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High-Occupancy Vehicle System Development in the United States

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HIGH-OCCUPANCY VEHICLE SYSTEM DEVELOPMENT IN THE UNITED STATES

A White Paper

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EXECUTIVE SUMMARY

"HOV facilities are an innovative, energy efficient, cost effective, and environmentally sound way of maximizing the capacity of freeways."

Ruth Fisher, Chair of House Transportation Committee,
Washington State Legislature

Overview

Preferential treatments for high-occupancy vehicles have proven to be flexible, cost effective alternatives for increasing the capability of congested urban transportation systems to move people. The results can be dramatic. The single high-occupancy vehicle (HOV) lane on the approach to the Lincoln Tunnel (N.J. Route 495) moves over 35,000 persons into New York City during a single hour in the morning. The Shirley Highway (I-395) HOV lanes carry over 15,000 persons into Washington, D.C. in the peak hour alone, nearly twice as many people as are moved on the adjacent four general-purpose freeway lanes. Outside of New York City, this is more peak-hour, peak-direction persons than are moved on any rail transit line in the United States.

Clearly, when implemented in appropriate corridors and operated properly, HOV facilities are an effective means of moving people; they encourage significant numbers of commuters to choose to ride a bus, vanpool, or carpool. This increases the average number of persons per vehicle and reduces the growth in vehicle miles of travel, which has beneficial impacts on mobility, air quality, and energy consumption.

The High-Occupancy Vehicle System Concept

A variety of transportation actions are now being taken to help deal with urban transportation-related problems. One action involves providing priority treatment on roadways for high-occupancy vehicles -- buses, vanpools, and carpools. An intent of these preferential high-occupancy vehicle (HOV) facilities is to help maximize the number of persons moved on a roadway by increasing the average number of persons per vehicle. This is accomplished by altering the manner in which a roadway is designed or operated to provide travel time advantages --. both a travel time savings and a more predictable trip time -- to those persons who travel in high-occupancy vehicles. The travel time advantages serve as incentives for commuters to choose to ride a bus, vanpool, or carpool rather than drive by themselves.

Developing a high-occupancy vehicle project typically involves designating a special roadway or lane(s) that is reserved for exclusive use by high-occupancy vehicles during at least portions of the day. These projects range from temporary re-striping of shoulders to delineate HOV lanes to constructing exclusive roads or lanes that are reserved for HOV use. Developing these projects also involves providing a system of complementary improvements. Some of these improvements require constructing physical facilities such as park-and-ride lots, while other important actions include initiating complementary policies, providing services such as carp001 and vanpool programs, and marketing. The success and acceptance of an HOV project can be highly dependent on pursuing the appropriate package of strategies and policies. Since there are a number of different elements involved in developing **HOV** projects, they are neither pure "highway" nor pure "transit" projects. Thus, multi-agency coordination and cooperation are important elements in project success.

Principal Objectives of High-Occupancy Vehicle Projects

While not applicable everywhere, a role exists for HOV projects. These projects are intended to offer a safe, cost-effective travel alternative that a significant number of commuters will find attractive. High-occupancy vehicle system projects are intended to attain some, or all, of the objectives listed below.

Increase the Average Number of Persons per Vehicle. As a result of the travel time advantages offered by giving priority on the roadway system to high-occupancy vehicles, HOV projects are designed to get single-occupant auto drivers to choose to ride a bus, vanpool, or carpool. Explicit recognition is given to moving people rather than moving vehicles, an objective being to move more persons in fewer vehicles.

Preserve the Person-Movement Capacity of the Roadway. Opportunities to expand freeway capacity are limited. By implementing HOV lanes in appropriate corridors and operating them properly, a single HOV lane assures that capacity will be available in the future to serve growth in person travel. The HOV lane, which typically moves two to five times as many persons as a general-purpose lane, effectively doubles the capacity of the roadway to move people. When an HOV lane becomes congested, the vehicle occupancy required to use the priority lane can be raised, or other adjustments made, to assure that the HOV lane always offers the high speeds and reliable trip times that are essential to HOV facility success. By their nature, HOV lanes are most heavily used and, therefore, most beneficial during the congested peak periods, the times during which it is most difficult to provide adequate roadway capacity.

Enhance Bus Transit Operations. In addition to attracting more bus riders, HOV lanes offer other advantages to the transit operator. Vehicle and labor productivity improves as does schedule adherence. Transit operates in a safer environment.

High-Occupancy Vehicle Development in the United States

Interest in high-occupancy vehicle facilities has come about recently. The first major HOV project on a U.S. freeway was implemented in 1969 on the Shirley Highway (I-395) in northern Virginia serving Washington, D.C. Interest in the HOV concept developed gradually in the 1970s and increased markedly in the 1980s.

At present, over 20 urban areas in all parts of the U.S. are either operating HOV lanes or are in the process of actively developing this type of priority facility; nearly 40 separate HOV projects are now in operation. Six urban areas -- Seattle; Los Angeles; Santa Clara County, California; Orange County, California; Fairfax County, Virginia; and Houston -- are committed to developing an extensive system of freeway HOV facilities. These areas have tested the HOV concept, found it attractive, and decided to pursue construction of significant additional HOV mileage.

Approximately 340 miles of HOV facilities, built at a cost of about $1.5 billion (1988 dollars), are now operating in the United States. If only the projects that are currently in some stage of development are completed in the 199Os, roughly $3 billion will be spent on HOV development in that decade, and 850 miles of HOV lanes will be operating by the turn of the century.

Reasons for Developing High-Occupancy Vehicle Projects

While not an appropriate improvement in all corridors, HOV facilities are being looked at more often as one approach for addressing problems associated with urban mobility. Some of the reasons that greater attention is being focused on the HOV alternatives are highlighted below.

HOV Projects Achieve Their Objectives. When implemented in the right corridors and operated properly, HOV facilities move a large number of persons at relatively high speeds. The following are being realized as a result of HOV projects: 1) the average number of persons per vehicle increases as auto drivers choose to ride a bus, vanpool, or carpool; 2) the HOV lane gives the roadway the capacity needed to continue to satisfactorily serve growth in travel demand, something that often can't be realized by just adding general-purpose lanes; and 3) the efficiency of bus transit operations improves.

