ENFORCEMENT ISSUES ASSOCIATED WITH HOV FACILITIES

A White Paper for Presentation at the
National HOV Conference
Seattle, Washington
April 29 - May 1, 1991

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Abstract

Enforcement is recognized as an essential element in HOV operation. The role enforcement serves has been well documented in various publications since the mid 1970s. Still, enforcement issues are frequently raised as needing increased awareness among the profession and practitioners. The emergence of HOV facilities in new areas and the creation of regional HOV networks has increased the need to address issues of common interest.

The purpose of this white paper is to place perspective on available literature, recent experiences, and issues of concern regarding HOV enforcement. The current state of the practice is examined. Information is provided from selected projects on how enforcement is facilitated. Factors are presented that appear to influence the effectiveness of enforcement. Current issues are examined. Where demonstrations and tests have been conducted to resolve selected issues, these are presented. Areas in need of additional research or testing are highlighted. This paper concludes with some observations and considerations that clarify what has recently been learned and where the role of enforcement appears to be going over the next decade.

1. INTRODUCTION

This paper addresses enforcement issues on HOV facilities constructed within freeway rights-of-way. Of the 37 or so freeway-based HOV projects in operation throughout the U.S., all require some complement of enforcement activity to preserve their operation benefits (i.e., travel time savings and trip reliability). The need for enforcement is manifested in the inherent nature of preferential treatment. Higher occupancy vehicles are afforded travel benefits over their lower occupancy counterparts. This incentive is often so enticing that violators attempt to thwart rules and regulations that are imposed. Accordingly, occupancy violations are the most common infraction. Distinguishing eligible from ineligible has been a vexing problem for policing agents vested with enforcement responsibilities. Design features, operation policies, public attitudes, and enforcement strategies all play a role in the changing character of this topic and issues that result therefrom. The role effective enforcement serves in sustaining project viability has been documented in various publications. Still, striking the proper balance to best meet enforcement goals remains an enigma on some projects. It is not uncommon to find some HOV operations where a majority of users do not meet eligibility requirements, and responsible policing agents who, for a variety of reasons, do not feel capable of performing enforcement activities. These are issues that continue to erode public confidence in this concept, threatening viability of the respective operations.

The purpose of this paper is to place some perspective on recent experiences and issues of concern regarding HOV enforcement needs and practices. The current state of the practice is examined in Section 2. In Section 3 enforcement issues more commonly experienced are discussed. Examples are borrowed from selected projects on how these issues have affected local attitudes and operations. Section 4 provides a discussion of various demonstrations and innovative techniques being tried to address or mitigate identified issues. Areas needing additional research or testing are mentioned. The final section concludes with some observations and considerations that clarify what has been learned and where the role of enforcement appears to be headed over the next decade.

2. CURRENT PRACTICE AND EXPERIENCE

Regular enforcement activities are conducted on most freeway-based HOV facilities. The degree of enforcement varies, and where enforcement is not performed or performed sufficiently, there are often some fundamental reasons why. If operation policies or project design make enforcing an HOV facility difficult, unsafe, or expensive, it is unlikely that sufficient enforcement will be applied to assure acceptable compliance (Figure 1). An enforcement policy for the HOV facility should protect travel time and reliability benefits for eligible HOVs, promote fairness and the integrity of HOV operation among eligible users, and discourage ineligible vehicles from using the facility[7]*. One enforcement agency, usually the state or local police, has this responsibility. Various guidelines over the years have regularly stressed involvement of the respective enforcement agencies during the planning process for an HOV facility, when the operation plan and facility design are being formulated. Involvement at this time helps ensure that the selected operation and design concepts are enforceable.

Methods of Enforcement

A number of enforcement strategies are used on various HOV projects. The type of HOV operation and design features play heavily on the type of enforcement strategy that may be applicable. Other factors affecting the selection of an effective strategy include signing and pavement markings, lighting, and presence of closed circuit television. Enforcement strategies can also be influenced by the compliance goal set for a facility, accepted local practices of enforcement agencies, and available staffing and resources.

The type of strategy is often dictated by the type of HOV operation being served (Table 1). Barrier-separated facilities (either operated in a two-way or reversible-flow fashion) allow for a "captive audience" to be more easily monitored and apprehended with a minimum of effort, inherently serving as a deterrent to violators. A single police officer can be located in a strategic stationary position and observe most users, flagging over potential violators as they pass by. This strategy is also applied to contraflow operations and HOV queue bypasses at metered freeway entrance ramps as well, with the same relative effectiveness[7].

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*( ) Denotes reference number in bibliography.

Figure 1
Typical Design Shortcomings for Enforcement

No place to enforce

Pullouts not adjacent to HOV facility

Photo: The Metropolitan Council, Minneapolis

Enforcement activities exposed to moving traffic

Inadequate or ineffective regulatory signing

Source: Reference 7.

Table 1
Enforcement Procedures For Selected HOV Projects

HOV Facility	HOV Code*	Detection					Apprehension/Citation				
		Foot Patrol	Line Patrol	Mobile Patrol	Stationary Patrol	Hidden Enforcement	Standard Procedure	Stationary Apprehension	Wave-off Violator	Mail-out Warnings	Team Approach
Washington, DC, I-395 (Shirley)	1A		X		X		X				
Houston, TX, I-10, I-45 (Katy and Gulf)	1A				X			X	X		
Los Angeles, CA, I-10 (El Monte)	1B		X				X				
Miami, FL, I-95	2		X				X				
Los Angeles, CA, Route 91	2		X			X	X	X			
Marin County, CA, US 101	2		X		X		X				
Minneapolis, MN, I-394	1, 2		X		X		X				
New Jersey, Route 495 (Lincoln Tunnel)	3				X			X	X		
Minneapolis, MN, I-35W	4		X		X	X	X	X		X	X
Los Angeles, CA, I-10 (Santa Monica)	4		X		X		X	X			X
Seattle, WA, I-5	5		X	X	X	X	X			X	
San Francisco-Oakland Bay Bridge, CA	6	X	X		X		X	X		X	X

* HOV Code

1A Barrier-Separated Facility (Reversible-Flow)
1B Barrier-Separated Facility (Two-Way)
2 Buffer-Separated or Nonseparated Facility (Two-Way)
3 Contraflow Facility
4 Entry Ramp with HOV Bypass
5 Direct Connection Access Ramp
6 Toll Plaza Queue Bypass Lane(s)

Source: Reference 7.

HOV Facilities which are not physically separated from adjacent freeway lanes allow virtually uncontrolled access in which violators can enter and leave the facility at will. This can, at the very least, increase the need for enforcement presence. To be able to monitor and apprehend violators at any point, roving patrols become a more popular deterrent. The efficiency of the roving patrol strategy is compromised if a violator cannot be apprehended and cited "on the spot," usually via a shoulder adjacent the HOV facility[6]. Escorting violators across several lanes of traffic onto an outside (right) shoulder is not considered an efficient or safe way of performing this activity.

Table 2 provides general information on the methods of enforcement applied to selected HOV projects.

Quite often extra enforcement personnel are assigned to an HOV facility when it opens, to help ensure a safe initial operation and guard against noncompliance. Over time the extra patrols are removed to a typical complement of one or more officers per shift, who may share HOV enforcement responsibilities with other traffic enforcement and incident handling obligations. If violations rise above a level deemed locally unacceptable, saturated enforcement is applied in which a higher number of officers converge on the HOV facility for a time period sufficient to manage the violation rate. This practice is repeated as necessary.

Violation Rates

Violation rates experienced on various projects are arrayed in Table 2. For limited access facilities with barrier separation, they are generally below 10 percent. Rates below 5 percent are considered good, with 20 percent considered the maximum acceptable before remedial action is required[17].

