Agency Practice for Monitoring Violations of High-Occupancy-Vehicle Facilities

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Various states monitor their high-occupancy-vehicle (HOV) facilities for violations of passenger occupancy requirements. Few states have long-term programs to monitor violations and little published literature is available. Most current monitoring activities involve human observers; however, new photographic techniques may soon offer improvement.

As urban congestion increases, the need and justification for high-occupancy-vehicle (HOV) facilities increase. Concurrently, the temptation for motorists to violate the occupancy restrictions also increases with increased congestion levels in the general-purpose lanes (*1*). If HOV facilities are to play an increasingly important role in urban mobility, transportation and law enforcement agencies will need to work together to find effective means to maintain violations at a reasonable level or face possible public and political demands for the elimination of HOV facilities.

The methods agencies use to monitor violations on HOV facilities are reviewed. Although the primary objective of this review was to locate and examine agencies that surveyed compliance rates over long periods of time, short-term studies of HOV compliance rates were also reviewed. Although little published information was available on this subject, both published and unpublished literature, as well as telephone conversations with knowledgeable professionals, provided the information presented. This information is not meant to be a complete list of freeway HOV facilities in the United States, or the monitoring methods used in all areas, but rather a sample of the monitoring methods used on some HOV facilities. Given the nature of the information, little detailed data or analysis regarding costs, design effects, and reliability of methods can be presented.

MONITORING ACTIVITIES

Short-Term Monitoring

Short-term monitoring of violation rates on HOV facilities is fairly common and is often used to determine the effectiveness of recently constructed HOV lanes. Because the justification often given to policy makers for the construction of HOV lanes is to significantly increase the people-carrying capacity of the transportation network, transportation agencies usually monitor the new facilities just after their construction to determine their impact on traffic flow.

Violation rates are commonly examined because high violation rates may indicate a need for better enforcement or marketing of the HOV lanes, or a need to make engineering design changes (*2*). Although HOV facilities with high violation rates may improve overall traffic conditions, the HOV lanes may still be unacceptable, because the presence of many violators in the HOV lanes produces poor public perception and may erode public respect for HOV facilities in general.

Another reason for monitoring violation rates on new HOV facilities is that high violation rates may indicate a potential safety problem (*3*). Construction of HOV lanes and their operation should not have a negative impact on the accident rate (*4*). HOV lanes are most likely to affect and be affected by accidents in areas in which the HOV facilities are not physically separated from the mixed-flow lanes. This lack of separation allows vehicles to weave in and out of the HOV lane, creating a potentially dangerous situation, particularly when traffic in the HOV lane is flowing much faster than that in the mixed-flow lanes. High violation rates in such an area indicate a need to study the lanes more closely to determine whether a substantial amount of weaving is occurring.

Another type of short-term monitoring program examines the effects that selected changes in the HOV facility have on the violation rate. Examples of such changes include

- Changes in occupancy requirement (*5,6*),
- New signs or markings (*7*),
- Changes in hours of operation (*8*), or
- An increased level of enforcement (*2*).

Of these changes, an increased level of enforcement is usually reviewed in conjunction with violation rates because enforcement probably has more impact on violation rates than the other modifications. Many agencies examine the effects of changes on HOV lanes as part of the study conducted immediately after the facility has opened.

Long-Term Monitoring

The literature contains few references to ongoing long-term HOV violation monitoring programs. This condition probably reflects the fact that such programs are relatively expensive and may have no immediate impacts on traffic congestion or that in some locations violations are not a major issue. Monitoring program expense is not easily justified when compared with construction activities or other, more visible projects. A

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TABLE 1 LONG-TERM MONITORING METHODS USED BY SOME STATES

Name of State	Location of Facilities	Parameters Measured	Monitoring Frequency	Monitoring Methods and Equipment Used
Virginia	I-66, I-95, I-395 Washington, D.C.	Occupancy; Violation rate	Quarterly	One person per lane records up to six occupants using traffic counter boards.
California	I-10, SR-91, SR-55; LA & Orange Counties	Occupancy	Bimonthly	Two people monitor at each location. One person records occupancy, one classifies vehicles.
Texas	Houston; others proposed	Occupancy	Monthly	One person per lane uses a tape recorder to record data.
Oregon	The Banfield Freeway; Portland	Occupancy, Violation rate	Monthly from 1975 to 1982	One or two people collected data on all lanes of traffic using traffic counter boards.
New Jersey	Entrance to George Washington Bridge; New York City	Occupancy	March 1983 to April 1984; November 1986 to October 1987	Two persons collected data for three lanes of traffic using traffic counter boards.

survey of states identified only three that have continuing HOV violation rate monitoring programs—Virginia, California, and Texas. Two other states, Oregon and New Jersey, have had long-term programs in the past. Table 1 presents these states' monitoring programs.