HOV Projects are Affordable and Low Risk. Compared to rail transit projects, HOV facilities are relatively inexpensive. A variety of funding sources are used to develop HOV projects; federal, state and local highway and transit monies are used for this purpose. If an HOV facility proves to be unsuccessful, it can be converted to other useful highway functions, such as additional general-purpose lanes or emergency shoulders; the capital investment can be largely salvaged, thus lowering project risk.

Public Operating Costs are Low. The operating cost per passenger for buses on HOV facilities is generally comparable to the cost on rail. However, carpools also use most HOV facilities and, on those facilities, typically move over half of the total person volume. These carpool trips are served at a very low marginal public cost. As a result, total public operating cost per passenger on HOV facilities is low.

Projects are Implemented Relatively Quickly and Can be Staged. Major projects have proceeded from planning to operation in a 3- to 8-year time frame. And, since the vehicles that operate on HOV facilities also operate on the existing roadways, HOV projects can be effectively developed in stages, with segments becoming operational prior to completion of the entire project.

HOV Projects Serve a Variety of Trip Patterns. HOV facility use by buses provides a means for moving large volumes of commuters to major employment centers. Carpools are a means of serving trips that originate or terminate where transit service either isn't convenient or doesn't exist. Carpools also serve trip patterns, particularly suburb-to-suburb travel, that are often difficult to serve with conventional, fixed-route transit. The value of HOV lanes in serving a variety of trip patterns is exhibited by the fact that these priority facilities operate both on radial and circumferential freeways.

HOV Development is Compatible With the Intelligent Vehicle and Highway System Program, HOV system projects can both complement, and benefit from, the large IVHS program currently being implemented at the federal level.

HOV Projects are Compatible with the New Clean Air Act. As urban areas develop strategies for complying with the new federal air quality standards, increasing the average number of persons per vehicle will be a key part of these plans. HOV lanes offer one of the more effective approaches available for increasing vehicle occupancy,

HOV Projects Reduce Energy Consumption. Increasing the number of persons per vehicle reduces vehicle-miles of travel, which lessens energy consumption.

HOV Development Has Public Support. Surveys in cities across the country show that HOV lane development has general public support.

HOV Needs are Recognized in the National Transportation Policy. The potential role and value of HOV facilities is explicitly recognized in the recently formulated National Transportation Policy.

Conclusion

A role clearly exists for HOV system projects in large, congested urban areas in the United States. These facilities offer a means for helping to address regional concerns relating to traffic congestion, air quality, and energy consumption. They are often the best means of using the limited available right-of-way.

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HIGH-OCCUPANCY VEHICLE SYSTEM DEVELOPMENT IN THE UNITED STATES

Purpose

A variety of transportation-related strategies are now being taken to help deal with urban problems associated with traffic congestion, energy consumption, and air quality. One approach involves providing priority treatment on our roadway systems for high-occupancy vehicles -- buses, vanpools and carpools. An intent of this approach is to alter the manner in which a roadway is designed and/or operated to offer individuals who ride a bus, vanpool, or carpool with travel time advantages -- both a time savings and a more reliable trip time. These travel time advantages serve as incentives that lead to significant numbers of single-occupant auto commuters choosing to ride a bus, vanpool, or carpool. With this mode shift, the average number of persons per vehicle increases, resulting in more effective use of the roadway system. Implementation of high-occupancy vehicle projects in appropriate congested corridors helps address many of the transportation-related problems facing urban areas today. The recently developed National Transportation Policy supports the continued development of priority high-occupancy vehicle facilities. Further, these types of facilities represent one method for meeting the objectives of the new Clean Air Act.

Since the 1969 opening of the Shirley Highway exclusive bus lanes in Washington, D.C., numerous metropolitan areas in the United States have developed, or are proposing to develop, priority facilities for high-occupancy vehicles. This *White Paper* has been prepared to present information that provides a better understanding of the HOV system approach. The *Paper* presents a description of the high-occupancy vehicle system concept and discusses the characteristics and applications of priority HOV projects.

Introduction

Urban areas across the United States are facing serious problems relating to traffic congestion, air quality, and energy consumption. As vehicle-miles of travel have continued to increase and the supply of petroleum has become less secure, these problems have intensified, Urban mobility, air quality, and energy concerns are all significantly exacerbated by our high dependence on the single-occupant automobile. Indeed, for urban work trips, there is, on average, only about 1.15 persons in each vehicle.

Areawide congestion is already at unacceptable levels in many large urban areas (1), and the costs of this congestion are substantial. One estimate (1) placed the annual congestion cost -- just the cost of increased delay and fuel consumption due to impaired mobility -- for 39 large U.S. cities at $41 billion in 1987. Personal vehicle mobility will continue to deteriorate. substantially, as roadway travel is expected to at least double by the year 2020 (2), and Federal Highway Administration estimates indicate that vehicle delay on freeways will increase by 400% between 1985 and 2005 (3). In addition, urban trip patterns are changing in a manner that further intensifies congestion. Suburb-to-suburb travel, trips not necessarily served well by traditional hub-and-spoke transportation systems, has increased rapidly and now represents the largest share of total urban commuting (4). Many of the large suburban employment and commercial centers that developed in recent years routinely experience large-scale congestion (5).

Increases in travel and congestion also lead to a deterioration in air quality. Mobile sources cause over 30% of carbon dioxide emissions, and motor vehicles contribute 40% to 60% of the hydrocarbons that produce urban ozone and smog problems. Autos cause 70% to 80% of carbon monoxide emissions. A result is that 68 cities are too polluted to meet federal standards for ozone, 59 cities fail to meet standards for carbon monoxide pollution, and over 100 suburban areas exceed current pollution standards (6). Partly in response to this, Congress has recently passed the Clean Air Act. This new federal legislation will require more than 100 cities that are failing to meet federal air quality standards to develop pollution control strategies to bring these areas into compliance within 17 years. Addressing single-occupant auto travel patterns and encouraging actions that will increase the average number of persons per vehicle is a part of these strategies.

The transportation system that serves the American lifestyle and its dispersed travel patterns is heavily dependent upon petroleum. Recent events in the Middle East and the resulting increases in the price of fuel have again underscored the consequence of dependence on foreign oil. Transportation currently accounts for 65% of U.S. petroleum use (6), an increase from 54% in 1978 (7). Again, less dependence on single-occupant auto travel will reduce vehicle-miles of travel and energy consumption.

