

GAUGING THE EFFECTIVENESS OF **High-Occupancy Vehicle Lanes**

**Applying Three Criteria
to Available Data
Reveals Benefits,
Viability**

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The benefits claimed for high-occupancy vehicle (HOV) lanes are many—from improving air quality to reducing traffic congestion. However, the primary goal of HOV lanes is to move more people in limited space, using scarce resources more efficiently. In achieving this goal, other benefits may or may not occur—including shifts in transportation modes to higher occupancy vehicles, improvements in air quality, and relief of traffic congestion.

Compared with adjacent general-purpose lanes during the most congested periods of the day, an effective HOV lane

- ◆ Carries more people per lane,
- ◆ Experiences higher speeds, and
- ◆ Can be appropriately managed and enforced.

An HOV facility that meets these criteria is likely to be effective.

A common criticism is that HOV lanes do not alleviate congestion (1); however, the purpose of HOV lanes is to increase the number of people—not the number of vehicles—carried on a roadway; in other words, HOV lanes increase mobility. Congestion management, not congestion reduction, is the objective of HOV lanes in areas that have no feasible ways to eliminate or reduce congestion. The primary advantage is that HOV lanes enable eligible vehicles to bypass roadway congestion. Significantly reducing or eliminating roadway congestion would reduce or eliminate incentives to use the HOV lane.

HOV projects in North America tally approximately 2,500 lane-miles. This overview describes the performance of a cross section of HOV lanes (Table 1),

TABLE 1 Freeway HOV Facilities Reviewed

Location	Facilities/Occupancy Requirement	Sources of Data
Washington, D.C.	◆ I-395 / 3+ ◆ I-95 / 3+ ◆ I-66 exclusive HOV facility / 2+ ◆ I-66 concurrent-flow HOV / 2+ ◆ I-270 east leg / 2+ ◆ I-270 west leg / 2+	Metropolitan Washington Council of Governments (2)
Texas	◆ Katy (I-10W) / 2+ or 3+ ◆ Northwest (U.S. 290) / 2+ ◆ East R.L. Thornton (I-30) / 2+ ◆ North (I-45N) / 2+ ◆ Southwest (U.S. 59S) / 2+ ◆ Gulf (I-45S) / 2+	Texas Transportation Institute and Texas Department of Transportation (3)
Portland, Oregon	◆ I-5 Northbound, downtown Portland to Columbia River / 2+	Oregon Department of Transportation (4)
Washington State	◆ I-5 North Seattle / 2+ ◆ SR 520 WB Shoulder Lane at Floating Bridge / 3+ ◆ I-405 north of SR 520 / 2+ ◆ I-405 south of I-90 / 2+ ◆ I-90 Rev at Lake Washington Bridge / 2+	Brown et al. (5)
Vancouver, British Columbia, Canada	◆ Barnet Highway / 2+	Ministry of Transportation and Highways (6)
New Jersey	◆ I-80 (No longer operating as HOV lane)	Parsons Brinckerhoff Quade & Douglas, Inc. (7)
Boston, Massachusetts	◆ Southeast Expressway contraflow HOV lane / 2+	Paiewonsky, L. (Correspondence to C. Wellander, April 30, 1999); Lisco, T., and K. Wall (Correspondence to L. Paiewonsky, June 9, 1999).

NOTE: 2+, 3+ = requirements for two or more or three or more occupants per vehicle, respectively.

TABLE 2 Summary of HOV Lane Performance

	Effectiveness Criteria			
	1. Person Throughput	2. HOV Lane Utilization	3. Travel Time Savings	
			Total Facility	Per Minute
Percent Meeting Minimum Threshold	80 percent	95 percent	70 percent	50 percent

assessing a limited amount of available data without collecting new data for analysis; it is not a comprehensive review and does not support general conclusions about the effectiveness of HOV lanes in North America.

Measures of Effectiveness

Measures of the effectiveness of HOV lanes vary and can include assessments of mode shift; air quality; travel time reliability; impact on overall vehicular travel (compared with building and not building another general-purpose lane); safety impacts; and impacts on fuel consumption. All of these are valid measures.

This review, however, focuses on three measures directly related to the primary goal of optimizing the number of people carried on a roadway: person throughput, HOV lane utilization, and travel time savings. Although these three effectiveness measures also are among the most disputed, the data are readily available. Table 2 summarizes the performance of the sample HOV lanes under the effectiveness criteria.