HOV VIOLATION MONITORING METHODS

Most states that currently have or have had HOV lanes have monitored those lanes for at least a short period just after the lanes were constructed. However, not all states have examined violation rates as part of their initial study, and of those that have, not all of them have included methodology information in their reports. For this reason, letters were sent to states that operate HOV lanes asking for information regarding HOV monitoring methodology. Thus, the methodology information that follows came from sources other than published literature on the subject, including unpublished literature, written responses to a letter, and telephone conversations with the respective operators.

Virginia

The Virginia Department of Transportation annually uses human observers to collect data on HOV violation rates and usage on Interstates 66, 95, and 395. Table 2 presents violation rates for these three facilities and other states. On I-95, the HOV lanes, which have a violation rate of 34 percent, are concurrent-flow, nonseparated diamond lanes, whereas the Shirley Highway (I-395), which is a continuation of I-95, contains two fully separated and reversible HOV lanes and has a violation rate of 2 percent. On I-66, the two lanes in the peak direction are reserved for carpools, buses, and Dulles airport traffic during peak periods. The minimum occupancy

TABLE 2 REPORTED VIOLATION RATES ON SOME FACILITIES

State	Location	Type	Violation Rate*
Virginia	I-95 I-395 I-66	Concurrent, non-separated Fully separated, reversible HOV and airport in peak	34% 2% 20-30%
California	I-10 SR-91 SR-55		
Texas		Exclusive transitway	1%
Oregon	Banfield Freeway	Concurrent, non-separated	(3+) 20% (2+) 10%
New Jersey	George Washington Bridge	Concurrent, non-separated	30%
Colorado	South Santa Fe Highway	Concurrent, non-separated	9-31%
Massachusetts	I-93	Concurrent, asphalt curb Entrance monitored by state police	1%

$$^{*}\text{Violation rate} = \frac{\text{\# Violating Vehicles in HOV Lane}}{\text{Total \# of Vehicles in HOV Lane}}$$

Note: These numbers are very difficult to compare due to many factors and are listed for illustration only.

required for use of the HOV lanes is three persons on all HOV facilities in the state. However, airport traffic has no occupancy requirement. Therefore, monitoring I-66 is a challenge and the reported 20 to 30 percent violation rate is difficult to verify.

On the Shirley Highway, one person observes each lane and records up to six occupants per vehicle on traffic counter boards. In addition, vehicles are classified as cars, public buses, and private buses. Occupancy data on the buses are furnished by the bus companies. On I-66, no trucks are allowed any time and on I-95 and I-395 trucks are allowed with three-or-more-person occupancy.

Other HOV lanes in Virginia are monitored in a similar manner. However, I-95 is more difficult to monitor because the shoulders are quite narrow, making observation of the lanes difficult. High violation rates on this facility, presented in Table 2, are caused by the lack of physical separation between the general lanes and the HOV lane and the difficulty in enforcing the lane. High rates on I-66 are probably caused by Dulles airport traffic.

California

The California Department of Transportation (Caltrans) operates a number of HOV facilities throughout the state. However, only the HOV lanes in the Los Angeles and San Diego areas are monitored on a regular basis. Caltrans monitors occupancy on both mixed-flow and HOV lanes bimonthly on a number of freeways in Los Angeles and Orange counties. The three freeways monitored that include HOV lanes are Interstate 10 (the El Monte Busway) and State Routes 55 and 91. A portion of the El Monte Busway is physically separated from mixed-flow traffic, but the rest of the HOV lane is separated from general traffic by a 13-ft buffer zone. Occupancy requirements also vary among the lanes—minimum occupancy is three on the busway and two on the other lanes.

In order to obtain HOV occupancy rates, data are collected in ½-hr segments by a team of two counters for each location. One person is responsible for counting the number of persons in each vehicle, classifying each as having one through five occupants or six or more occupants. The second person records data on vehicle type, classifying vehicles as vanpools, motorcycles, buses, or trucks. Automobiles are not classified. The information collected from both people is then combined to determine the number and type of vehicles and the number of persons using the HOV facility. Violation rates can be extracted from these data.