To help alleviate these concerns, a wide range of transportation actions is being pursued. These include: 1) building more streets and highways; 2) enhancing the operation of the roadway facilities already in place; 3) expanding public transportation services, including rail transit development; 4) pursuing the intelligent vehicle and highway system (IVHS) program; and 5) undertaking numerous demand management strategies. Appropriate roles exist for each of these actions, and coordination is needed to maximize the benefits derived from transportation investments.

However, the action of reducing dependence on the single-occupant auto, by itself, represents a meaningful approach for addressing the regional concerns of congestion, air quality and energy consumption. If the average number of persons per vehicle is increased by getting more people to ride buses, carpools, or vanpools, as a minimum the rate of increase in vehicle-miles of travel can be reduced. However, incentives need to be provided to attract a significant number of single-occupant auto drivers to ride a bus or form a carpool. This leads to the high-occupancy vehicle system concept, an intent of which is to explicitly give priority on the transportation system to those individuals who are willing to share a ride.

The High-Occupancy Vehicle Concept

Developing a high-occupancy vehicle project typically involves implementing a system of improvements. Designating a special roadway lane(s) that is reserved for exclusive use by high-occupancy vehicles -- buses, vanpools, and carpools -- during at least portions of the weekday is often an integral feature of these projects. In different parts of the country, these priority lanes are referred to by a variety of names, including busways, transitways, high-occupancy vehicle (HOV) lanes, diamond lanes, commuter lanes, and authorized vehicle lanes, Regardless of the name given to the project, the priority HOV measures that have been implemented throughout the United States, while sometimes differing in design and operation, have similar purposes. In general, the preferential high-occupancy vehicle (HOV) facilities are intended to help maximize the number of persons moved on a roadway by increasing the average number of persons per vehicle. This is accomplished by altering the manner in which a roadway is designed and/or operated in order to provide. Travel time advantages -- both a travel time savings and a more predictable travel time -- to those persons who choose to travel in high-occupancy vehicles. These travel time advantages serve as incentives for commuters to choose to ride a bus, carpool, or vanpool rather than drive by themselves.

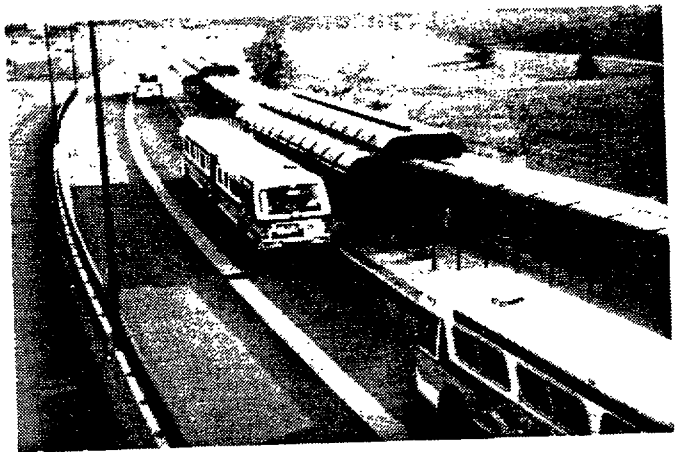
In addition to designating a priority lane for HOV use, successful HOV project development generally involves implementing a system of complementary improvements. Some of these improvements involve provision of physical facilities, such as park-and-ride lots and HOV bypass ramps. Other important actions involve providing services and supportive policies, such as carpool and vanpool programs, appropriate parking policies, public relations, and marketing. The success and acceptance of an HOV project can be highly dependent on pursuing the appropriate package of strategies.

Preferential HOV facility systems are a means of making the best possible use of the available transportation right-of-way, which is particularly important since opportunities for building new freeways are limited. Explicit recognition is given to moving persons rather than to moving vehicles. For a variety of reasons, including physical, economic and environmental constraints, it is neither possible nor desirable to attempt to serve all travel demand at 1.1 or 1.2 persons per vehicle. The average number of persons per vehicle must increase. By doing this, regional problems caq be more easily addressed. High-occupancy vehicle systems have demonstrated that they can be effective in encouraging individuals to choose to carpool, vanpool or ride a bus.

The travel time advantages offered by the HOV lane, combined with the benefits derived from the complementary system improvements, serve as incentives for commuters to choose to ride a bus, carpool, or vanpool rather than drive by themselves. Since both transit and carpooling are given priority, the attractiveness of the HOV project is increased; not only are numerous advantages given to the bus transit rider and operator, but benefits also are extended to those who will carpool or vanpool. An intent of HOV projects is to provide a safe, cost-effective travel alternative that a significant number of commuters will find attractive. This results in an increase in the average number of persons per vehicle. Another intent is to protect the person-movement capacity of the roadway so that increasing travel demands can continue to be served on the existing facility in future years; this often can't be done by just building additional general-purpose lanes. HOV systems offer the greatest incentives during peak travel periods; thus, their major impact is during the times when available roadway capacity is most scarce and the costs of congestion are greatest.

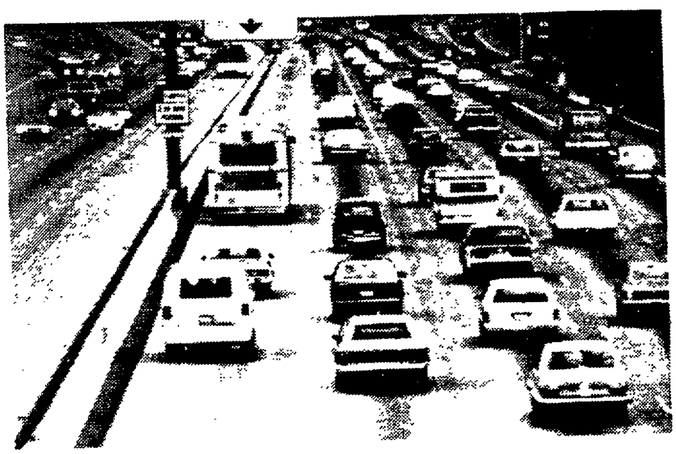
Types of High-Occupancy Vehicle Facilities

High-occupancy vehicle lanes are designed and operated in a variety of different manners. Projects range from temporary re-striping of shoulders to delineate HOV lanes to constructing exclusive roads or lanes reserved for HOV use. Flexibility in implementation allows HOV improvements to be better matched to specific needs within in a given corridor. This *White Paper* focuses on HOV facilities developed either in freeway or in separate rights-of-way. These types of facilities can generally be grouped into the four categories described below. Examples of these priority treatments are depicted in Figure 1.