For lanes without physical separation (with or without buffers), rates are generally above 10 percent. With little to no enforcement, violation rates can climb to above 60 percent and effectively clog the operating capacity of the lane. By their very nature, these concurrent flow lanes are more difficult to enforce and are more sensitive to the presence of enforcement. Violators can enter or exit the facility at will. Inadequate budgets and personnel restrictions are reasons commonly given in preventing better management of violation rates. There are no specific strategies or number of officers that may ensure a

Table 2
Summary of Enforcement-Related Information for Selected HOV Projects

HOV Facility	Method of Enforcement	Yearly Cost	Violation Rate[1] (%) Peak Hour	Violation Rate[1] (%) Peak Period	Fine Amount	Enforcement Features	Assigned to Enforcement: Number of Persons	Assigned to Enforcement: Adequate?	Enforcement Responsibility (agency)
FACILITY IN SEPARATE R.O.W.									
• Ottawa, Canada	Charged w/trespassing	$200,000	1	1	$53.75	Use shoulder	3	Yes	Transit
• Pittsburgh, PA	Citation	$100,000	1	1	$300 + court	None	4	Yes	Transit
FACILITY IN FREEWAY R.O.W.									
Reversible-Flow									
• Houston, TX I-45, I-10, US 290	Special citation areas, vehicles diverted	$60,000	1	14am, 1pm	$75	Enforcement areas, widened or separate ramps to exit violators	2	Yes	Transit
• Virginia (Washington, DC) I-395 (Shirley)	Vehicles identified[2]	$35,000 each officer	5	15	$50	Shoulder, HERO program	2-5	No	State
• Pittsburgh, PA, I-279	Vehicles stopped	---	---	---	$82.50	Continuous shoulder	---	Yes	State
• San Diego, CA, I-15	Vehicles stopped	---	3	5	$246 + court	Shoulder	2	Yes	State
Two-Way Barrier-Separated									
• Los Angeles, CA, I-10	Citation on HOV Shoulder	$20,000	11	11	$246 up + court	Wide shoulder on HOV lane	2	Yes	State
Two-Way Buffer-Separated									
• Hartford, CT, I-84	Citation on HOV buffer	---	---	---	$40	None	---	---	State
• Orange County, CA, Route 55 & I-405	Special citation areas	$30,000	6	7	$246 + court	Protected median areas	6[3]	Yes	State
• Los Angeles, CA, Route 91	Special citation area	$30,000	7	7	$246 up + court	Protected median areas	6[3]	Yes	State
• Miami, FL, I-95	Vehicles diverted, not enforced	---	40	---	$43.50	None	10-12[3]	Yes	State
• Ft. Lee, NJ, I-95	Vehicles stopped	---	30	30	$50	None	1	Yes	State, Regional Auth.
• Honolulu, Moanalua Fwy.	Vehicles diverted	$35,000	20	20	$40	None	3	No	State
• Orlando, I-4	Not enforced	0	75	75	$43.50	None	0	No	State
• San Francisco, CA area (Santa Clara, Marin, San Francisco Counties) US 101, Rte. 237	Vehicles diverted	$215,000	5	10	$50-500	None	1-7	Yes	State
• Seattle, WA I-5[4] and I-405	License plates identified, routine, special, & HERO program	---	11	11	$47	None	---	Yes	State
SR 520		---	8	8	$47	None	---	Yes	State

Table 2 (continued)
Summary of Enforcement-Related Information for Selected HOV Projects

HOV Facility	Method of Enforcement	Yearly Cost	Violation Rate[1] (%) Peak Hour	Violation Rate[1] (%) Peak Period	Fine Amount	Enforcement Features	Assigned to Enforcement: Number of Persons	Assigned to Enforcement: Adequate?	Enforcement Responsibility (agency)
Contraflow									
• Honolulu, Kalanianaole Hwy.	Vehicles diverted	$25,000	5-10	---	$35	User permit	1	No	State
• New Jersey, I-495 (Lincoln Tunnel)	Vehicles diverted	$35,000	---	---	---	Vehicle check point and diversion lanes	3	Yes	State,Regional, Auth.
• New York City, NY Gowanus and L.I.E.	Stopped at termination	---	---	---	$65	None	1 each	No	City
Queue Bypasses									
• San Francisco-Oakland Bay Bridge, CA	Vehicles diverted	$200,000	2	2	$50-500	Wide shoulder	4	Yes	State
• Los Angeles - ramp bypasses	Vehicles diverted	---	5	10	$160	Wide shoulder	Varies	Yes	State
• Minneapolis - ramp bypasses	Vehicles diverted	---	---	---	---	Wide shoulder	Varies	Yes	State

---Data not available or not provided.
[1]As a percentage of legal HOV traffic.
[2]Citations issued by mail.
[3]For entire freeway, not specifically HOV.
[4]Violation rates vary widely by location and time of day.

Source: Reference 7.

given violation rate[17]. Each project is different. Design and operational characteristics play a significant role in defining the ease or difficulty associated with enforcement activities.

Innovative Techniques

Aside from standard enforcement procedures, selected projects have adopted strategies to reduce enforcement costs and promote better compliance. One approach to help curb high violation rates involves self enforcement (termed "HERO" in several locales). Through signing and a public information program, other freeway and HOV users are asked to report violators by calling a hotline telephone number with information about the violating vehicle (Figure 2). Form letters are initially sent to the offending motorists, advising of the purpose of the lane and potential penalties. Follow-up reports of the same offender result in notification from the Washington State Patrol, and ultimately efforts to apprehend the violator on the facility[10].

The first application of the HERO program was reported to have reduced violations about 33 percent without the need for additional enforcement personnel[10]. In subsequent years, this technique has become more of a public information and relations tool than a means of helping contain violations[9]. Other areas, including northern Virginia and Houston, have tried or are currently trying this technique.

Northern Virginia and California projects have attempted to improve the efficiency of issuing citations by mail by applying various audio and video techniques. With the aid of changes in state legislation, Virginia State Police began using tape recorders to document violators by license plate and issued citations by mail. Due to a number of cases which were appealed and overturned by local traffic courts, this approach has been refined. Troopers must accurately record information for later court use, either via written or taped information on license number, sex of driver, and number of observed occupants. An alternative means of briefly stopping each violator to obtain license and social security information has been pursued on rental vehicles, company trucks, etc. when the troopers know the driver is probably not the registered owner (Figure 3).

The Virginia State Police still lose some cases if the registered owner comes to court and rebuts. But the resulting 85 percent conviction rate is considered locally acceptable. This procedure expanded the ability of an officer to apprehend more violators and thus, manage rates with fewer field personnel.

Figure 2
Self-Enforcement Program Begun in the Seattle Area

Sign Of The Times

Times are changing. Sharing the ride is no longer just a vision of the future. It's the present. That's why the Washington State Department of Transportation developed new Transportation System Management (TSM) programs that support the Diamond Lanes. (These are also called "HOV lanes," for use by high-occupancy vehicles).

One element of the TSM program is **Thanks for Being a HERO.** The Department of Transportation, Metro, and the Washington State Patrol work together and with the public to discourage improper use of the special Diamond Lanes reserved for carpools, vanpools, buses, and motorcycles only!

The **HERO** program is an example of the ongoing commitment to the best management of our transportation system. The following pages of this brochure tell more about how to use these special lanes, and tell the story of other TSM techniques that make the best use of our existing transportation system.

Comments or questions are welcome.
Please contact the:
Washington State Department of Transportation
15325 S.E. 30th Place
Bellevue, Washington 98007-6538
206 562-4000