Data are collected only on clear-weather weekdays with no unusual traffic conditions. Counts are not made on Mondays, Fridays, or any other days that may exhibit unusual traffic conditions (e.g., the day before a holiday). In general, counts are conducted from elevated positions, to the right of the vehicle passenger side. Examples of such positions are overpasses, pedestrian overcrossings, and the tops of cut areas.

Texas

The Texas Transportation Institute (TTI) collects a wide range of data on the use of the HOV facilities in Houston. HOV facilities in the Houston metropolitan area are reversible, barrier-separated lanes located in the freeway median. Data collected monthly on these lanes include person and vehicle volumes and vehicle occupancy. Additional data on travel times and speeds are collected quarterly (*6*).

The Metropolitan Transit Authority of Harris County (Metro) police (in the Houston area) enforce all transitways. Most violators are cited, with the possible exception of violators who sneak by when an officer is issuing a citation to another person. Therefore, the number of violators using the HOV lane is close to the number of citations issued. The violation rate is currently estimated to be 1 percent (D. L. Christiansen, informal communication).

Human observers collect occupancy data over 3½-hr peak periods. One person observes each lane and records the occupancy of each vehicle by speaking into a tape recorder. Only vanpools and buses are classified because their occupancy can be determined later from data provided by other sources (e.g., from Metro, which operates the buses).

Currently, occupancy rates are determined from the data collected in the field, which is then loaded into a computer. The state has recently ordered new computerized equipment that is capable of recognizing hundreds of words. Information recorded by this machine can be loaded directly into a computer, greatly shortening the time necessary to process those data (D. L. Christiansen, informal communication).

Oregon

Oregon does not currently operate any mainline HOV lanes, although the state does have 14 HOV bypass lanes on metered on-ramps (*9*). The Banfield Freeway, near Portland, did contain a HOV lane in each direction, but these lanes were discontinued in 1982 when construction began for Portland's light rail system, which operates in the same corridor. However, when these HOV lanes were in operation, the Oregon Department of Transportation conducted an extensive monitoring program on the lanes to determine their effectiveness. Violation rates were also determined as part of this study.

Occupancy counts were usually conducted by two people, each of whom used a four-column traffic counter board on three consecutive days (Tuesday through Thursday) on the second full week of the month. One person collected data on the two general-purpose lanes, whereas the second determined occupancy in the HOV lane only. The counters recorded each vehicle as having one, two, or three-or-more occupants, but vehicles were not classified by type. However, when sufficient personnel were not available, one person collected all the data using two four-column counter boards.

When two people were available, data were collected for 10 min in the peak direction and then, following a 2-min break, were collected in the nonpeak direction for 5 min. This cycle was repeated throughout the 3-hr peak period. If only one person was collecting data, only one direction of traffic would be counted per day.

The average numbers of one-, two-, and three-or-more–occupant vehicles were found by taking the average of each over the 3 days. These figures were then used to determine both occupancy and violation rates. Violation rates varied over the course of the lane's operation largely because the

minimum occupancy necessary to use the lane was changed. Before February 1979, when the minimum occupancy was lowered from three-or-more to two-or-more persons, the violation rate was approximately 20 percent. However, after the carpool definition changed, the violation rate dropped to about 10 percent.

New Jersey

The Port Authority of New York and New Jersey operates a HOV lane at each Hudson River Crossing between New Jersey and New York (*5*). In addition, the New Jersey Department of Transportation operates several HOV lanes. However, the only HOV lane in the state that has been recently monitored is located on the approach to the George Washington Bridge into New York City. In 1983, the New Jersey Department of Transportation conducted an extensive monitoring program of the bridge when it decided to expand the bus-only lane into a longer bus-carpool lane. Violation rates were examined as part of this study.

Data were manually recorded with a five-button traffic counter. The first three buttons were used to record the number of cars containing one, two, and three-or-more persons. The fourth button recorded the number of trucks, and misses were recorded with the fifth button. If the observer saw a vehicle but could not determine the number of occupants, the sighting was counted as a miss.

If the number of misses was low in comparison with the total traffic volume, this number was included in the total traffic figure but was not used for computing automobile occupancy. However, if this number was large, project personnel then extrapolated how many one-, two-, and three-or-more–person occupied vehicles this figure contained by examining the nonmiss data. Project personnel assumed that the miss data would exhibit the same one, two, and three-or-more split that the nonmiss data had displayed. Excessive misses were considered reason to discount the affected interval's data.