Exclusive HOV Facility on Separate Right of Way Ottawa, Canada

Exclusive HOV Facility in Freeway Right-of-Way, Houston, Texas, Katy Freeway



Concurrent Flow Lane, I-5, Seattle, Washington

Contraflow Lane, Gowanus Expressway, New York City

Figure 1. Examples of High-Occupancy Vehicle (HOV) Facilities

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Exclusive HOV Facility, Separate Right-of-Way. A roadway or lane developed in a separate right-of-way and designated for exclusive use by high-occupancy vehicles. Existing facilities of this type are used by buses only. Most are two-lane, two-direction roadways. Examples of this type of HOV treatment are the South and East Busways in Pittsburgh.

Exclusive HOV Facility, Freeway Right-of-Way. A lane(s) constructed within the freeway right-of-way that is physically separated from the general-purpose freeway lanes and used exclusively by HOVs for all, or a portion of, the day. Most exclusive HOV facilities are physically separated from the general-purpose freeway lanes through the use of a concrete barrier. Examples of this type of HOV treatment include the Houston transitways and the Shirley Highway HOV lanes in the northern Virginia/Washington, D.C. area. However, a few exclusive facilities are separated from the general-purpose lanes by a wide pavement area painted to serve as a buffer. An example of this type of treatment is the I-84 HOV lanes in Hartford, Connecticut; these priority lanes utilize a 15-foot wide painted pavement area to separate the HOV and mixed-traffic lanes. Exclusive facilities, whether barrier- or buffer-separated, are usually open to buses, vanpools, and carpools.

Concurrent Flow Lane. A freeway lane in the peak direction of travel, not physically separated from the general-purpose traffic lanes, and designated for the exclusive use by HOVs for all, or a portion of, the day. Concurrent flow lanes are usually, although not always, located on the lane or shoulder nearest to the median. Paint striping, pavement markings, and signing are common means used to delineate these lanes. Examples of concurrent flow HOV lanes are SR 520, I-5 and I-405 in Seattle, Route 55 in Orange County, and Route 101 in San Jose, California. HOV facilities of this type are usually open to buses, vanpools, and carpools.

Contraflow Lane. A freeway lane in the off-peak direction of travel, commonly the lane closest to the median, designated for exclusive use by HOVs traveling in the peak direction. The lane is typically separated from the off-peak direction, general-purpose travel lanes by some type of changeable treatment, such as plastic posts or pylons that are inserted into holes drilled in the pavement. Contraflow lanes are usually operated during the peak-periods only and revert back to normal use in non-peak periods. Examples of this type of facility include the approach to the Lincoln Tunnel on Route 495, the Long Island Expressway, and the Gowanus Expressway; all of these are located in the New York/New Jersey area. Due to safety concerns, these types of facilities are often used only by buses, although in some instances taxi drivers and trained vanpool drivers have been allowed to use contraflow lanes.

Extent of HOV Development in the United States

The extent of current and planned HOV development in the United States is overviewed in this section.

History of HOV Development

Interest in priority high-occupancy vehicle facilities is relatively recent. The first major HOV project on a U.S. freeway was implemented in 1969 on the Shirley Highway (I-395) in Northern Virginia. A second major project was opened in 1973 on the San Bernardino Freeway (I-10) in Los Angeles.

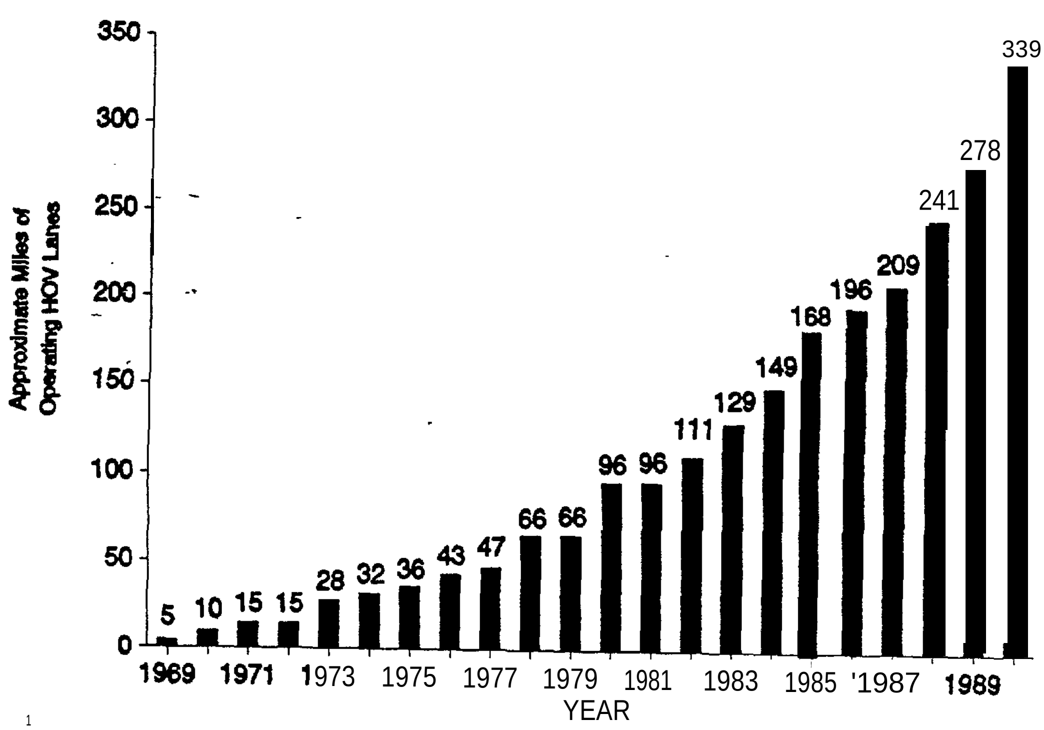
By the early to mid-1970s, these two projects had demonstrated the potential effectiveness of the freeway HOV concept. Both projects showed that a single HOV lane could move 6,000 to 10,000 persons in an hour, and thus established that HOV facilities could offer a moderate cost approach for nearly doubling the number of persons moved in the peak direction during the peak hour on a freeway. It became apparent that, in at least some highly-congested corridors, the HOV concept worked.

