A PZEV meets SULEV exhaust (tailpipe) emissions, is certified to the "zero-evaporative" standard, and has extended (150,000-mile versus 120,000-mile) durability requirements compared to SULEVs.

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.

Positive Separation: The use of physical barriers or other treatments to prevent vehicles on one portion of a facility from encroaching on another.

Queue: A line of vehicles or persons.

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.

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.

Ramp Metering: Procedure used to reduce congestion by managing vehicle flow from local-access on-ramps. The entrance ramp is equipped with a traffic signal that allows vehicle to enter the freeway at predetermined intervals.

Ramp Meter Bypass: A form of preferential treatment in which bypass lanes are provided at a ramp meter for the exclusive use of HOVs.

Reversible HOV Lane: Facility on which the direction of traffic flow is changed at different times of the day to match the peak direction of travel.

Restricted Access: See Limited Access.

Right-of-Way: Area of land on which a transportation facility is constructed and vehicles are entitled to pass.

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.

Sight Distance: Sight distance is the length of roadway visible to the driver who is traveling along the roadway or waiting to enter, cross, or pass along the roadway. Types of sight distance include stopping sight distance, passing sight distance, and intersection sight distance.

Single-Occupant Vehicle (SOV): A 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.

Super-Ultra-Low-Emission Vehicle (SULEV): A specific category of vehicle emission standard under California's LEV program that is more stringent than the ULEV standard.

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.

Toll Violation Camera: Fixed, short-range, still cameras used to obtain single-frame pictures which are deployed in individual lanes at tolling points. Toll violation cameras are aimed and focused to obtain images of the license plates of violating vehicles.

Traffic Control Device: Device such as a sign, signal, or pavement marking used to regulate, warn, and inform drivers of the performance requirements essential to safe operation.

Transponder: A credit-card sized electronic tag usually mounted on the inside front windshield of a vehicle (using Velcro) to enable electronic payment of user fees in HOT and other tolling applications.

Transportation Equity Act for the 21st Century (TEA-21): The Transportation Equity Act for the 21st Century was enacted June 9, 1998, and authorizes the federal surface transportation programs for highways, highway safety, and transit for the six-year period 1998–2003.

Treatment: Technique used to achieve a desired safety or operational effect.

Ultra-Low-Emission Vehicle (ULEV): A specific category of vehicle emission standard, established by the U.S. EPA and also by the state of California (the federal and California ULEV standards differ) that is more stringent than the LEV standard.

Unrestricted Access: See Contiguous Access.

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: Prearranged ridesharing arrangement in which groups of people travel together on a regular basis in a van.

Variable Message Sign (VMS): Electronic signage that employs ITS technology and centralized control systems to change messages in real time, providing motorists with timely and useful information.

Video Surveillance: The use of pan-tilt-zoom, steerable moving picture cameras to survey a toll plaza, ETC collection area, or a segment of roadway to monitor for incidents.

Violation Enforcement Systems (VES): Manual and computer systems used to enforce vehicle and motorist compliance with the usage guidelines for HOT lanes.

Violation Rate: Percentage of vehicles using an HOV facility that do not meet the facility requirements.

Zero-Emission Vehicle (ZEV): Vehicle that meets more stringent ZEV emissions standards. This vehicle has zero tailpipe and evaporative emissions.

APPENDIX B
REFERENCES

[1] *HOV Systems Manual*. Report 414, National Highway Cooperative Research Program, National Academy Press, Washington, D.C., 1998.

[2] *Guide for the Design of High-Occupancy Vehicle Facilities*. Revised edition. American Association of State Highway and Transportation Officials, Washington, D.C., 2004.

[3] Nancy L. O'Connell, William R. Thornewell, Wayne R. Ugolik, and Martin Youchah. "HOV Lanes on the Long Island Expressway: How Are They Doing?" *Tenth International High-Occupancy Vehicle (HOV) Facilities Conference*, Conference Proceedings, Seattle, Washington, August 28–30, 2000, and April 28–May 1, 1998.

[4] N. Craig Miller and Robert B. Deuser. *Enforcement Requirements for High-Occupancy Vehicle Facilities*. Beiswenger, Hoch and Associates, Inc., North Miami Beach, Florida, December 1978. Prepared for the Federal Highway Administration, Office of Research and Development.

[5] *High-Occupancy Vehicle (HOV) Guidelines for Planning, Design, and Operations*. California Department of Transportation (Caltrans), Division of Traffic Operations, Sacramento, California, August 2003.

[6] Katherine F. Turnbull and Tony DeJohn. *New Jersey I-80 and I-287 HOV Lane Case Study*. Texas Transportation Institute, The Texas A&M University System, College Station, Texas, July 2000. Prepared for the Federal Highway Administration.

[7] *I-80 HOV Lane Evaluation Study and Appendices*. Parsons, Brinkerhoff, Quade, and Douglas, June 1997. Prepared for the New Jersey Department of Transportation.