I-405, Bellevue, Washington.



Person Throughput

Effectiveness Index

The most significant measure of whether an HOV lane is meeting its primary goal is person throughput—the number of persons carried on the HOV lane per hour. An HOV lane's person throughput may be considered effective if it carries more people during congested hours of the day than each of the adjacent general-purpose traffic lanes. The HOV person-throughput effectiveness index—developed by the authors—shows whether or not an HOV lane is carrying more people than the average adjacent general-purpose lane:

$$\text{Person-Throughput Effectiveness Index} = \frac{(P_{\text{HOV}}) \div (P_T)}{(L_{\text{HOV}}) \div (L_T)}$$

where

P_{HOV} = number of persons carried in the HOV lane(s),

P_T = number of persons carried on the facility as a whole, including the HOV lane(s),

L_{HOV} = number of HOV lanes

L_T = total number of lanes on the facility.

If the HOV lane is carrying more people than each of the adjacent general-purpose lanes, the index is greater than 1.0. If the HOV lane is carrying fewer people than an average adjacent general-purpose lane, the index is less than 1.0. In other words, an index of more than 1 means that the HOV lane has increased the number of persons carried on the roadway, and an index of less than 1 means that it has not.

For example, a roadway facility has one HOV lane and three general-purpose lanes, with 2,100 persons carried in the HOV lane and 1,800 persons in each general-purpose lane:

$$\begin{aligned} \text{Person-Throughput Effectiveness Index} &= \frac{(2,100) \div [(3 \times 1,800) + (1 \times 2,100)]}{(1) \div (3 + 1)} \\ &= 1.2 \end{aligned}$$

The person-throughput effectiveness index of 1.12, then, shows that this HOV lane is performing as intended, increasing the number of people carried on the roadway.

Figure 1 summarizes the HOV person-throughput index for selected North American facilities. For all 20 facilities for which adequate peak-hour, peak-direction data were available, the index ranged from 0.8 to 1.8; 80 percent were carrying proportionately more people in the HOV lane than in the adjacent general-purpose lanes.

The most effective facilities were those with a relatively high percentage of transit. For example, on Washington State SR 520 westbound, the shoulder HOV lane carried 34 percent of the morning peak-hour corridor persons in only 5 percent of the corridor vehicles. The lane's occupancy requirement was three persons or more per vehicle, and transit vehicles represented nearly one-half of all HOV-lane vehicles.

Preserving Options

However, an HOV lane with a person throughput index of less than 1.0 is not necessarily a failure. There are other circumstances to consider. For example, the facility may provide a level of travel time reliability critical to the success of regional transit. Alternatively, utilization of the lane may be marginal now, but significant growth and associated traffic congestion are projected for the area.

Maintaining a marginally utilized facility to preserve future mobility options may be a legitimate strategy. A more desirable option may be to employ other strategies to increase the utilization of the lane while maintaining mobility options for the future.

Utilization

Utilization refers to the number of vehicles using the HOV lane. Designed to be free of congestion, HOV lanes sometimes appear lightly traveled, especially compared with adjacent, congested general-purpose lanes at the fringes of the peak periods. HOV lanes may appear empty during off-peak hours when general-purpose lanes also may not be fully utilized. Poor utilization—either real or perceived—often is the reason for converting HOV lanes back to general-purpose lanes.

Utilization of an HOV lane is a function of the eligibility requirements, the number of eligible vehicles using a facility, and the traffic conditions on the general-purpose lanes. Local travel conditions, current levels of congestion, and projected HOV lane use are determinants of the eligibility requirements.

For example, an already large number (1,200 to 1,500) of two-person carpools may cause congestion in the HOV lane (8). Yet the public might perceive the lane as empty if there are not enough three-person carpools and buses. Therefore the requirements should maintain the benefit of unimpeded high-speed travel while providing enough volume that the public does not perceive the lane as underutilized.

Balancing these objectives can be difficult. Some areas have experimented with adjusting the HOV-lane hours of operation, raising or lowering vehicle occupancy requirements, or establishing tolls or other access controls.