Figure 2 shows historical trends in the number of miles of operating HOV facilities in the United States. Interest in the HOV concept developed gradually during the 1970s. However, as urban transportation problems intensified and as successful HOV projects began to illustrate the potential of these improvements, interest in the HOV concept increased markedly in the 1980s. Many U.S. cities now operate HOV lanes on the urban freeway system, and more cities are looking seriously at developing priority HOV facilities.

Current and Future Status of HOV Development[1]

Over 20 urban areas in the U.S. are either operating HOV lanes or are in the process of actively developing this type of priority facility (Figure 3). Many different types of HOV projects have been implemented; Table A-l in the appendix provides a more detailed description of the various projects in cities in this,country.

[1] A detailed survey of current HOV projects in North America is included in Reference 8.



[1] Data shown are for continuously operating HOV lanes located either on freeways or in separate rights-of-way In the U.S. Mileage is not shown for HOV lanes that have been discontinued.

Figure 2. Miles of Operating HOV Lanes[1]

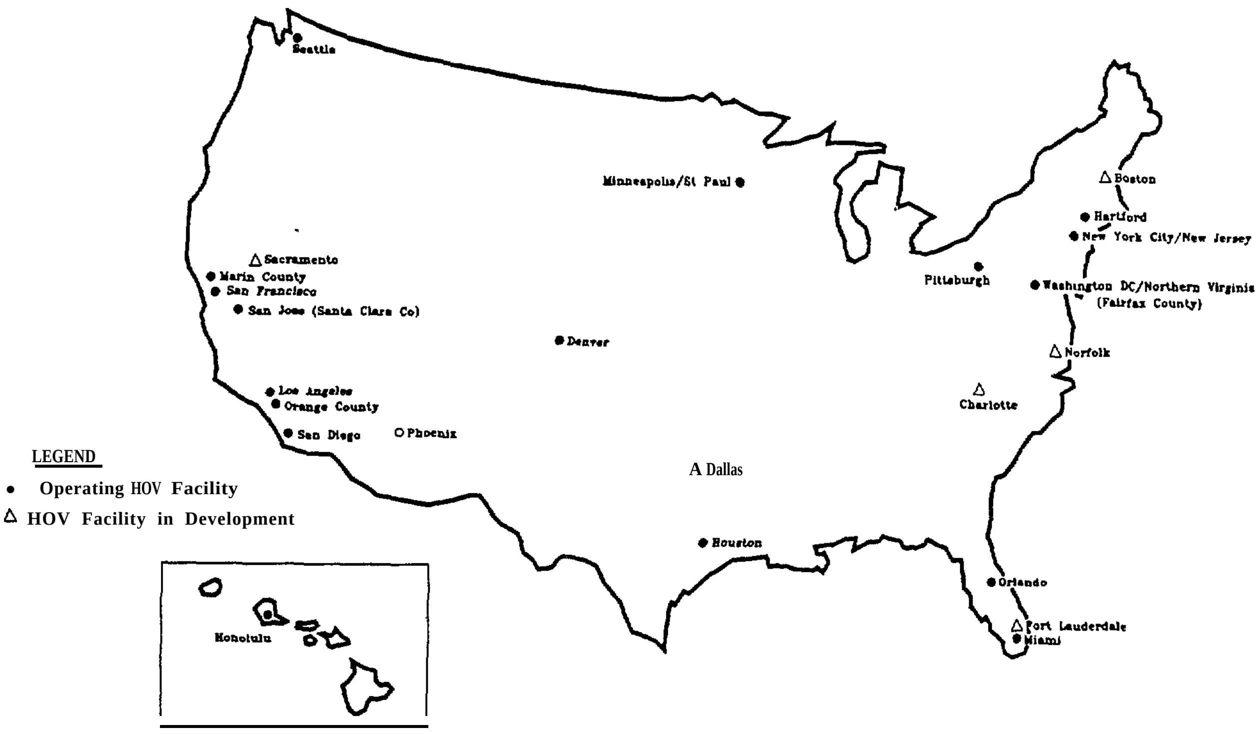


Figure 3. U.S. Urban Areas *Where* HOV Facilities Are Currently in Operation or Being Develop

Six urban areas -- Seattle; Los Angeles; Santa Clara County, California; Orange County, California; Fairfax County, Virginia; and Houston -- are committed to developing an extensive system of freeway HOV facilities. Each of these locations has experienced success with initial freeway HOV lane projects, and, based on that success; is firmly committed to using HOV facility systems as a means of helping to satisfactorily serve the growth in freeway travel demand. The fact that these areas tested the HOV concept, found it attractive, and decided to aggressively pursue additional HOV lane development is significant.

Approximately 340 miles of HOV facilities are now in operation in the United States. In addition, a number of new HOV projects are in the planning, design, or construction stage (Figure 4). If these projects all become operational, operating HOV lane mileage will increase by another 150%, to 850 miles by the year 2000. Further, based on several assumptions, a "ballpark" estimate suggests that, by the year 2010, as many as 1500 miles may be in operation. That is roughly five times the number of miles operating today.