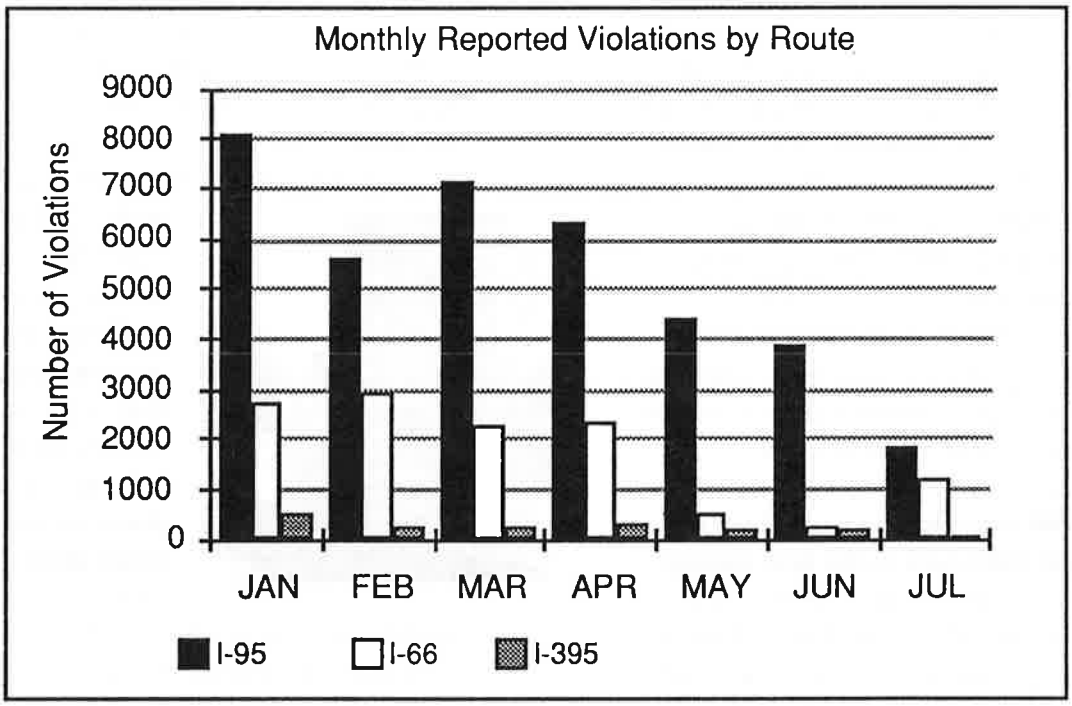
Thanks For Being A HERO

Here's one we can all get involved in! By encouraging motorists to phone **764-HERO** when they see a vehicle (motorcycles are okay) with one occupant (or only two people in a car where three or more are required) in a Diamond Lane, we can all be winners! So exercise that memory . . . we need to know the license number of the vehicle, plus a date, time, the location, number of people (children count!), and some description of the vehicle. Vehicle owners are informed by mail about the proper use of the lanes in order to deter repeat violations. The Washington State Patrol is kept informed about repeating violators. Whenever possible,the State Patrol contacts them, or they are issued a moving violation on the road. Violation reports also help the Washington State Patrol determine where to focus officer enforcement.

Looking at 1987 records:
Less than five percent of those reported were reported a second time.
Fewer than one percent were reported three or more times!

Source: Reprinted from Seattle HOV Task Force Brochure, 1989

Figure 3
Changes in the Number of Violations on HOV Projects in Northern Virginia Due to Innovative Enforcement Techniques



Notes: I-95 lanes are nonseparated without buffers or median shoulder.
I-66 is a standard freeway, the peak direction of which is reserved for HOVs during peak periods.
I-395 (Shirley) is a two-lane reversible-flow facility that is fully barrier-protected.

Source: Reference 7.

The California Highway Patrol, in conjunction with California DOT staff, has demonstrated the use of video in documenting occupancy violations from up to three closed circuit television cameras mounted and synchronized to record vehicle movement along an HOV facility[15]. However, California state statutes currently require that police physically apprehend and cite any violator in person, and for this reason, they have not used video for routine enforcement activities. A change in the statutes will be required to further advance this approach.

Penalties

An alternative means of managing violations through customary apprehension is to adopt an aggressive scale of penalties to thwart violators. Current penalties range from fines and in selected cases, penalty points against the driver's record. Penalties on HOV projects in 1989 varied from $40 to over $246 for first offenses. In California, penalties for the third offense rise to over $800. A common theme heard outside California is that penalties are not high enough to deter violators. Another common experience is that individual judges may not agree with the fine structure and impose a lessor penalty or worse, allow a substantial number of offenders to go free. Appropriate actions taken to date have included public information and staff outreach to familiarize motorists, police, the courts and judges of the intent of the HOV project and its regulations. The California DOT has gone so far as to promote public awareness of penalty information on signs on several projects as a means of managing violations (Figure 4). The number of citations noticeably declined by 61 percent when fines were posted.

Figure 4
HOV Penalty Notification

Route 55, Orange County, California

Public Attitudes and Education

There are two common HOV violators: those who do it knowingly, risking apprehension, and those who are uninformed of the restrictions. Single drivers have been known to violate HOV restrictions and vocalize their deeds in the media or newsprint because they did not believe in the HOV concept[7]. Other violators end up in the HOV lane because they are legitimately confused about who is eligible and how the facility operates. Either event makes the role of the enforcement officer more difficult.

Experience with HOV facilities has demonstrated that enforcement is required to develop an understanding public attitude toward these facilities. The simple presence of a police officer has a beneficial impact. The level of benefit realized in enforcement can be effected by the following factors:

- Is the enforcement unit moving with traffic or is it parked?
- Where and how frequently are enforcement units observed?
- Are enforcement units observed issuing citations?
- Are costs of citations sufficiently high to deter the illegal use of the HOV facility?

Public education has been applied and found helpful for this purpose. Education can go hand-in-hand in helping sustain a high compliance rate and understanding of the HOV benefits to all motorists. Public education can elicit more support for, and compliance with, the regulations needed to sustain locally acceptable project operations. Notifying the public of enforcement activities can increase the effectiveness of the enforcement effort and can reduce the commensurate manpower required to achieve compliance goals.

3. ISSUES ASSOCIATED WITH ENFORCEMENT ACTIVITIES

Experiences from current projects suggest a number of broad issues that deserve attention. Enforcement issues are so integral to HOV design, development, and operation, it is often difficult to isolate them. Addressing each seems to have a cumulative effect on meeting overall goals of acceptable compliance with limited enforcement. Five issue "areas" are discussed in this Section:

- Different agency perspectives and priorities
- Adequate design provisions for enforcement
- Public attitudes
- Adequate penalties
- Improving enforcement strategies

Different Agency Perspectives and Priorities

HOV projects often need close coordination between the planner, designer and operator. Input from the enforcement agent is commonly overlooked, especially early in the planning and development phases of a project. Input, when offered after critical decisions have been made, can be more difficult to accommodate. State police in northern Virginia cite this as an issue on both the I-95 and I-66 interim extension projects.

Even when enforcement agents are invited to participate, they may lack an understanding of project objectives and perspective to provide a meaningful response. This was the case when transitways were first proposed in Houston. A similar situation also occurred when an operating plan was first proposed for the Charlotte HOV facility on U.S. 74.

Too much involvement from multiple enforcement agents can create an aire of disharmony. This happened on one project in Orange County when two different state police precinct jurisdictions overlapped the project limits, and invited representatives from each brought forth conflicting input for what they felt was needed. On another project, the policing agents may have been given too much latitude in providing input; their requirements for 14-foot shoulders adversely affected the project schedule and budget and raised questions if the project was, in fact, feasible.

Sometimes, there is no clear enforcement agency delineation for this role. As the project evolves, the agency responsibility is sanctioned by formal agreement. Until this happens policing jurisdictions may be reluctant to get involved, or serve in a representative role only passively as a "bystander".

Even with the best of intentions from a policing agency, higher priorities can leave HOV needs on the short end of the budget. Few HOV projects have a dedicated enforcement agency; practically all rely on policing agencies to perform this role in concert with the

myriad other requirements placed on them. There are a few locations where dedicated enforcement is provided, but when emergencies arise, police may leave their posts on the HOV facility. HOV enforcement, unless it is protected by some form of dedicated funding for extra duty officers, is often a function that is reduced or eliminated when making difficult trade-offs in resource allocations for competing police service needs.

Perspectives of other agencies can create equally vexing challenges in developing an HOV facility and operation that is in balance with its enforcement needs. Designers caught up in the crux of protecting project feasibility by reducing design standards do not always have the latitude to provide what is needed to manage enforcement. Examples of such trade-offs can be seen on US 101 in Marin and Santa Clara Counties in California. Retrofitting additional lanes within highly constrained corridors, where limited right-of-way exists, can require substantial compromises in desirable design applications. The resulting configuration sometimes falls short in meeting enforcement needs, reflecting an additional lane and little else in the way of lateral offsets or available shoulders.

Where widening can facilitate shoulders for enforcement, other constraints may be responsible for precluding them. Such constraints can include limited available funding or the need for immediate action, resulting in development of an "interim" project. Route 55 in Orange County is one such project that would not have been implemented if inside shoulders had been required. Other projects developed in a similar vain include the I-95 and I-66 extension interim projects. To keep costs within budget for the initial Route 55 HOV project, short enforcement areas were provided in isolated widened segments. When these proved to be inadequate for enforcement, modifications were made to lengthen them when funding became available.

Adequate Design Provisions for Enforcement

As mentioned earlier, incorporating point-specific enforcement areas along barrier-separated HOV facilities is usually sufficient to manage enforcement. This is not true of non-physically separated lanes (either separated by paint stripe or buffer from adjacent traffic). This issue primarily pertains to this latter design, of which over half the HOV lane mileage in the U.S. qualifies. A majority of these lanes offer no adjacent shoulder or enforcement area of any type (including projects in northern and southern California, Seattle, Miami and Boston). Some projects provide a shoulder that is of nominal width (i.e., an 8 or 10-foot

width suitable for emergency breakdowns), but not necessarily wide enough, from the perspective of some policing agencies, for regular enforcement). Providing a wide buffer width between HOV and general purpose traffic, as is reflected in Los Angeles on I-10 and on I-91 in Hartford is not always considered safe by enforcement agents due to the exposure to high speed moving traffic on both sides[6].