[8] Online at http://www.wsdot.wa.gov/hov/hero.htm.

[9] Catherine C. McGhee. *Final Report: Traffic Control for High Occupancy Vehicle Facilities in Virginia*. Virginia Transportation Research Council, Charlottesville, Virginia, 1998. Prepared for the Virginia Department of Transportation.

[10] *HOV Performance Monitoring, Evaluation, and Reporting Handbook*. Federal Highway Administration, Washington, D.C. Forthcoming.

[11] *I-15 Congestion Pricing Project, Phase II Year 3 Enforcement Effectiveness and Violation Assessment Report*. San Diego State University Foundation, San Diego, California, June 2001. Prepared for the San Diego Association of Governments.

[12] John Billheimer. *HOV Lane Violation Study*. Systan, Inc., Los Altos, California, January 1990. Prepared for the California Department of Transportation.

[13] *Report of the High-Occupancy Vehicle Enforcement Task Force.* High-Occupancy Vehicle Enforcement Task Force, Virginia Department of Transportation, Richmond, Virginia, August 15, 2003.

[14] *Second Report of the High-Occupancy Vehicle Enforcement Task Force.* High Occupancy Vehicle Enforcement Task Force, Virginia Department of Transportation, Richmond, Virginia, January 4, 2005. Online at http://www.virginiadot.org/infoservice/resources/HOV Task Force Report 1-4-05.pdf.

[15] Benjamin G. Perez and Gian-Claudia Sciara. *A Guide for HOT Lane Development*. Parsons Brinckerhoff, Inc., and the Texas Transportation Institute, College Station, Texas, 2003. Prepared for the Federal Highway Administration. Online at http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/13668.html.

[16] Sec. 1012(b), Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), Pub. L. 102-240, 3 January 1991, 105 Stat. 1914.

[17] Sec. 1604, Safe Accountable Flexible and Efficient Transportation Equity Act: A Legacy for Users, 2005. Online at http://www.fhwa.dot.gov/safetealu/.

[18] Sec. 149, California Streets and Highways Code, 2004.

[19] Sec 72-2-120, Utah Code, 2004.

[20] Section 42-4-1012(1)(b)(III), Colorado Revised Statutes, 2004.

[21] Sec. 1121(a), Safe Accountable Flexible and Efficient Transportation Equity Act: A Legacy for Users, 2005. Online at http://www.fhwa.dot.gov/safetealu/.

[22] *MnPASS I-394 Express Lane: Community Task Force Final Report.* I-394 Express Lane Community Task Force, Minnesota Department of Transportation, St. Paul, Minnesota, 2004. Online at http://www.mnpass.org/394/finalreport/finalreport.doc.

[23] Katherine F. Turnbull. *Potential Impact of Exempt Vehicles on HOV Lanes.* Texas Transportation Institute, The Texas A&M University System, College Station, Texas, 2005.

[24] Sec. 1121, Safe Accountable Flexible and Efficient Transportation Equity Act: A Legacy for Users, 2005. Online at http://www.fhwa.dot.gov/safetealu/.

[25] Title 40, Code of Federal Regulations, Part 88, 2005.

[26] Sec. 28-737, Arizona Revised Statues, 2004.

[27] Section 42-4-1012(2.5)(a), Colorado Revised Statutes, 2004.

[28] Sec. 316.0741, Florida Statutes, 2005.

[29] Sec. 32-9-4, Georgia Code, 2004.

[30] Sec. 40-2-76, Georgia Code, 2004.

[31] Texas State Legislation, Section 502.186, Chapter 1171.

[32] Sec. 41-6a-702, Utah Code, 2004.

[33] Sec. 46.2-749.3, Code of Virginia, 2005.

[34] Sec. 33.1-46.2A, Code of Virginia, 2005.

[35] Adapted from: Chris Porter, Anita Vandervalk, and Michael Williamson. Cambridge Systematics, Inc., to Jeff Weidner, Florida Department of Transportation, memorandum, October 12, 2002, "Analysis of the Impact of Inherently Low-Emission Vehicles on I-95 High-Occupancy Vehicles Lanes." Online at http://www.hovworld.com/reports_assets/M_FDOT/ILEV_Complete.pdf.

[36] *Vehicle Enforcement Observations on the Katy and Northwest HOV Lanes, October 2003 and April 2004.* Texas Transportation Institute, The Texas A&M University System, College Station, Texas, 2004.

[37] Sec. 2400(d), California Vehicle Code, 2004.

[38] Sec. 2400(a), California Vehicle Code, 2004.

[39] Sec. 291C-163(a), Hawaii Revised Statutes, 2004.

[40] Sec. 451.108(b)(3), Texas Transportation Code, 2003.

[41] Sec. 452.110(a), Texas Transportation Code, 2003.

[42] Sec. 451.108(c), Texas Transportation Code, 2003.

[43] Sec. 143, California Streets and Highways Code, 2004.