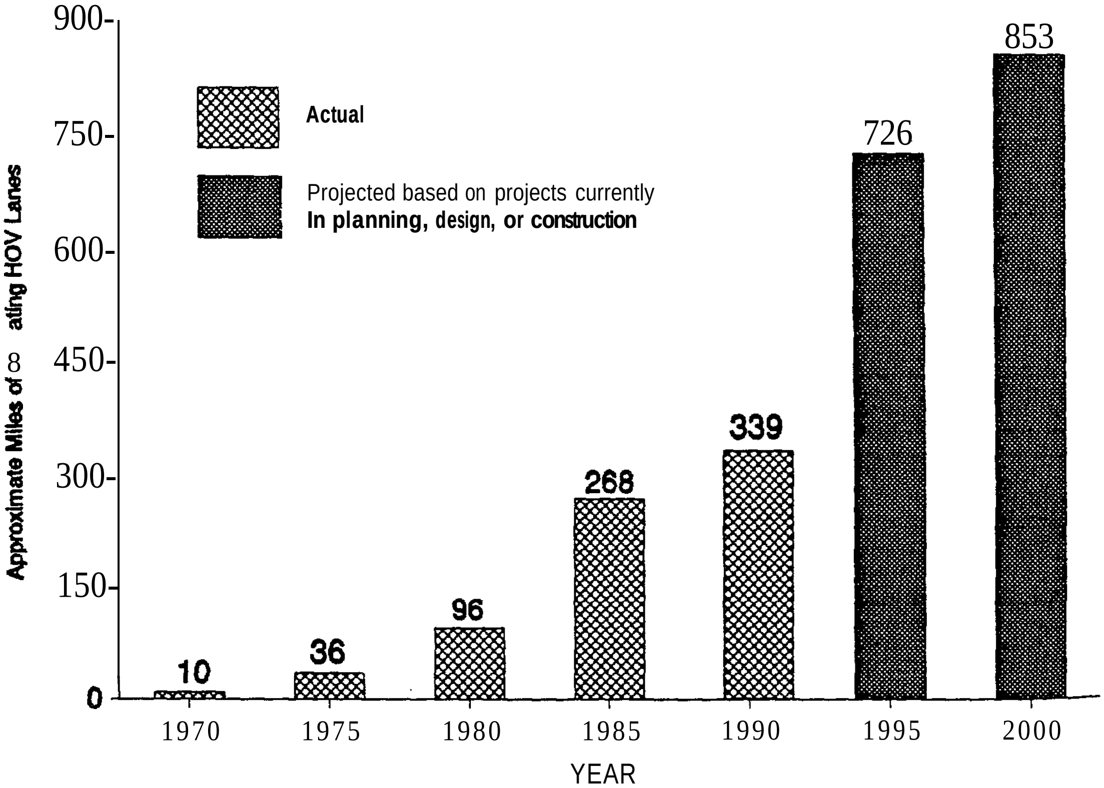


Figure 4. Projected Miles of Operating HOV Lanes
in the United States

The extent of HOV lane development is becoming impressive. While rail transit projects receive more publicity than do high-occupancy vehicle projects, it is of interest to note that the miles of operating HOV facilities are generally comparable to the miles of operating rail transit facilities in the United States (Table 1). And it is apparent that, if the currently planned HOV improvements are built, by the turn of the century there will be more miles of HOV facilities operating in this country than there will be miles of urban rail transit (not including New York City). Thus, HOV facilities are probably already a bigger player in the urban mobility picture than is commonly thought.

Table 1. Estimated Miles of Fixed-Guideway Facility in the United States

Type of Guideway Facility	Miles
High-Occupancy Vehicle Lanes, 1990	340
Light Rail Transit, 1987	270
Heavy Rail Transit (not incl. NYC)	400

Sources: References 8, 9. and 10.

Estimated Capital Expenditures on HOV Projects

It is difficult to determine the precise capital expenditure that has been made in the development of HOV projects. However, an estimate suggests that the capital investment in HOV lanes in this country is presently in excess of $1.5 billion (1988 dollars). If an additional 500 miles of HOV lane are built in the U.S. by the year 2000, roughly $3 billion (1988 dollars) will be spent on HOV lanes during the decade of the 1990s.

A variety of different funding sources have been used to develop HOV facilities. Federal, state, and local highway and transit monies have been used to implement projects, and often various combinations of funding sources are used. Of the 36 HOV projects that have recently provided information on funding sources (8): the Federal Highway Administration participated in 80% of the projects; the Urban Mass Transportation Administration participated in 17% of the projects; state transportation funds were used in 86% of the projects; and other agencies participated in 36% of the projects. An array of different funding sources can be used to implement HOV projects.

Reasons for Developing HOV Projects

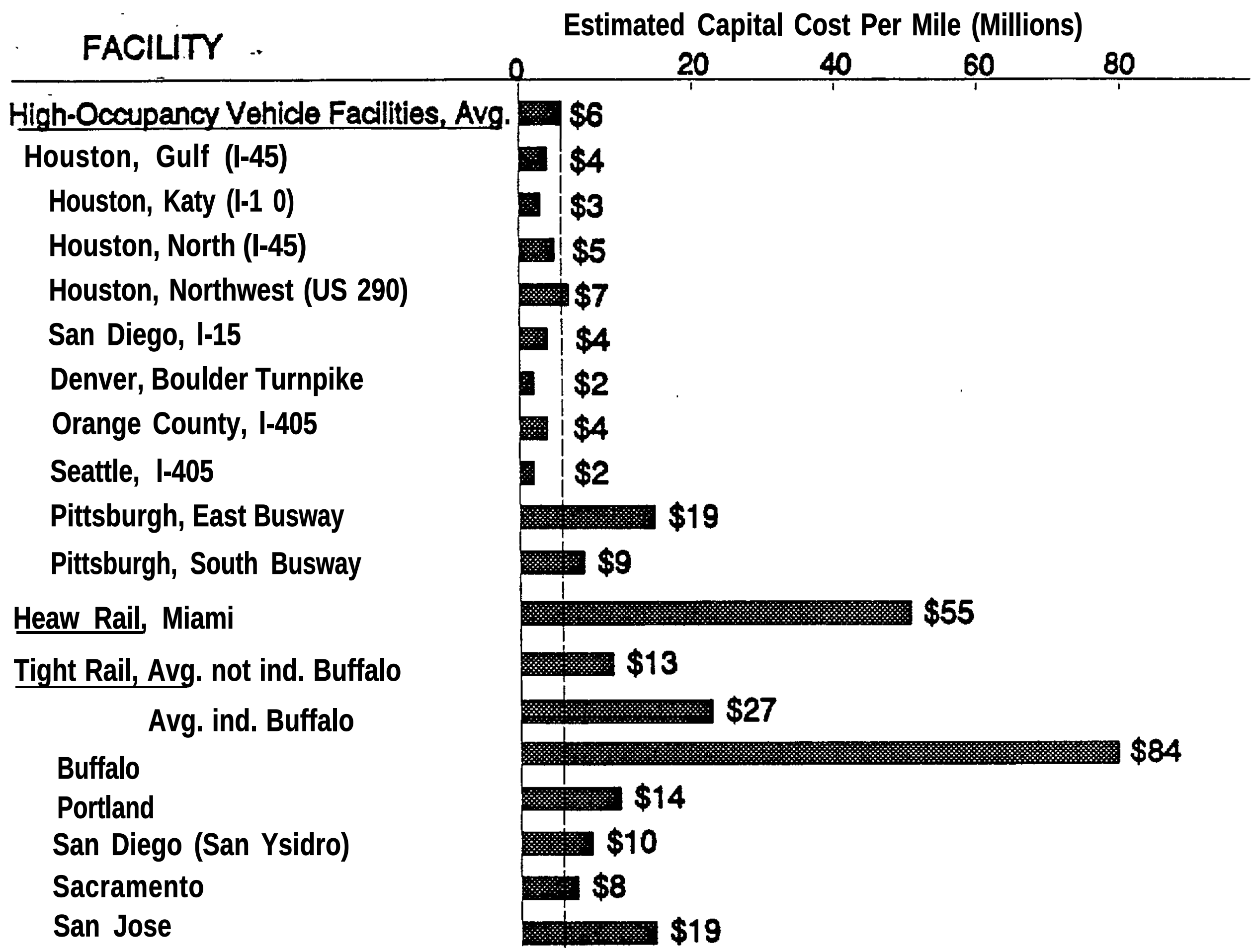
While HOV applications are not appropriate in all corridors, HOV lanes offer a number of advantages. This section documents some of the benefits that can be associated with HOV projects, and helps to illustrate the reasons why more urban areas are seriously considering implementing this type of project.