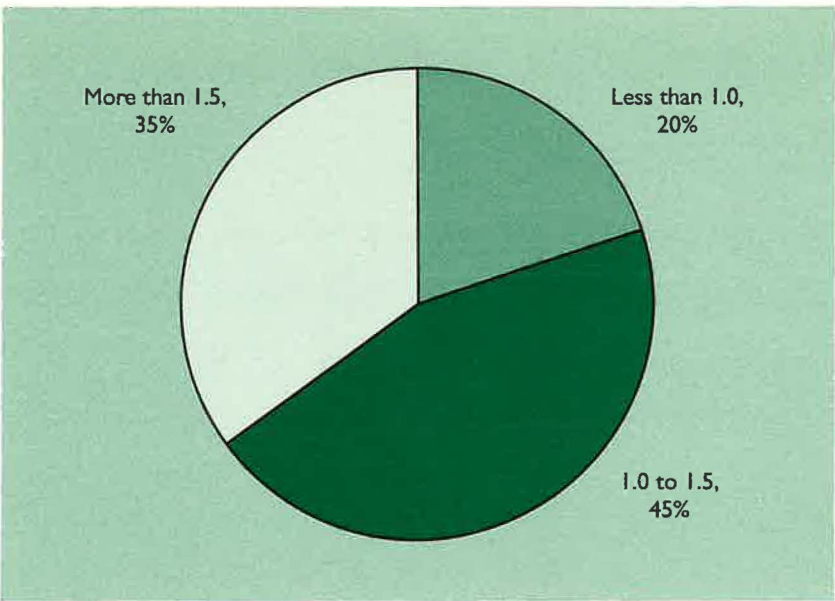


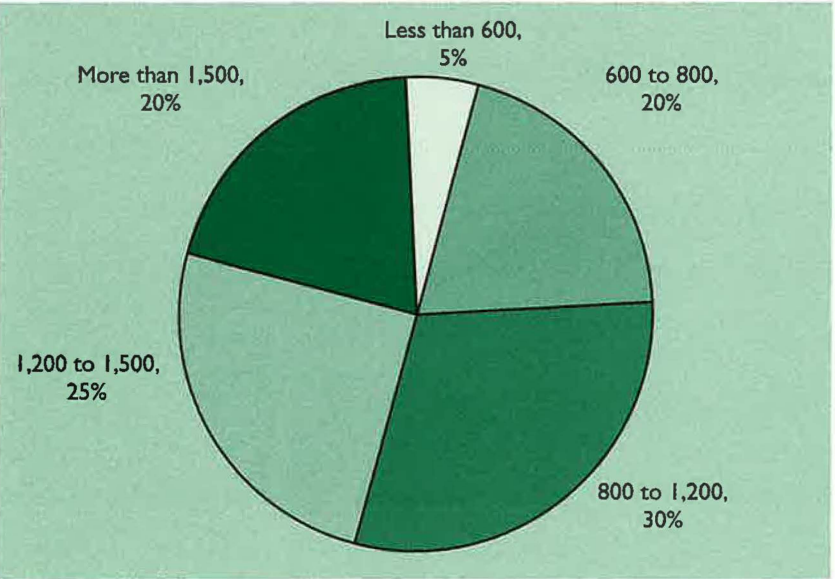
FIGURE 1 HOV person-throughput index results (20 samples; index range, 0.8 to 1.8; recommended index greater than 1.0).

Utilization Findings

Figure 2 shows that HOV-lane utilization rates for the facilities varied from 190 to 1,713 vehicles per hour per lane (vphpl) during peak hours. The average peak-hour utilization of HOV lanes for the facilities reviewed was about 1,100 vphpl.

What is the acceptable utilization rate? There are no hard-and-fast rules. A low vehicle utilization rate raises concern that even if the HOV lane is carrying more people than an adjacent general-purpose lane, single-occupant vehicle (SOV) travelers may perceive that too few vehicles are using the HOV lane. Nevertheless, to ensure travel time savings and trip reliability, a lower vehicle utilization standard is desirable for bus-only HOV lanes or for HOV lanes with higher occupancy requirements.

FIGURE 2 Vehicle utilization results in vehicles per hour (minimum of 600 vph recommended).