[44] Secs. 149.1 and 149.4, California Streets and Highways Code, 2004.

[45] Sec. 149.5, California Streets and Highways Code, 2004.

[46] Sec. 149.6, California Streets and Highways Code, 2004.

[47] Sec. 160.90, Minnesota Statutes, 2004.

[48] Sec. 299D.03, Subdivision 1, Minnesota Statutes, 2004.

[49] Sec. 15.061, Minnesota Statutes, 2004.

[50] Sec. 471.59, Subdivision 1, Minnesota Statutes, 2004.

[51] Sec. 471.59, Subdivision 12, Minnesota Statutes, 2004.

[52] Adapted from: A. Scott Cothron, Douglas A. Skowronek, and Beverly T. Kuhn. *Enforcement Issues on Managed Lanes.* Texas Transportation Institute, The Texas A&M University System, College Station, Texas, January 2003.

[53] 23 United States Code, Sec. 166, 2005.

[54] Sec. 291C-223(2), Hawaii Revised Statutes, 2004.

[55] Sec. 291D-8(a), Hawaii Revised Statutes, 2004.

[56] Sec. 40-6-54, Georgia Code, 2004.

[57] Sec. 33.1-46.2C, Code of Virginia, 2005.

[58] *Review of Concurrent Flow HOV Lane Enforcement in North America and Recommended Enforcement Programs for the Dallas Area.* Texas Transportation Institute, The Texas A&M University System, Arlington, Texas, January 1998. Prepared for the Dallas Area Rapid Transit.

[59] Sec. 23302(b), California Vehicle Code, 2004.

[60] Washington State Legislation, Revised Senate Bill 5396, 2004.

[61] Sec. 149, California Streets and Highways Code, 2004.

[62] Sec 72-2-120, Utah Code, 2004.

[63] Sec. 28-737, Arizona Revised Statutes, 2004.

[64] Sec. 21655.5(b), California Vehicle Code, 2004.

[65] Sec. 316.0741, Florida Statutes, 2005.

[66] Sec. 32-9-4(b), Georgia Code, 2004.

[67] Sec. 291C-223, Hawaii Revised Statutes, 2004.

[68] Sec. 160.93, Minnesota Statutes, 2004.

[69] Sec. 55-8-188, Tennessee Code, 2004.

[70] Sec. 41-6a-702, Utah Code, 2004.

[71] Sec. 33.1-46.2, Code of Virginia, 2004.

[72] Sec. 46.61.165, Revised Code of Washington, 2004.

[73] Sec. 1128 (c), New York State Consolidated Laws, Vehicles and Traffic, 2004.

[74] Sec. 45-337, Houston Code of Ordinances, 2004.

[75] Beverly T. Kuhn and Debbie Jasek. *State and Federal Legislative Issues for Managed Lanes.* Texas Transportation Institute, The Texas A&M University System, College Station, Texas, January 2003.

[76] Sec. 21655.8, California Vehicle Code, 2004.

[77] Sec.1128 (d), New York State Consolidated Laws, Vehicles and Traffic, 2004.

[78] Revised and expanded from: Puget Sound Regional Council, Seattle, Washington, 2002. Online at http://www.hovworld.com/PDFs/HOV_Violation_Fines.pdf.

[79] Sec. 42-4-1701 (4) (a) (I) (K), Colorado Revised Statutes, 2004.

[80] Sec. 40-6-54 (b), Georgia Code, 2004.

[81] Sec. 291C-227, Hawaii Revised Statutes, 2004.

[82] Sec. 33.1-46.2 B, Code of Virginia, 2004.

[83] Sec. 291D-8, Hawaii Revised Statutes, 2004.

[84] Judicial Council of California, Rule 4.102: Uniform Bail and Penalty Schedules, January 2005. Online at www.courtinfo.ca.gov/reference/documents/05JCBail.pdf.

[85] John Billheimer, Ken Kaylor, and Charles Shade. *Use of Videotape in HOV Lane Surveillance and Enforcement.* U.S. Department of Transportation, Sacramento, California, 1990.

[86] Shawn Turner. "Video Enforcement of High-Occupancy Vehicle Lanes: Field Test Results for I-30 in Dallas." *Transportation Research Record No. 1682,* Transportation Research Board, Washington, D.C., 1999, pp. 26–37.

[87] *Georgia Vehicle Occupancy System Brochure.* Georgia Tech Research Institute, Atlanta, Georgia, 1998.

[88] Online at http://www.dot.state.mn.us/guidestar/projects/hovlanecount.html.

[89] I. Pavlidis, V. Morellas, and N. Papanikolopoulos. "A Vehicle Occupant Counting System Based on Near-Infrared Phenomenology and Fuzzy Neural Classification." *IEEE Transactions on Intelligent Transportation Systems,* Volume 1, Issue 2, June 2000, pp. 72–85.

[90] Online at www.vehicleoccupancy.com.

[91] **"**The Eye Has It." *ITS International*, September 2005, pp. 58–59.