Capital Costs

In terms of capital cost, HOV projects typically have at least two advantages. First, as noted previously, a variety of different funding sources can be used.

Also, compared to other fixed-guideway projects, HOV facilities are relatively inexpensive. In an era of limited funding, this is a major reason for interest in the HOV concept. Comparing capital costs, both between HOV projects and between HOV and other fixed-guideway projects, is difficult. Project costs tend to be site specific, and, in analyzing projects, it is difficult to be sure that the capital cost values being used are made up of comparable components. There are examples of HOV projects that cost as much or more than many rail projects, and there have been rail projects implemented that were relatively inexpensive. However, just as it is possible to conclude that arterial street projects are typically less costly than freeway projects, it can also be concluded that HOV projects are, in general, much less costly than rail projects. Building HOV facilities in existing freeway rights-of-way and/or in conjunction with other freeway projects often lowers the cost of these improvements. The data in Figure 5 provide an indication of the general magnitude of capital costs associated with fixed-guideway projects; HOV projects tend to fall at the low end of the cost scale. And many HOV projects have been built for costs even lower than those shown. For example, the Route 55 Commuter Lanes in Orange County, California, were implemented for less than

$40,000 per mile, and the New Jersey Route 495 contraflow lane on the approach to New York City cost less than $700,000 per mile.



Note: All costs in 1986 to 1988 Dollars
References: Texas Transportation Institute, 8 and 11.

Figure 5. General Magnitude of Capital Costs Associated With Fixed-Guideway Projects

Implementation Time and Staging

The development of HOV facilities has at least two advantages relative to implementation time and scheduling. First, implementing HOV facilities in freeway rights-of-way and/or building these projects in conjunction with scheduled freeway improvements can significantly reduce the time required to bring about operational HOV projects. While the exact timing depends on the nature of the project being pursued and the site, many major HOV lane projects have been planned, designed, and constructed within a 3- to 8-year time period.

Second, since the vehicles that use HOV facilities can operate on the regular street and highway system, staged construction of HOV facilities can be effectively pursued. Individual project segments can be opened and operated prior to completion of an entire project.

Lower **Risk and Flexibility**

The flexibility of HOV projects lowers the risk associated with these projects. Potential advantages can be grouped into four general categories.

Lower Risk. If an HOV facility proves to be unsuccessful, it can be converted to other useful highway-related functions, such as additional mixed-flow lanes or emergency shoulders. The capital investment is lower than that required for rail, and it generally can be largely salvaged if the HOV project does not prove to be a success.

HOV Lanes Can Serve Different Functions. HOV lanes serve a range of functions, and these functions can change over time as necessary. In some areas, such as San Diego, a single HOV lane operates in one freeway corridor. Other areas, such as Orange County, California, are developing an extensive system of interconnected HOV lanes on several different freeways; this represents an evolution from a single facility in one corridor to an HOV system. In other locations, such as the Shirley Highway in northern Virginia, buses operating on the HOV lane feed a rail transit system. Again, this role has evolved, as the HOV project was implemented many years before Metro Rail; after Metro Rail opened, the HOV lane buses began feeding the rail as a means of better using available rail capacity and keeping buses off the downtown streets. In Seattle, plans have been made to allow the downtown bus tunnel to be converted to light rail transit in the future.

Collection and Distribution Can Use Existing Roadways. Buses, carpools and vanpools use the existing street system for the collection and distribution portion of the trip. This provides flexibility in service orientation, especially in matching the service provided to changing travel patterns. When appropriate, park-and-ride and other support facilities are located remote from the HOV facility on less expensive land.

Hours of HOV Operation Can be Altered. Due to the nature of the design used to implement many HOV facilities, and since HOV facilities offer most of their benefits during peak periods, the pavement space devoted to HOV can serve other purposes during certain times of day. Particularly on concurrent flow and contraflow projects, the lane used by priority vehicles during peak periods can, if desired, be used for other purposes (such as emergency shoulders or extra- general-purpose freeway lanes) during non peak-period operation.