HOV enforcement guidelines dating from 1978[11] have emphasized that an HOV lane must have design provisions for enforcement to be viable. The definition of what these provisions are has varied interpretations. Based on comments from prior HOV conferences[13, 14, 15], what has been provided is considered by enforcement agents to generally be insufficient. Existence of outside, or right hand, shoulders is not deemed satisfactory. This practice requires hazardous weaves across all lanes, induces additional risk to the violator and enforcement officer, and slows the ability to effectively enforce the HOV lane.

The lack of some form of safe enforcement area on non-barriered lanes, whether it be at irregular intervals or continuous, appears to be one of the most frequently criticized aspects of HOV facility design. One state police sergeant's quote from a recent survey sums up this attitude:

> "The greatest problem we face in enforcement in (our state) is the lack of areas/facilities or shoulders. It appears that rather than learning from past mistakes, we are continuing to make them. The latest HOV expansion project will remove the (outside) shoulder to incorporate an inside (non-separated) HOV lane. The inside shoulder is inadequate and unsafe for enforcement, but it appears plans are moving forward despite our objections."

Not all locales reflect such proactive sentiment as projects are implemented. Police apathy toward HOV facilities without enforcement provisions is another prevailing attitude. Excessively high project violation rates can be a barometer of this design shortcoming after the facility has been opened. This attitude should be explored further, and may be grounds to consider additional improvements to make enforcement easier.

Public Attitudes

The role of enforcement is vulnerable to the same array of public and political perceptions that routinely affect the HOV concept in general. Implementing an HOV facility and sustaining its long term viability has been infrequently fraught with a lack of early public awareness, education, and marketing. This is one factor contributing to the termination of the Garden State Parkway project several years ago and the Santa Monica diamond lanes in 1976.

As the application of HOV concepts grows and experiences are shared, sensitivity toward public awareness and marketing has become widely recognized. Fewer instances of this issue surfacing on newly opened projects have been experienced. Still, politicians occasionally dabble in specific HOV operation policies and regulations. These matters can influence enforcement activities. Varying occupancy restrictions by time of day on such projects as the Katy Transitway and I-66 in northern Virginia I-66 can adversely impact enforcement activities and the level of enforcement required. The Houston police claim that having different occupancies during various hours of the day complicates their abilities to enforce. Virginia police apply a grace period surrounding the transition from higher to lower occupancies on I-66. California police share similar concerns; on two recent occasions, California politicians have attempted to override local staff decisions on eligibility regulations and hours of operation.

Enforcement agents are caught in the middle in such issues. They find themselves in a reactive role to conditions often beyond their control. They look to the sponsoring agencies and the potential of public awareness and marketing activities for help.

Adequate Penalties

As noted in previous Table 2, penalties for HOV occupancy violations commonly rank equivalent to other minor traffic infractions. Research documents[13,14,15] confirm a general feeling that HOV penalties are not high enough, in most instances, to offset errant driver behavior. When respondents were asked what would be a proper first offense penalty, respondents favored a range of between $50 and $100. Clearly, few current operations attain this level of penalty. Surveys from prior years appear to indicate that in most states, penalties have tracked inflation. Only one state--California--has substantially raised penalties to lofty levels as a deterrent. There is no documentation to ascertain how many

California motorists are aware of these penalties and what deterrent the higher fine has been.

Adequate penalties are only as effective as the traffic courts that uphold them. Where police have believed in the penalty and actively pursued enforcement activities, their liaison with the traffic judges has been generally effective in helping uphold penalty statutes.

Improving Enforcement Strategies

The common method of detecting, stopping, and citing violators is time consuming, expensive, and often unsafe to the offender and officer. Several strategies have been tested to streamline citation efficiency. Some have proven more acceptable than others. Most alternative enforcement strategies have focused on the use of either audio recording license plates for subsequent citation by mail or video photographing of offenders[14,15]. Neither demonstration can prove satisfactorily that the violator is the vehicle owner, an element sometimes contested in court. As long as mail-out citations are sanctioned by the legal system and the officer can vouch for driver identity in court, selected application of audio and video devices can improve efficiency. So can automating the process of license checks, printing of summonses, and issuing of citations. The Virginia State Police have recently received grant money to purchase equipment for this purpose. Automating the citation process can free up the police officers' follow up time considerably.

Countering visual and procedural efficiencies, certain emerging vehicle features can obscure visibility. Heavily tinted or mirror finished window glass is preventing visual inspection of potential violators at high or low speeds. Night visibility, never a good option, can be further hampered by this problem and compounded by a lack of lighting in the enforcement area.

Innovative enforcement techniques are improving the efficiency of the citation process. Demonstrations of such techniques are still limited. Policing agencies have yet to alternative solutions to the difficulty or risk associated with on-site enforcement activities in most instances.

4. RESOLUTIONS TO ISSUES

Few projects can be found that do not exhibit some weakness in one or more of the above issue areas. Yet no projects are facing any immediate demise from such issues. The profession has identified these issues as needing attention. Experiences show some case study successes in each issue area. This section highlights some of these. This section also provides some thoughts for future research in support of resolutions.

Agency Perspectives and Priorities: Building Close Working Relationships

No one solution will work in bridging the agency perspective gap commonly found between the planners, designers, traffic engineers, operations staff, and enforcement agents, in particular. Awareness of each others' turf can help, particularly with respect to agency limitations and attitudes.

Awareness of the need to involve enforcement agents as equal partners in dialog is a good starting point. The initiative for seeking enforcement involvement will typically have to come from the agency(s) performing lead sponsorship of the project. For most projects, this is the state DOT. Creating an environment in which all participants feel comfortable to provide meaningful participation is one element to ensure better communication. Providing enforcement agents a better understanding of the HOV concept is another. Many states and locales now have good information and useful resources to share with enforcement agencies, explaining the purpose and role of this concept. There are also many good generic resources, including HOV guidelines from professional transportation organizations. These include reports and video media from the Institute of Transportation Engineers, American Association of State Highway and Transportation Officials, Transportation Research Board, and Federal Highway Administration, among others[1,7,11,13,14,15].

Continuing outreach will be equally beneficial in helping ensure that enforcement agencies maintain a high priority on their responsibilities. One such strategy is to formalize an operation team, including representation from enforcement. Team members should be capable of responding to the changing nature of lane use and enforcement needs. This may require periodic modifications to specific project design or operation features. Providing responsiveness to enforcement agents' concerns can foster a close working

relationship that helps them "buy" into the project. This relationship can protect the project's longevity during periods when enforcement priorities are reassessed. Similarly, having enforcement representatives involved in discussions affecting changes in operation policies can help overcome their resistance to actions that may increase or complicate their duties.

Several case studies can be drawn where good working relationships have evolved. In California, the state highway patrol is brought in during the planning activities of any HOV study. Their involvement is considered a requirement for project approval within the DOT. Enforcement agents offer input and are involved throughout the project development process. Over time, regional and statewide operation and design policies adopted from state police needs are "given" criteria for any project. The state police play an active role in operation management of the lanes, setting enforcement strategies and providing ongoing feedback to the state DOT. Where selected design treatments and enforcement strategies have been found lacking, modifications have been undertaken to correct or amend the condition. To document these findings, several statewide research activities have been undertaken to ascertain the effectiveness of various enforcement strategies, in order to establish realistic compliance goals.

In Minneapolis, the I-394 project is a good example of interagency cooperation in handling traffic and providing HOV incentives during construction activities. The Minnesota State patrol was actively involved in project operations. They were an integral member of the project management team.

In Houston, Texas, the transit police is vested with the responsibility of enforcing HOV facilities throughout the region. They are members of an operation management team composed of other representatives of the transit agency and state DOT[15]. Collectively, this group has the responsibility and authority to manage rules and regulations of the HOV system. Financial resources are available to make design and operational changes as needed to respond to enforcement issues. These enforcement agents, in turn, coordinate their activities with the other local and state enforcement agencies. Such a management approach has allowed the enforcement agents to best respond to violations and keep rates under control as occupancy rules have changed.

Design Provisions: Building on Experience

Significant strides have been made in recent years in identifying enforcement design provisions that appear to be safe and acceptable[16] (Table 3)[1,4,5,7]. Unfortunately, this experience has not been widely disseminated, nor been found practical to all situations. The reluctance to invest more in HOV facilities as a permanent feature of the urban roadway may be in part, responsible. Guidelines for permanent facilities, in several states (including Washington and California) reflect design policies that promote the provision of a continuous adjacent shoulder sufficient to perform enforcement activities on. The acceptable width varies, but is usually at least 10 feet wide (Figure 5). This provision allows the greatest flexibility for enforcement agents to apply a number of apprehension strategies in a safe fashion.