Monitoring locations were three toll plazas, two of which had three outbound lanes. The third plaza had only two outbound lanes. At the larger toll plazas, two people monitored the three lanes. One person observed the outside lane and the other observed the two inside lanes. Data were collected over 5-min intervals, with one person observing the outside lane and the other observing the two closer lanes. Every 5 min, the two observers switched positions, but the counters were set back to zero only after 20 min had passed. At that point, the two observers took a 10-min break, after which counting resumed for another 20 min. The same procedure was used to monitor lanes at the smaller toll plaza, except that a single person monitored the two lanes.

Although the HOV lane was operational only from 7 to 9 a.m., data were collected from 6:30 to 9:30 a.m. Counts were done once per month during the midweek (Tuesday through Thursday), usually during the third week of the month. Data were generally not collected during inclement weather and darkness was not a deterrent because the count locations were relatively well-lit toll plazas.

Results from the monitoring program showed that violation rates varied during the hours in which the lane was in operation. Violation rates averaged about 40 percent during the first and last 15 min of the lane's operation, whereas these rates averaged only 30 percent during the core 1½ hr of operation.

Washington

The Washington State Department of Transportation (WSDOT) does not monitor violation rates on the state's HOV facilities on a continuing basis. WSDOT periodically collects data on HOV violation rates and vehicle occupancy in the HOV lanes, but these studies are not conducted regularly. Little effort has gone into either collecting information on HOV violation rates at a given location over a long period of time or compiling the information that has been collected so that long- or short-term trends in the violation rate can be observed.

The Seattle area has a number of HOV facilities consisting of both concurrent flow HOV lanes in the inside or outside lane and HOV on-ramps, some of which bypass metered general-purpose on-ramps. HOV lanes on the outside shoulder of westbound SR-520 were the first to be opened in the Seattle area (1973), followed by the opening of HOV lanes on the inside lanes of I-5 in 1983 and the outside lanes of I-405 in 1984. The newly constructed (June 1989) I-90 bridge across Lake Washington will also have two reversible HOV lanes when the entire bridge system is completed in 1992. In the interim, there is a single, westbound HOV lane. HOV lanes also exist on SR-522, north of Seattle, and on Aurora Avenue and SR-509 in Seattle.

Several studies have been conducted since the inception of these lanes to evaluate their overall performance. However, these studies have generally focused their attention on the HOV facilities on I-5 (*10,11*) with their intent not to establish violation rates, but to examine a range of parameters, such as HOV volumes, vehicle occupancy in the HOV lanes, and the accident rate on roads that contain HOV lanes. One recent study examined the violation rate on the I-405 HOV lanes associated with an enforcement emphasis program (*12*), and a previous study investigated violation rates on the I-5 HOV lanes after the HERO program was implemented (*11*). However, both studies were short-term monitoring projects and little effort has been spent in monitoring HOV violation rates over the long term.

Generally, human observers with traffic counter boards collected HOV violation data for the studies that examined violation rates. However, observers also used small, portable computers to collect vehicle occupancy data (*13*). The use of these computers offered several advantages. First, the computers were able to record the time of each observation, an ability that largely eliminated the need to supervise data collectors. Second, the data collected could easily be transferred to a microcomputer for further analysis. Third, the computer program for collecting occupancy data allowed the data collector to correct bad observations.

Colorado

Colorado has operated a HOV lane on the South Santa Fe Highway in Denver since October 1986 (*14*). The Colorado

Department of Highways recorded the lane's occupancy and violation rate for 1 year after the lane's inception but no longer monitors the facility regularly. Violation rates during the year the lane was monitored varied from 9 to 31 percent. However, no clear link between congestion in the mixed-flow lanes and the HOV violation rate existed. In fact, the variation may have been caused by the low usage of the lane. Small changes in the actual number of violators could have caused relatively large changes in the violation rate. The low usage of the lane was probably a result of the lack of congestion in the adjacent mixed-flow lanes. This supposition is borne out by the fact that as many as 50 percent of the vehicles eligible to use the lane drove in the mixed-flow lanes instead.

Florida

Although Florida has no ongoing compliance monitoring program, several years ago the University of Florida conducted a study of HOV lane usage on Interstate 95 in Miami (*15*). Violation rates were determined by field observations made from a vehicle driving in the direction opposite to the movement in the HOV concurrent flow lane, which is on the far left-hand lane (*15*). This study could not obtain more specific details on data collection because of changes in staff.