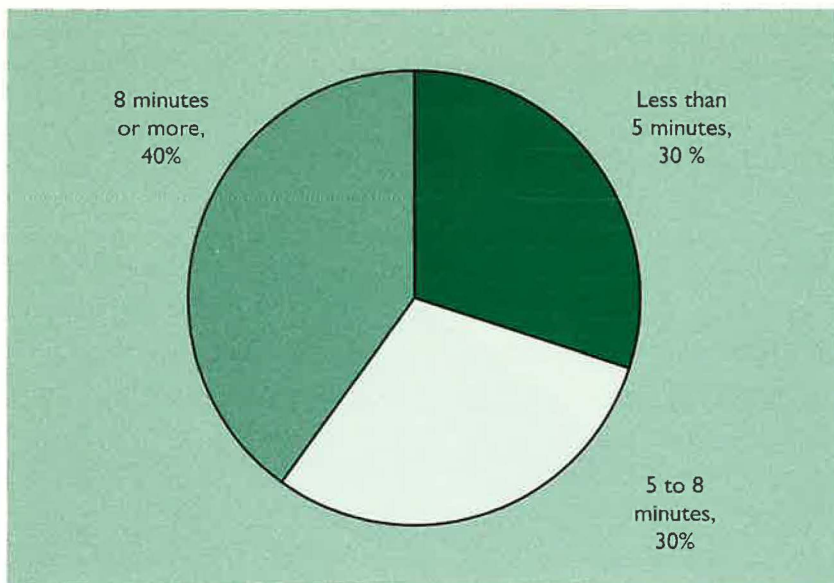


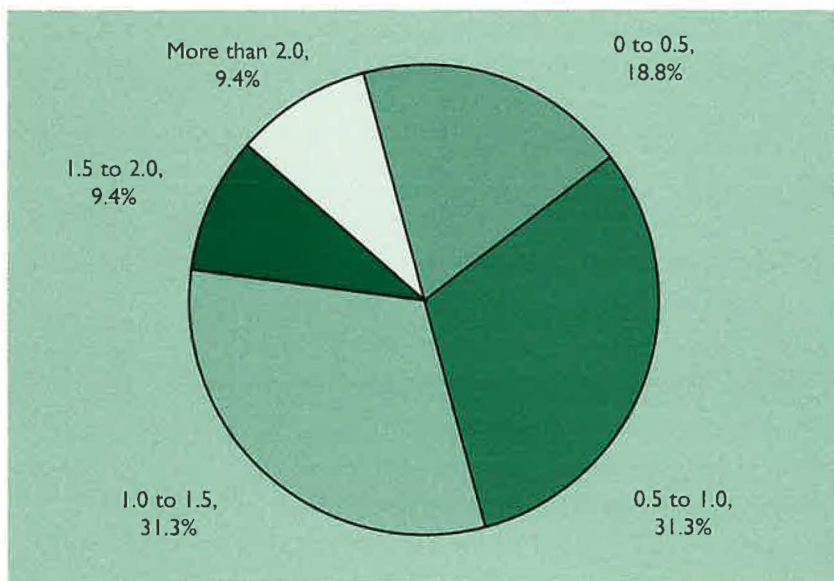
FIGURE 3 Total travel time savings (5 minutes/facility recommended).

For example, Washington SR 520 in the Seattle area includes an outside HOV lane with an occupancy requirement of three or more, which reduces the volume of eligible vehicles. However, because the HOV lane is an outside lane, merging and diverging general-purpose traffic must cut through it. Therefore a relatively modest volume is necessary in the HOV lane to maintain safe operations. But despite the low volume of vehicles, the lane has a high proportion of buses, moving more people than each of the adjacent general-purpose lanes during peak hours.

Utilization Guidelines

The *HOV Systems Manual* (8) presents general guidelines for the utilization of various HOV facilities. The utilization rates vary by the type of HOV lane; for example, the way that the HOV lane is

FIGURE 4 Travel time savings in minutes per mile (1 minute per mile recommended).



separated from general-purpose lanes (e.g., a physical barrier, paint stripe, etc.) can have an effect. The guidelines indicate a minimum threshold of 400 to 800 vphpl and a maximum threshold of 1,200 to 1,500 vphpl for a concurrent-flow freeway HOV lane. For a bus-only facility with its own right-of-way, the minimum threshold is 200 to 400 vphpl, and the maximum threshold is 800 to 1,000 vphpl.