In cases where continuous shoulders are not feasible, isolated shoulders, or enforcement areas, are utilized (Figure 6). Again the width and spacing of these is largely a local matter. In southern California the interval between isolated enforcement areas is every two to three miles. In New York, a project is being considered with three-mile spacing. These designs, as noted in Figure 6, can be oriented so as to reduce accident exposure to the enforcement officer. They can also be designed to offer monitoring capability in both directions of travel. Adoption of such features and incorporation of these design treatments within the context of locally accepted practice seems to be a common way this issue is getting resolved.

On other project treatments, including reversible-flow and contraflow lanes and queue bypass treatments, enforcement pads located at the entrance is increasingly applied (Figures 7 and 8, respectively). Although enforcement pads are usually capable of being accommodated in a project design, their inclusion is sometimes overlooked.

As various designs emerge and are applied, experiences are gained. There is a need at some point to perform research and document which designs work and under what conditions. Only then will more uniform applications be appropriate to consider.

Maintaining Favorable Public Attitudes

Increasing use of public awareness activities are being applied during the critical early phases of project opening, when enforcement activities are most visible. Use of newsletters, marketing, and brochures helping educate the public of the role of the HOV concept and the

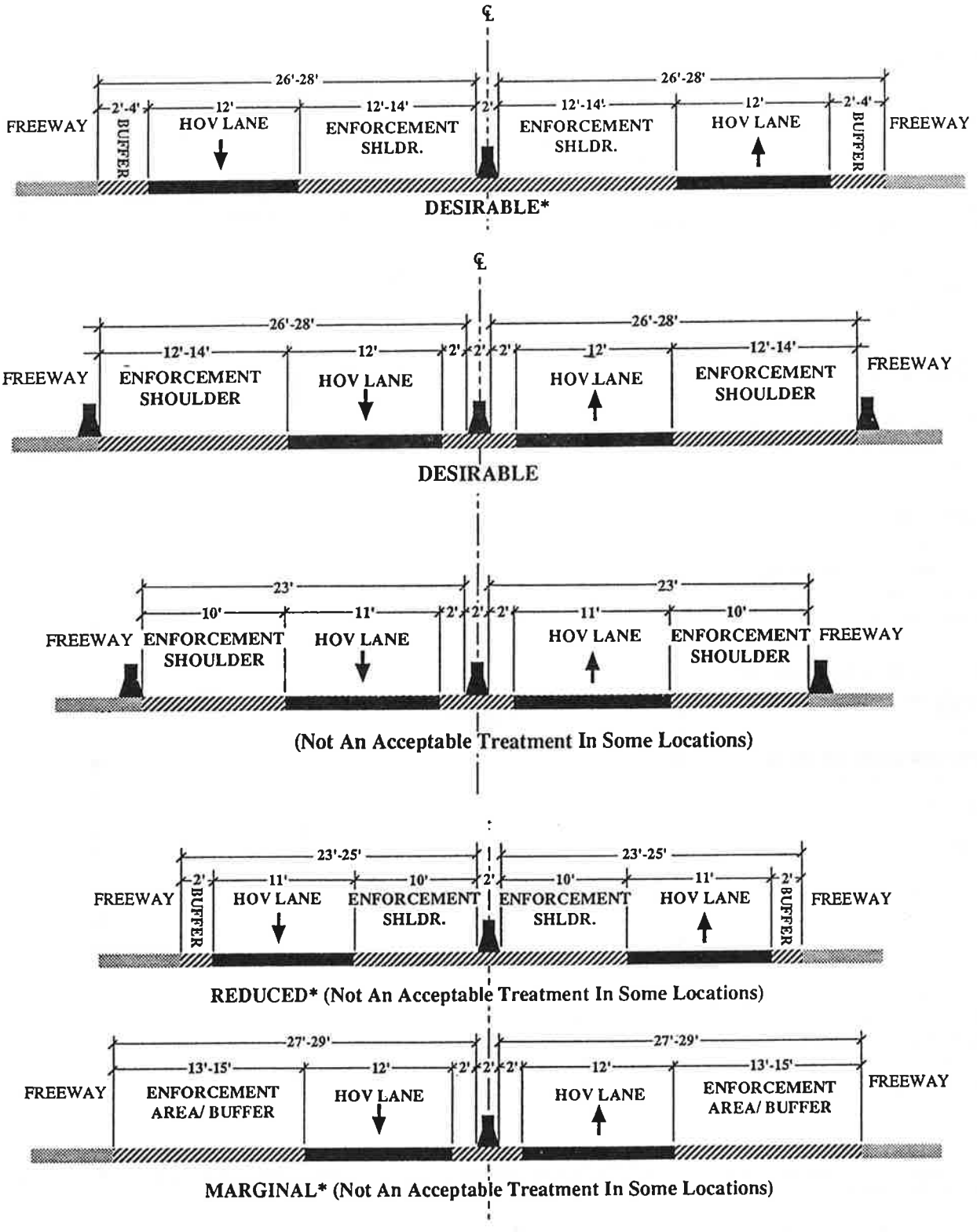
Table 3
Enforcement Provisions Employed by Various HOV Projects

	Full Shoulder(s) or Wide Buffer	Designated Enforcement Areas: At Entrance or Termination	Designated Enforcement Areas: Along Guideway	Designated Enforcement Areas: Designated Pad(s)	Self Enforcement	Citation by Mail	No Provisions
REVERSIBLE (Barrier-Separated)							
Houston, TX							
I-45 (North)		X		X			
I-45 (Gulf)		X		X			
US-290 (NW)		X					
I-10 (Katy)		X					
Virginia (Washington, D.C.)							
I-395 (Shirley)	X				X	X	
I-66	X				X	X	
San Diego, CA, I-15	X						
Pittsburgh, PA, I-279	X						
Minneapolis, MN, I-394			X				
TWO-WAY							
Barrier-Separated							
Los Angeles, CA, I-10 (El Monte)	X						
Orange County, CA, I-5 (Proposed)	X		X				
Hartford, CN, I-91	X						X
Buffer-separated and Nonseparated							
L.A./Orange County							
I-405	X[1]		X				
SR 91			X				
Santa Clara County, CA, US 101	X						X
Marin County, CA, US 101							X
Seattle, WA							
I-405					X		X
SR 520					X		X
I-5					X		X
N. Virginia, I-95						X	X
Miami, FL, I-95							X
Phoenix, AZ, I-10	X						X
CONTRAFLOW							
New Jersey, Route 495		X		X			
New York City, NY, Route 495 (LIE)		X					
New York City, NY, Gowanus		X					

[1]A short portion of this project has a wide buffer separation, but this area is not used for enforcement. Continuous shoulders are not available in all sections.

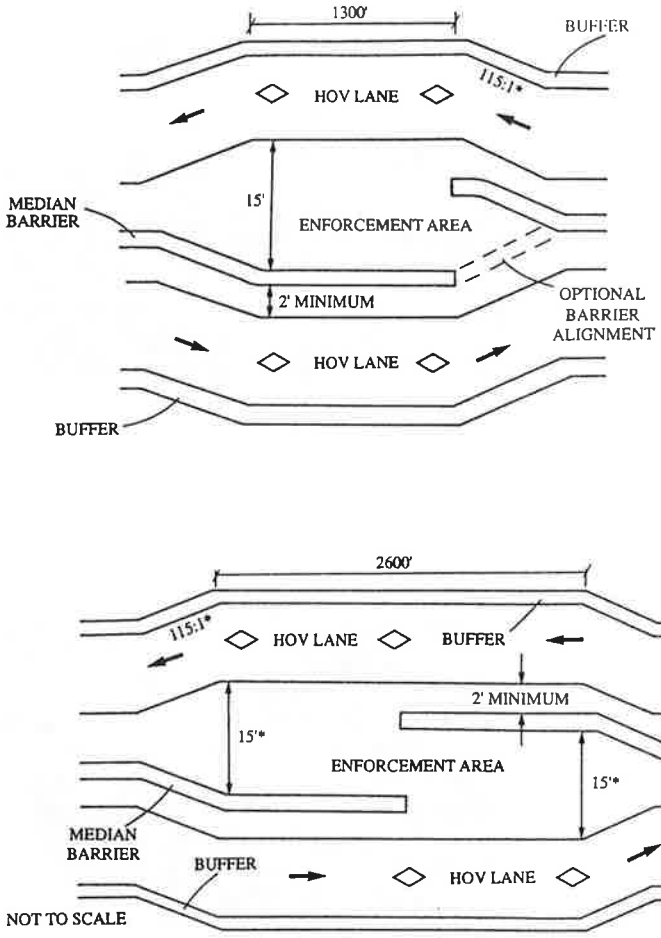
Source: Reference 7.