Hawaii

Hawaii incorporated HOV lanes on several roads in the Honolulu metropolitan area—the Kalanianaole Highway and the Moanalua Freeway. Although the HOV lanes on both roads were evaluated several years after they were constructed (*16,17*), the lanes have not been regularly monitored since that time because of safety concerns. The shoulders on the sections of roadway with HOV lanes are extremely narrow (sometimes less than 2 ft wide), thereby making observation of vehicles from the side of the road hazardous. Attempts to monitor the lanes from overpasses have not been successful either (G. Hirokawa, informal communication).

Massachusetts

The only HOV lane in Massachusetts is on southbound I-93 in Boston. This lane, which is only about 4,000 ft long, is separated from the regular traffic lanes by a bituminous concrete curb located in the adjacent lane. The facility is enforced daily by the state police, who position themselves about 1,000 ft beyond the entrance to the lane. About 10 percent of the violators are actually cited; the remainder are directed by the police to reenter the general lanes through an enforcement chute designed for that purpose (C. Sterling, informal communication). As a result of constant police surveillance, violation rates are low, around 1 percent (*18*). Thus, a formal violation monitoring program is probably not necessary.

Minnesota

Currently, Minnesota is operating a single, reversible HOV lane in the median of Highway 12 in Minneapolis (*19*). This facility is only temporary because Highway 12 is being rebuilt into I-394. When complete, the new freeway will include two HOV lanes.

The state department of transportation does not regularly monitor compliance on the temporary facility. However, when citizens complain about HOV violations, the state patrol enforces the lane but finds few people actually violating the lane. Many of the apparent violators have children or dozers aboard who are not easily visible. Actual violation rates are not available.

PHOTOGRAPHIC MONITORING METHODS

Although much interest has been expressed in the use of photographic or video equipment to monitor HOV violations, the review of the literature revealed that no state has used photography for this purpose. Therefore, research was conducted to determine whether photographic equipment that has been used for other traffic monitoring purposes might be applicable to monitoring HOV violations. In addition, research was conducted to identify those factors that influence the selection of photographic equipment.

Three primary considerations that affect photographic equipment selection include the cost, ability of the equipment to take usable pictures in low light conditions, and size of the equipment. The cost of obtaining a camera capable of accurately determining vehicle occupancy is high. However, because the camera can probably be used for other tasks besides monitoring vehicle occupancy, its cost could be spread among several different tasks. Furthermore, although the camera should be able to take usable photographs in low light conditions, such as the early morning or evening hours (7:30 a.m. or 5:00 p.m.), the equipment does not need to determine occupancy at night or under weather conditions in which human observers would be unable to determine occupancy. However, it is extremely important that the equipment be unobtrusive to passing motorists. Highly visible equipment may cause traffic disruptions or at least may cause HOV lane violators to alter their behavior as a result of the camera's presence.

Given these considerations, several types of photographic equipment have promise for determining the occupancy of moving vehicles—still photography, closed-circuit television, and video cameras.

Still Photography

The prototype photographic system developed by the Naval Surface Weapons Center in 1977 is one example of a monitoring system that uses still photography (C. Sterling, informal communication). The system consisted of a 16-mm camera and a flash unit (200 watt-sec), both mounted on a single tripod, and an optical vehicle sensor to ensure that the camera and flash unit operated in unison. The Shirley Highway (I-95) HOV facility in Virginia was selected as a test site for the prototype to ensure that the system could accurately determine the occupancy of vehicles with people in the back seat.

Initial tests of the system demonstrated that, of all the film, filter, and developer combinations tested, black and white

infrared film with an infrared filter on the flash achieved the best results. These first tests also revealed that the best vantage point from which to see inside passing vehicles was in front of passing vehicles at an angle of about 45 degrees measured from the axis of the vehicle.

Following the initial development tests, operational tests were conducted to determine how well the system performed under actual, continuous field conditions. The equipment was set up under a ramp buttress to minimize the visibility of the 4-ft-tall system.

Several important results were revealed by these tests:

- Presence of the camera had no adverse effects on passing traffic,
- Equipment was capable of recording the entire peak period without failure, and
- Number of occupants could usually be determined.