Therefore most HOV lanes requiring a vehicle occupancy of two or more probably must carry at least 600 to 800 vehicles during the peak hour to move more people than a congested general-purpose lane without appearing too lightly utilized. Approximately 95 percent of the HOV facilities carried more than 600 vphpl, approximately 75 percent carried more than 800 vphpl, and approximately 45 percent carried more than 1,200 vphpl during the peak hour.

Even if an HOV lane carries less than the desired volume of vehicles, conversion to a general-purpose lane may not be the best strategy. Other considerations may prevail. For example, population and employment growth may increase congestion, and the HOV lane may become more heavily utilized, offering more person throughput than general-purpose lanes. Maintaining the HOV lane—perhaps experimenting with occupancy requirements and hours of operation, or even with tolls for single- or low-occupancy vehicles—can preserve a “mobility corridor” in the short term without abandoning the long-term vision of an exclusive HOV facility as volumes increase.

Travel Time Savings

Travel time savings for HOV-lane users is a critical measure—without time savings, the utilization and person throughput of an HOV lane would diminish. Figure 3 summarizes travel time data for selected North American facilities in terms of total time saved on the facility, and Figure 4 summarizes minutes saved per mile.

Saving a Minute

A common guideline states that freeway “HOV facilities should provide 1 minute per mile in travel time savings and an overall travel time savings of at least 5 minutes,...[with] 8 minutes...desirable” (8). However, for some types of facilities, achieving a travel time savings of 1 minute per mile can be difficult. For example, a highly utilized HOV lane approaching capacity may not meet this standard, but still may be effective in terms of person and vehicle throughput.

One option to increase travel time savings would be to increase the vehicle occupancy requirement (for example, from two or more to three or more per-

sons). However, this may result in less HOV-lane volume and apparent underutilization.

The separation of some HOV lanes from general-purpose lanes can affect the speed differential, making it difficult to gain a travel time savings of 1 minute per mile. For example, in a facility with a paint-stripe separation, the speed in the HOV lane generally will not exceed the speed in the general-purpose lanes by more than 20 mph. Therefore, to achieve a travel time savings of 1 minute per mile, the speed in the general-purpose lanes must be 26 mph or less, with the HOV lanes traveling at 46 mph. If the general-purpose lanes are traveling at 30 mph and the HOV lane at 50 mph, the HOV lane does not achieve a travel time savings of 1 minute per mile. Therefore 1 minute per mile as a minimum travel time savings may be too ambitious, especially for some types of facilities, such as those separated from general-purpose lanes with paint stripes only.

Posted Times

Nevertheless, of the 30 facilities represented in Figure 4, 15 facilities, or 50 percent, recorded travel time savings of 1 minute or more per mile. As shown in Figure 3, 21 facilities (70 percent) experienced overall travel time savings of at least 5 minutes, and 12 facilities (40 percent) showed overall time savings of 8 minutes or more. Notably, 13 of the 30 cases were in Washington State, and the travel time savings for these facilities were typically less than for the other facilities for two probable reasons:

- ◆ The Washington State facilities' travel time savings were averaged over a 3-hour peak period rather than the peak congested hour, resulting in slightly less travel time savings, and
- ◆ HOV lanes in Washington State are concurrent lanes separated only by a paint stripe, so that eligible vehicles can move in and out of the lanes at any time.

If the data from Washington State facilities are removed from the calculations, 76 percent of the facilities experience travel time savings of 1.0 minute per mile or more, 94 percent show an overall savings of at least 5 minutes per trip, and 59 percent experience travel time savings of at least 8 minutes per trip. These travel time savings represent typical peak hour conditions under recurrent congestion.

Travel Time Reliability

The figures, however, do not reflect the travel time reliability advantage that HOV lanes can provide during periods of nonrecurrent congestion, such as that caused by incidents or special events. Travel time reliability can be as important to the traveler as overall travel time savings. A well-managed HOV lane will provide consistent and predictable travel times for the user regardless of the varying levels of congestion in the general-purpose lanes.

For example, a travel time study conducted by the Central Transportation Planning Staff¹ found that the Southeast Expressway contraflow HOV lane in the Boston, Massachusetts, area typically provided 7 to 8 minutes of savings in the morning peak hour and approximately 14 minutes of savings in the evening peak hour. However, during the data collection, a multivehicle accident in the general-purpose lanes added about 10 minutes to the general-purpose travel times. The HOV lane was largely unaffected by the accident and provided an even more significant travel time savings of up to 24 minutes.