Figure 5
High-Speed Enforcement Areas

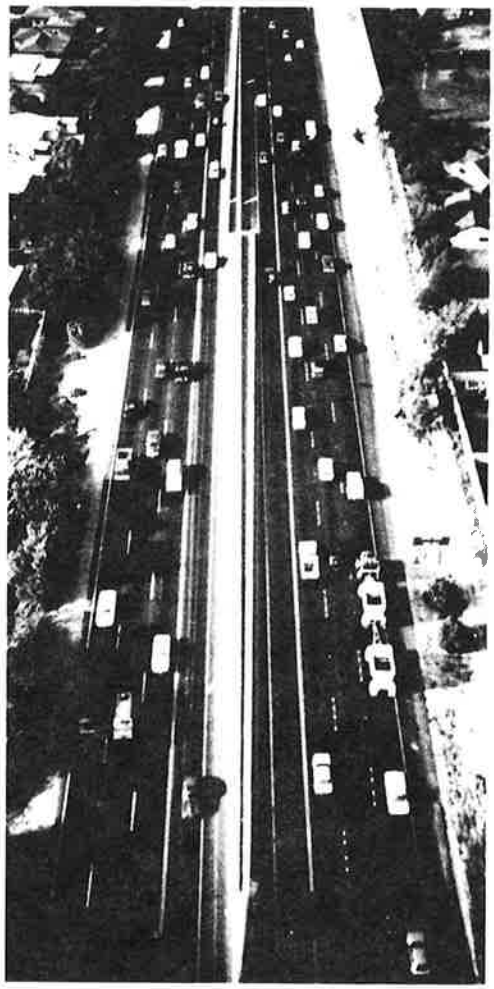


*An alternative to continuous enforcement along the HOV lane is periodic enforcement areas that provide a desirable cross-section

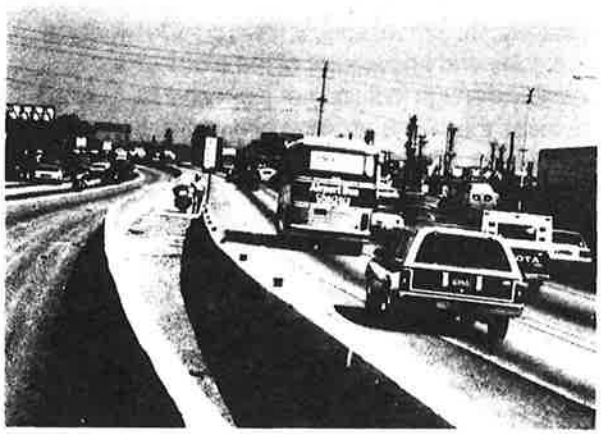
Figure 6
Typical Layouts for Designated High-Speed Enforcement Areas



Source: Caltrans, HOV Guidelines, 1990.



Aerial view of a double-sided high-speed enforcement area

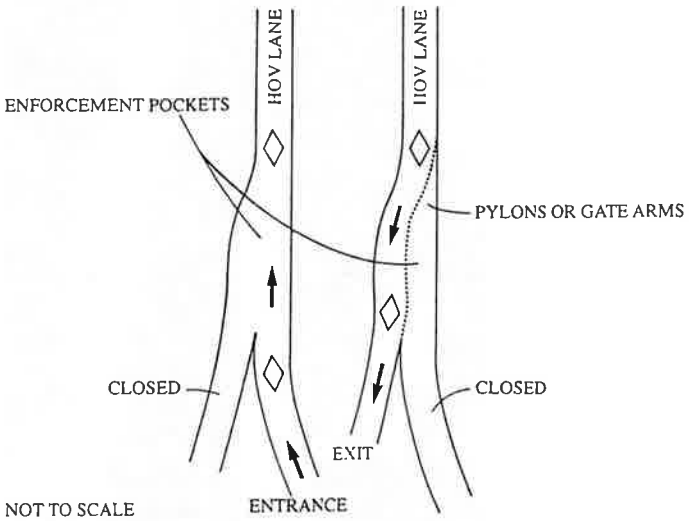


Patrol officer in barrier-protected pocket of enforcement area

Relative width of enforcement area

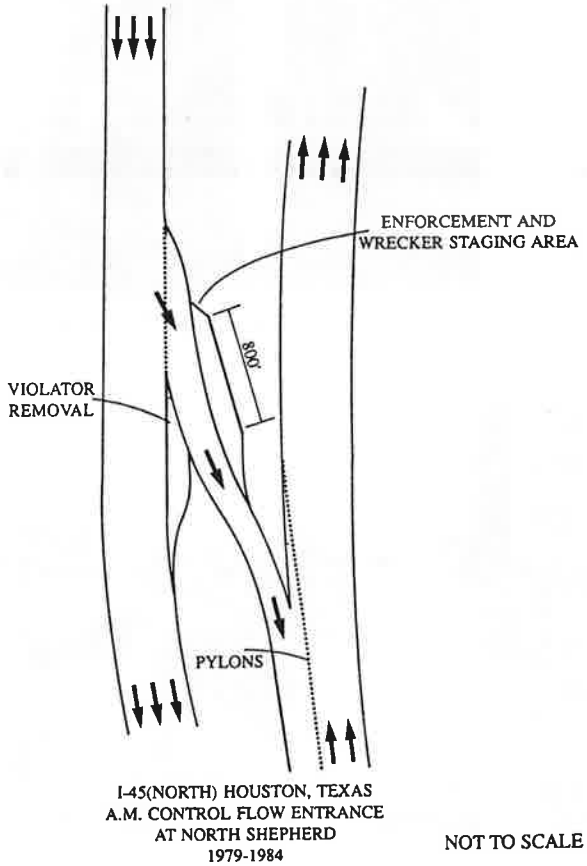
Photos courtesy of California DOT

Figure 7
Opportunities for Low-Speed Enforcement Areas on Reversible-Flow HOV Facilities



Enforcement area occupies unused roadway in each respective operating period

Enforcement and Violator Removal Facilities on Contraflow Facilities

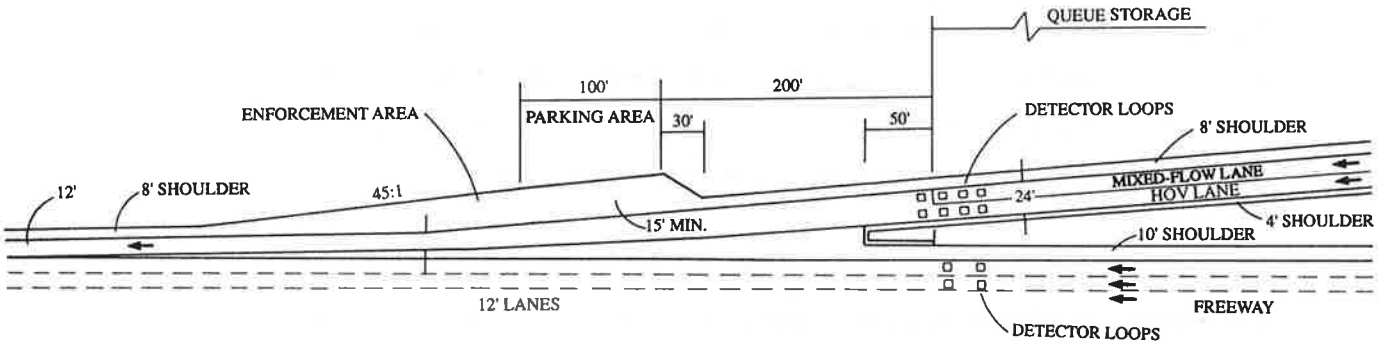


Layout of contraflow crossover and enforcement area

View of police monitor

Figure 8
Typical Layouts for HOV Bypasses on Shared Ramps

FOR SINGLE-LANE MIXED-FLOW RAMP



Source: Reference 4.

role of enforcement are appropriate. Good sample material is reflected in project operations in Hartford, Connecticut (Figure 9) and project planning in Seattle, Washington (Figure 10), respectively. Such material should target specific markets and issues that are locally important. Police agencies generally feel distribution of this information can reduce the amount of on-site presence needed.