However, a major problem was also revealed by the operational tests. Infrared light from the flash unit was absorbed by some car windows without penetrating and illuminating the insides of these vehicles. As a result, human forms in the pictures of these vehicles could be discerned only slightly, if at all.

Several other camera systems using still photography have been developed since the Naval Surface Weapons Center conducted its research. However, these new systems have generally been developed for purposes other than for monitoring HOV violation rates. Zellweger Uster Ltd., a Swiss firm, has designed several high-speed camera systems (R. P. Umdemstock, informal communication). One was designed to photograph the license numbers of vehicles that illegally cross an intersection during a red light. Another system photographs the license plate or the interior of vehicles violating the posted speed limit. Each system is attached to a flash unit and can therefore take pictures at night. Although neither system was designed to monitor vehicle occupancy or HOV violation rates, development might be possible of a camera system specifically for monitoring vehicle occupancy from equipment similar to Zellweger's. However, the cost of using a system to monitor HOV violation rates might well be prohibitive. Zellweger Uster estimated the price of a photo-radar unit on a tripod with a protective steel box to be $72,000. This price does not include installation.

Closed-Circuit Television

The simplest photography monitoring method may be closed-circuit television (CCTV) cameras. WSDOT has approximately 40 of these permanently mounted on roads in the Puget Sound area. However, slightly less than half of these are located adjacent to HOV lanes. In addition, several difficulties may be associated with the use of these cameras for monitoring HOV violation rates. First, no CCTV cameras are located adjacent to the SR-405 or SR-520 HOV lanes; only the I-5 HOV lanes can be viewed through CCTV. Second, the lenses currently installed on the cameras are unable to determine the occupancy of even the front seats of passing vehicles, largely because the cameras were installed to allow WSDOT personnel to scan roads for accidents and other incidents and not to see inside individual vehicles.

These problems do not necessarily preclude CCTV cameras from further consideration as a potential means of monitoring HOV compliance. WSDOT plans to install additional cameras along both SR-405 and SR-520 adjacent to the current HOV lanes. Therefore, WSDOT should determine whether the existing cameras could be fitted with new lenses that could both view the road and focus into the interiors of individual vehicles.

A Texas firm named Traffic Monitoring Technologies is currently experimenting with the use of CCTV in combination with still photography (M. Fustus, informal communication). A TV camera and computer are set up in a vehicle near the HOV facility. A person inside the vehicle monitors the HOV lane and takes pictures of suspicious vehicles. Owners of vehicles who are found violating the HOV facility are then issued citations through the mail. However, because the primary purpose of the system is to enforce, rather than to monitor, HOV facilities, the equipment is not currently set up to photograph every vehicle in the HOV lane.

Video Cameras

Use of video cameras to monitor HOV violation rates should also be considered. Advantages of video cameras over more sophisticated photographic equipment are that the equipment is far less expensive, easier to acquire, and more lightweight and mobile. The video camera Caltrans currently uses to observe traffic is capable of determining the front-seat occupancy of vehicles.

A video system might also be specially designed to photograph the entire interior of moving vehicles. Infrared light might be used to illuminate vehicles' interiors in the morning or evening hours. Further research on newly developed video equipment will be undertaken as part of this project to determine whether such a system could be developed.

CONCLUSION

A review of the literature on HOV lanes and conversations with knowledgeable personnel across the country revealed that long-term monitoring of HOV facilities is rare. In fact, of the states contacted, only three—Virginia, California, and Texas—currently monitor their HOV facilities on a regular basis. Many of the other states surveyed had monitored HOV violation rates at least once in the past.

None of the states reviewed had used any method other than human observers to collect HOV violation data. However, photographic equipment has been used for other traffic monitoring purposes, such as detecting and photographing vehicles that violate the posted speed limits. Three types of photographic equipment were identified that might be used to monitor HOV violation rates, including closed-circuit TV, still photography, and video equipment.

This survey left several important questions to be answered through additional research:

- What is an acceptable level of violations for various facilities?

- What is the relationship between enforcement and violations?
- How do various physical designs affect violations and enforcement?
- Why are agencies not monitoring HOV facilities on a routine basis?
- Should a monitoring manual be developed that details methods and costs?

Many current transportation plans assume that HOV facilities will provide substantial added mobility to urban areas. Given this assumption, monitoring must be considered essential for operational reasons, enforcement, facility justification, and program evaluation. Without solid information on effectiveness, HOV programs will not be able to compete with other facility needs.

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