Public Perception

The media have been questioning the effectiveness and legitimacy of HOV lanes. For example, New Jersey recently converted HOV lanes on two facilities to general-purpose lanes. However, as shown in Table 3, recent public surveys indicate that in many areas public support for HOV facilities is relatively high.

¹ Memorandum from Tom Lisco and Kate Wall, Central Transportation Planning Staff, to Luisa Paiewonsky, Massachusetts Highway Department, June 9, 1999.

TABLE 3 Public Perception of HOV Lanes				
Location	Issue	Respondents		
		Transit	Carpool/Vanpool	SOVs
Washington	HOV lanes are a good idea	94%		74%
Washington	Don't want HOV lanes opened to all	85%		58%
Oregon	Favor HOV lane trial	77%		
Oregon	HOV lanes a good or excellent idea	70%		
Texas	Average corridor commute will benefit	63%		
Texas	HOV lanes are good improvements	N/A	N/A	65%
Texas	HOV lanes are sufficiently utilized	63%	90%	19% to 48%

For example, surveys about the Puget Sound Region HOV-lane system in Washington State (9) indicate that 94 percent of HOV users and 74 percent of SOV users think that “HOV lanes are a good idea.” Portland, Oregon, has conducted public opinion surveys of corridor users to monitor a recently implemented HOV lane pilot-test program (4). As shown in Table 3, a majority of users favor the HOV lane trial and believe HOV lanes are either a “good” or “excellent” idea.

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remain an effective strategy, when applied appropriately,
for managing and improving mobility.**

In Texas, although the vast majority of transit riders and carpool and vanpool users indicate that the HOV lanes are sufficiently utilized, less than half of SOV users think HOV lanes are sufficiently utilized (3). Nevertheless, most SOV users indicate that HOV lanes are a good idea.

I-35, Dallas, Texas.

Promoting and Defending HOVs

This review of the effectiveness of HOV-lane facilities yields the following observations:

◆ The vast majority of the HOV-lane facilities reviewed appear to be operating effectively with respect to the measures assessed, indicating that on the whole these facilities are meeting the primary goal of moving more people in less roadway space during congested hours of operation. The majority of these facilities also meet the minimum utilization and travel time savings thresholds for HOV lanes.

◆ There is a lack of adequate and consistent performance monitoring data for most HOV facilities around the country. With recent media and political questioning of HOV facilities, establishing ongoing and consistent performance monitoring programs is critical. Washington State and Texas provide good models for monitoring HOV lanes. In addition, the Los Angeles Metropolitan Transportation Authority recently started a comprehensive monitoring program for Los Angeles County HOV lanes. (For performance monitoring information from these sources, visit the websites listed on page 19.)



◆ Despite media criticism and political questioning of HOV lanes, recent surveys from several parts of the country with operating HOV lanes indicate strong public support for the facilities.

Viability Issues

A review of the data also shows that HOV lanes—although not the right solution for every situation—remain an effective strategy, when applied appropriately, for managing and improving mobility. Close attention to the planning, design, and operation of HOV facilities is necessary to avoid the dissolution of potentially effective facilities. Three issues come into focus:

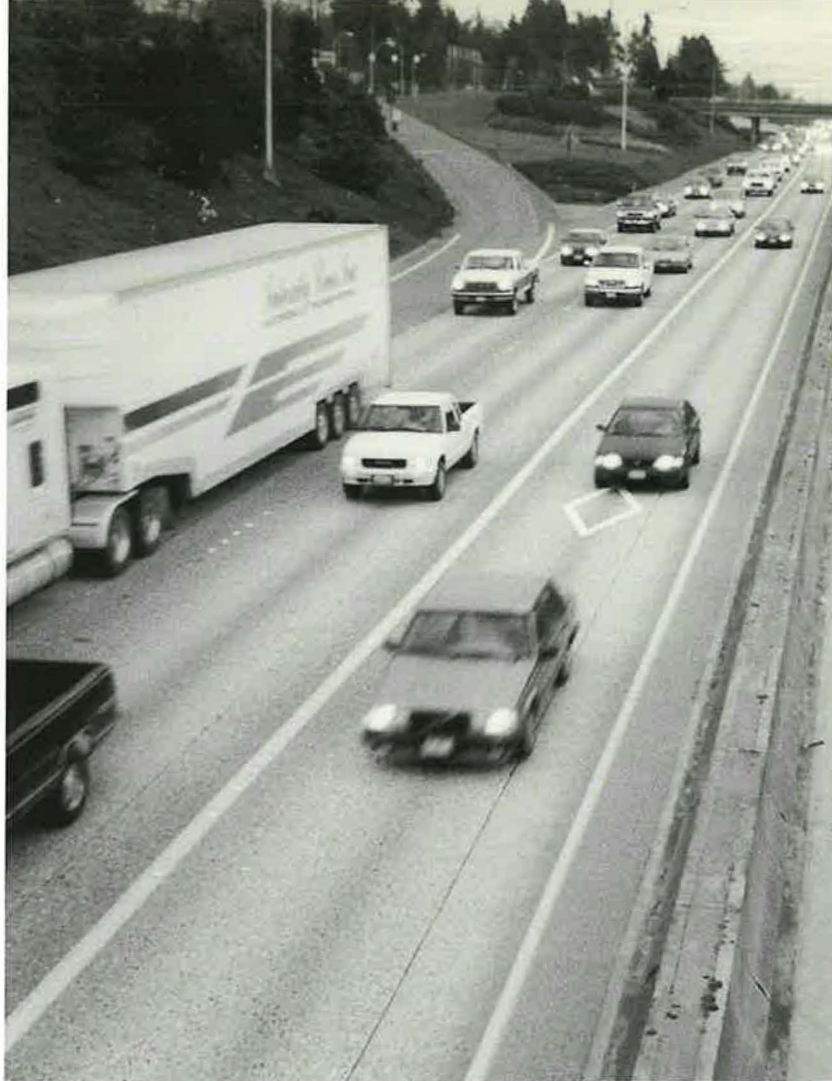
◆ In the planning stages, it is critical to recommend HOV facilities that will meet the minimum standards for utilization and person throughput. Ineffective or poorly implemented HOV lanes turn public and political opinion against HOV lanes in general and may discredit other potentially effective HOV facilities. Planners should identify contingency strategies to make potentially marginal or underutilized facilities more effective in the near term and to preserve the HOV option in the long term.

◆ Several HOV facilities around the country operate marginally; however, instead of re-designating these facilities for general purpose, authorities should consider alternatives such as adjusting the occupancy requirement or allowing lower occupancy vehicles to use the lane for a toll (but keeping the lane relatively free-flowing). These options are preferable to converting an HOV lane to general purpose. Although there are examples of general-purpose lanes successfully converted into HOV lanes (8), it is difficult—if not impossible—to redesignate a lane for HOV use after turning it over to general-purpose traffic. Losing the HOV lane option means losing a future option for mobility in the corridor.

◆ There is a dire need for improved performance monitoring of HOV facilities. This information can be used in defense of HOV lanes that are operating effectively and also can identify HOV lanes that are candidates for alternative management strategies.

References

1. Poole, R. W. Jr., and C. K. Orski, *Building a Case for HOT Lanes: A New Approach to Reducing Urban Highway Congestion*. Reason Public Policy Institute, Los Angeles, Calif., April 1999.
2. *1997 Performance of Regional High-Occupancy Vehicle Facilities on Interstate Highways in the Washington Region: Draft*. Metropolitan Washington Council of Governments, Washington, D.C., May 8, 1998.
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8. *NCHRP Report 414: HOV Systems Manual*. TRB, National Research Council, Washington, D.C., 1998.
9. *HOV System Performance Snapshots*. Washington State Department of Transportation, February 1990.

I-5, Portland, Oregon.

Websites

- Los Angeles County Metropolitan Transportation Authority HOV Performance Program:
<http://www.mta.net/corporate/depts/CPD/HOV/index.htm>
- Texas Transportation Institute:
<http://tti.tamu.edu/>
- Washington State Department of Transportation HOV Web Page:
<http://www.wsdot.wa.gov/regions/northwest/hovpage/hovmain.htm>
- Washington State Transportation Center:
<http://depts.washington.edu/trac/>