Maintaining favorable attitudes toward enforcement can be critical to the project's success. Some form of public awareness and education activity should be considered in perpetuity. This is one of the primary reasons that the HERO program is maintained in the Seattle area[9]. It continues to involve the public in the role of enforcing the HOV facility, and the perception of the public is that this involvement is worthwhile and promotes compliance. Public perceptions toward enforcement are thereby enhanced by this program.

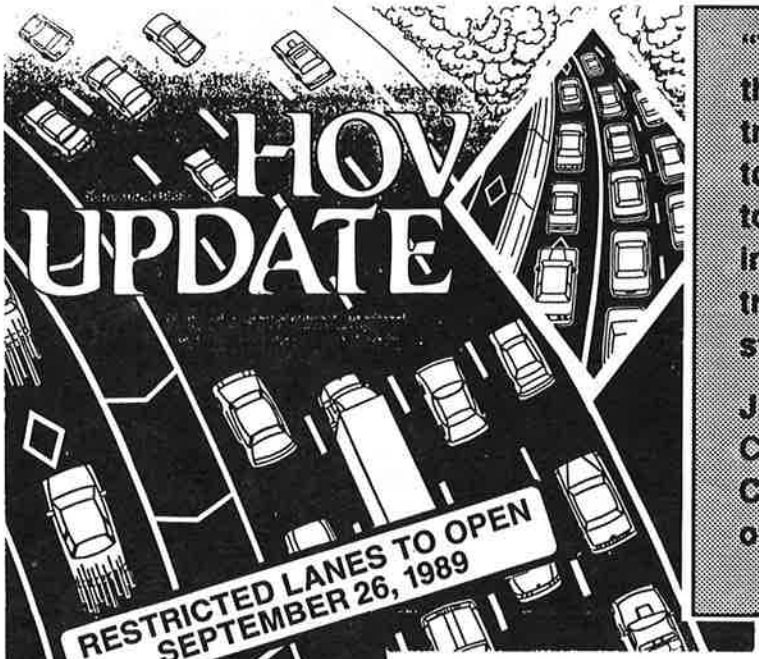
Penalties: Will a Larger Stick Help?

It is not clear whether the California approach of aggressively raising penalties will have the desired effect on all statewide projects in thwarting violators. Certainly, doing this and advertising the penalties, taken collectively, seems to have helped the state police manage violation rates on Route 55 in Orange County. However, other factors including perceived use of the facility, presence of enforcement, and the facility design may have an equally important role in regulating the number of violators. There is little correlation in the penalties applied and violation rates experienced on projects arrayed in previous Table 2.

Possibly a more appropriate question that should be asked in each locale is what penalty the public would support and traffic court system would be willing to uphold. With proper education and awareness, the police and court system may be willing to enforce higher fines associated with this type of violation. Model ordinances are available in at least one reference[11].

More research into the effectiveness of penalties would be meaningful. Currently, a wide array of penalties are prevalent from one project to another. With few exceptions, revenue from penalties is seldom recycled directly back into enforcement or evaluation activities. California is one exception, in which revenues are transferred to counties, which in some cases, are applying these toward dedicated HOV enforcement programs.

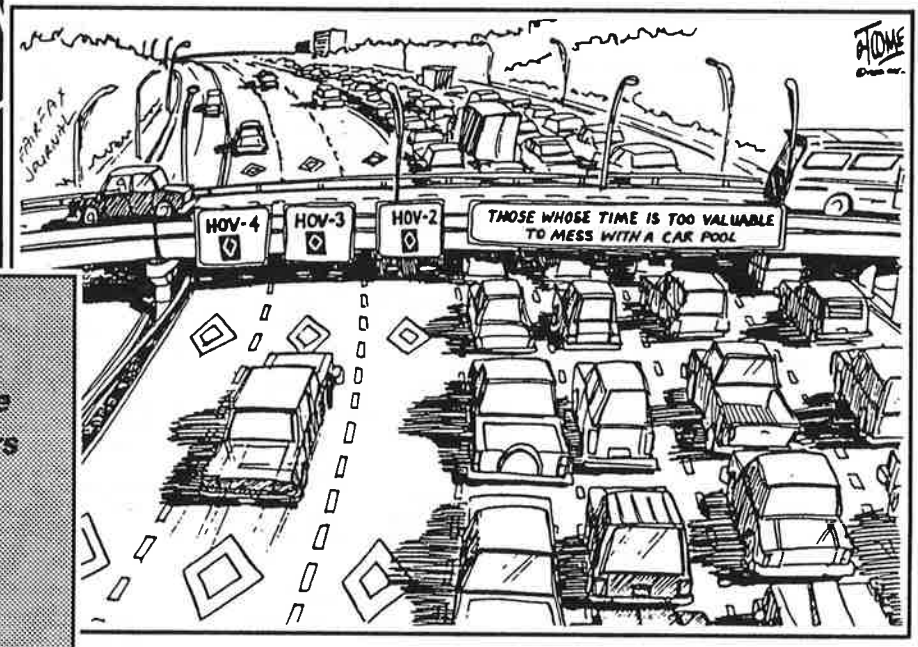
Figure 9
Sample HOV Promotional and Educational Literature



"The HOV lanes are the state's newest traffic management tool. We're dedicated to integrating them into the overall transportation system."

J. William Burns
Commissioner,
Connecticut Department
of Transportation

Reprinted from the Fairfax Journal



"We'll be watching speed, number of passengers and lane weaving. Our officers will be out there making sure the public is adhering to the rules."
Sgt. George Constantine
State Police

RIDE TOGETHER
CONNECTICUT
It's the Best Way to Work!

The HOV lanes are a Transportation Management Program of the Connecticut Department of Transportation and the Federal Highway Administration.

CONNECTICUT DEPARTMENT OF TRANSPORTATION

Reprinted from Connecticut DOT Newsletter on Hartford HOV Lanes, September 1989.

Figure 10
Public Awareness Bulletin from Seattle, Washington

I-5 South High Occupancy Vehicle STUDY

Bulletin

A Publication of the Washington State Department of Transportation
for people living or working in North Pierce County and South King County
March 1991

Construction Begins on HOV Lanes

Interstate 5 travelers in South King County will receive some welcome traffic congestion relief this summer, in the form of new high-occupancy vehicle (HOV) lanes.

Northbound, a new HOV lane will begin at S. 272nd and end at S. 200th. Southbound, carpoolers, vanpoolers and bus riders will access a new HOV lane south of the Klickitat/Southcenter on-ramp. The southbound HOV lane will end at SR 516.

To avoid adverse environmental impacts, the new lanes are being constructed by widening the inside of the existing north and southbound roadways. Construction activities include the widening of three bridges, excavating the shoulder and paving full-depth for the new "5th lane".

Bridge widening, which requires the construction of additional footings, has already begun. Excavating and paving should begin in late spring and is scheduled to minimize peak-hour traffic disruptions.

Grass Roots Activism Stimulates HOV Discussion

The fact that these HOV lanes are being built at this time is a testimony to citizen activism and intergovernmental cooperation.

Long-range WSDOT plans call for the construction of continuous HOV lanes between Seattle and Tacoma. However, that tentative schedule indicated that construction of HOV lanes between Federal Way and Southcenter, the most congested segment of the corridor, would not be completed, at the earliest, until 1995.

"Not good enough" was the loud and long response of SHOVE -- Southend High Occupancy Vehicle Enthusiasts. Armed with reams of petitions, a core group of SHOVE members gathered over 2,000 signatures from people willing to support new HOV lanes, even if that meant converting I-5 general purpose lanes to HOV lanes to get them.

SHOVE organizers followed their petition drive with a letter writing campaign to Secretary of Transportation Duane Berentson and Representative Ruth Fisher, Chair of the House Transportation Committee. Their message was clear and succinct -- "give us HOV lanes -- NOW!"

(see HOV Lanes... on back)

Study Recommendations Submitted to Steering Committee

In the last issue of The Bulletin, you read about some of the transportation strategies being evaluated by the I-5 South HOV Study Team for potential implementation between Lakewood in Tacoma and downtown Seattle.

These strategies included narrowing lanes on I-5 to allow for adding new HOV lanes, converting existing lanes to HOV lanes, constructing reversible "express lanes", restricting truck traffic and promoting increased HOV travel.

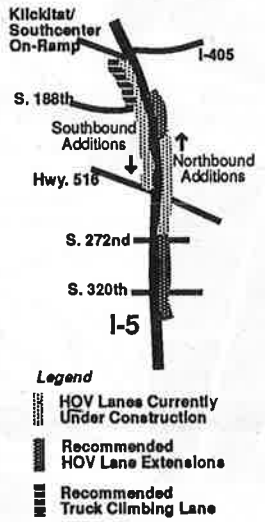
Evaluation of those, and other, strategies has recently been completed. The following draft recommendations were presented to the I-5 South HOV Study Steering Committee on Feb. 14.

Expand HOV Lane System, Construct a Truck Climbing Lane

The HOV lanes currently under construction and scheduled to open in August of 1991 begin northbound at S. 272nd and extend to S. 200th. The study team recommended that the lane begin at S. 336th and extend north past S. 188th Street.

In the southbound direction, construction is underway for an I-5 HOV lane between Klickitat/Southcenter on-ramp and Highway 516. The study team recommends that a truck climbing lane also be constructed between Klickitat and S. 188th St. It is anticipated that with the combination of a new HOV lane and a truck climbing lane, congestion through the I-5/I-405 interchange area should be lessened.

Lane Addition Recommendations



Implement the "Flow" System

The "Flow" System -- a set of traffic management techniques currently used on I-5 north of downtown Seattle -- is recommended implementation in the study corridor. These traffic management techniques include variable-message highway signs, closed circuit television cameras, ramp meters (stop-and-go signals at entrances to I-5) and incident management teams.

When the Flow System was implemented on I-5 north of downtown Seattle, vehicle speeds through the congested corridor increased 15% in the a.m. and 25% in the p.m. while accidents decreased 40%.

The Flow System promises particular advantages for Pierce County travelers, as accidents on I-5 in the downtown Tacoma area are two to three times the Washington State interstate average. Most of these accidents are sideswipes, rear end and "fixed-object" accidents, often caused by unbroken lines -- "platoons" -- of traffic merging onto the freeway.

(see Recommendations... on back)

Source: I-5 South HOV Study Project Data.

More Efficient Enforcement Strategies

The advent of sophisticated electronics still limits police in their ability to more effectively see occupants inside vehicles. The state of the art is improving. Automation of the citation process is more easily feasible. However, state statutes in some locations inhibit ticket by mail and other more efficient strategies for face-to-face apprehension. Virginia changed the state statute to permit citations of occupancy violations by mail. Visual inspection and automated ticket by mail allows police there to be more efficient. This process does not substitute for in all instances, and there is some percentage of cases that are not accepted by the courts, but there are clearly some techniques that have demonstrated higher level of efficiencies. Accordingly, Washington is now pursuing a similar state statue that would allow ticket by mail on projects in the Seattle area.

Laws are being drafted in several states that would outlaw the use of mirrored windows on vehicles. This is one method of easing the difficulty of seeing inside vehicles. Other, more sophisticated electronic devices may also be tested shortly.

Wider application of automated processing equipment, vehicle identification (AVI), and intelligent vehicle/highway systems (IVHS) may open opportunities for more widespread efficiencies to be applied. Several projects in the past, including the I-45 contraflow lane in Houston and I-10 El Monte busway in California, have authorized eligible vehicles by windshield mounted permit. This process allowed some control over who was eligible. Such a method is most amenable to AVI technology that identifies and records each user.

Documentation of current demonstrations, with particular focus on the Virginia experience, is needed. No tests are currently being proposed or conducted in this area. Perhaps interest in AVI or IVHS research can be focused on this issue as well.

5. CONCLUSIONS

Enforcement continues to play a key role in the operational viability of an HOV project. Enforcement representatives continue to find frustration in not being involved in project decisions until too late. Differences in agency perspectives and priorities, perceptions of the public, and a lack of enforcement provisions all contribute to less than desirable violation rates on many projects.

Apprehension strategies are expensive, sometimes unsafe, and in relative terms of the state of the art, quite primitive on most projects. Face-to-face contact is the norm when detecting and citing violators. The legal system frequently limits officers in their abilities to apply state of the art technology.

Resolutions to these issues are complex, and largely interrelated with the broader objectives that should be pursued in HOV projects. These include planning and operating a project from the direction of an interdisciplinary team that includes enforcement and public awareness components.

Success stories for most enforcement issues can be found. Following are trends that have been identified:

- Close interagency working relationships with enforcement agencies have been formed, particularly in areas where the greatest concentration of HOV systems are located. As this happens, the police begin playing a broader role in the day-to-day operation management of the system.

- Non-barriered lanes that encourage violators will continue to be popular among designers because they are most easily adapated into a freeway. However, designs incorporating adequate enforcement areas will become more widespread. Most new guidelines being published address the need for enforcement areas for all types of HOV facilities and provide design guidelines for their application.

- There are increasing commitments being made to the role of public awareness and education, both during the planning and implementation process and after a project opens. Such programs help instill a sense of purpose and support to the concept in general, and to enforcement in particular.

- Strategies for detection, apprehension and citation by more automated means will become more widespread in selected areas. These will not substitute for conventional apprehension techniques in all cases. Citation by mail appears to be the best near term option at improving enforcement efficiency. Automating the ticketing process can

substantially improve efficiency. Future innovations in AVI and IVHS may offer still further potential toward more efficient HOV enforcement.

Bibliography

1. American Association of State Transportation Officials, Guide for The Design of High Occupancy Vehicle Facilities, Washington, D.C., 1991.

2. Billheimer, John W., High Occupancy Vehicle Lane Violation Study, Final Report, Systan, Inc., for the California Department of Transportation, Los Altos, California, January 1990.

3. Billheimer, John W., Juliet NcNally and Rovert Trexler, TSM Project Violation Rates, Final Report, Systan, Inc., for the California Department of Transportation and the Department of the California Highway Patrol, Los Altos, California, October 1981.

4. California Department of Transportation, HOV Guidelines, Unpublished Draft, HOV Systems Branch, Sacramento, California, 1990.

5. California Department of Transportation, Ramp Meter Design Guidelines, Division of Traffic Operations, Office of Traffic Operational Systems, Sacramento, California, July 1989.

6. Cechini, Frank, Operational Considerations in HOV Facility Implementation: Making Sense of It All, Transportation Research Record 1232, Washington D.C., 1989.

7. Fuhs, Charles A., High-Occupancy Vehicle Facilities: A Planning, Operation, and Design Manual, Parsons Brinckerhoff Quade & Douglas, New York, New York, December 1990.

8. Hamm, Jeffrey T., and Ronald J. Lewis, HOV Enforcement Project Final Report, TWA-1006(001), Municipality of Metropolitan Seattle, Seattle, Washington, August 1985.

9. Jacobson, Leslie N., G. Scott Rutherford and Ruth K. Kinchen, Public Attitude Toward the Seattle Area HOV system and Effectiveness of the HERO Hotline Program, Presented at the Transportation Research Board Annual Meeting, Washington, D.C., January 13-17, 1991.

10. Kinchen, Ruth, et al., HOV Compliance Monitoring and the Evaluation of the HERO Hotline Program, Report No. WA-RD205.1, Seattle, Washington, February 1990.

11. Miller, Craig, et al., Enforcement Requirements for High-Occupancy Vehicle Facilities, FHWA-RD-79-15, Beiswanger, Hoch and Associates for the U.S. Department of Transportation, Federal Highway Administration, North Miami Beach, Florida, December 1978.

12. Miller, Craig, et al., Safety Evaluation of Priority Techniques for High-Occupancy Vehicles, Final Report, Report No. FHWA-RD-79-59, Beiswanger, Hoch and Associates for the U.S. Department of Transportation, Federal Highway Administration, North Miami Beach, Florida, February 1979.

13. Conference Proceedings, Second National Conference on High-Occupancy Vehicle Lanes and Transitways, Houston, Texas, October 25-28, 1987.

14. Conference Proceedings, Third National High Occupancy Vehicle (HOV) Facilities Conference, Minneapolis, Minnesota, October 17-19, 1988.

15. 1990 HOV Facilities Conference, Conference Proceedings, April 10-12, 1990, Washington D.C., Transportation Research Circular Number 366, Transportation Research Board, Washington, D.C., December 1990.

16. Rothenberg, Morris J., and Donald R. Samdahl, High Occupancy Vehicle Facility Development, Operation and Enforcement (Volume I and II), FHWA IP-82-1, JHK and Associates for the US Department of Transportation, Federal Highway Administration, Alexandria, Virginia, April 1982.

17. Texas Transportation Institute, High Occupancy Vehicle Lanes Enforcement Survey, Technical Memorandum, College Station, Texas, August 1988.