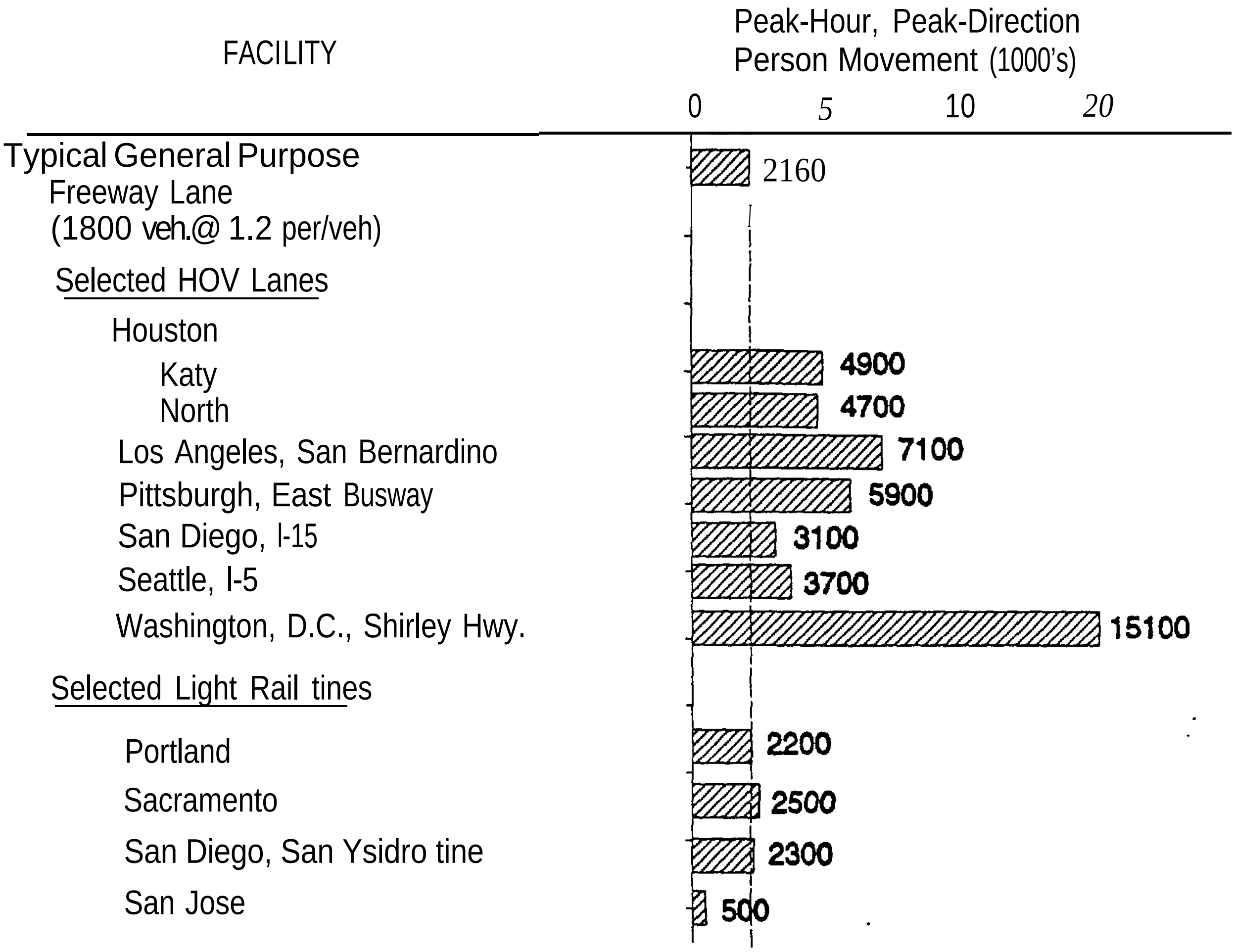
Move People, Preserve Capacity. and Increase the Number of Persons Per Vehicle

HOV facilities are intended to increase the person-movement capability of roadways, particularly during congested peak-travel conditions. This is accomplished through increasing the average number of persons per vehicle by attracting more persons to transit and car-pooling. This section presents data relating to person movement on HOV facilities.

Capacity, A Function of Operating Rules. The number of persons moved on an HOV facility depends on the demand that exists which, in turn, helps determine the mix of vehicles allowed to use the lane(s). At the upper end, the New Jersey Route 495 approach to the Lincoln Tunnel, which is used only by buses, moves 35,000 persons in the peak hour, peak direction (6), The Shirley Highway HOV lanes in the Washington, D.C. area have shown that, when vehicles' in the HOV lanes must have 4 or more persons, the person volume served in an HOV lane is in the range of 10,000 persons in the peak hour, peak direction. The San Bernardino HOV lane in the Los Angeles area accommodates about 7,000 persons in the peak hour, peak direction, and its use is restricted to vehicles with 3 or more persons. In Houston, where vehicles with 2 or more persons are allowed on the transitways, between 4,000 and 5,000 persons are moved in the peak hour.

The operating strategy associated with HOV lanes is to always assure that a high and reliable speed is offered by the HOV lane. A means of accomplishing this is to increase the occupancy requirements as necessary. For example, an HOV facility might open allowing use by carpools with two or more (2+) persons. As the vehicular carpool volume begins to approach the vehicular lane capacity, the requirements to use the HOV facility would be increased to 3+ carpools. The ability to do this has been demonstrated on the Katy Transitway in Houston. This approach assures that the person-movement integrity of the overall roadway can be assured in the future through effective application and operation of HOV facilities. This is a major **reason** why a new roadway lane would be designated as an HOV lane rather than as a general-purpose lane.

Ridership on HOV Lanes. HOV lanes are primarily intended to help serve travel demands during congested peak periods. During those times, HOV lanes typically move at least two to three times as many persons as does a general-purpose freeway lane. HOV projects also serve more peak-hour, peak-direction travel than do recently developed U.S. light rail transit lines (Figure 6). HOV lanes move these people at much faster speeds than either general-purpose freeway lanes or rail transit.



Source: Texas Transportation Institute, Respective Transit Properties, and 8.

Figure 6. Peak-Hour, Peak-Direction Person Volumes Served by Alternative Transportation Improvements

Increase the Number of Persons Per Vehicle. For HOV facilities to be successful, they must attract new riders to buses and carpools. Data showing actual changes in bus ridership and carpooling following HOV lane implementation are presented subsequently. As increases in transit ridership and carpooling occur, average vehicle occupancy also increases. Table 2 shows the types of peak-hour, peak-direction vehicle occupancies (persons per vehicle) that exist on selected freeways that have HOV lanes; these peak-hour occupancies are considerably greater than what might be expected to exist if the HOV lane had not been implemented.

Table 2. Average Vehicle Occupancies on Freeways with and without HOV Facilities, Peak-Hour, Peak-Direction

Freeway	Average Vehicle Occupancy' (persons per vehicle)
Typical U.S. Freeway Without HOV	1.15 to 1.25
Selected U.S. Freeways With an HOV Facility, Average	1.73
Houston, Katy Freeway	1.51
Houston, North Freeway	1.54
Los Angeles, San Bernardino Freeway	1.70
Seattle, I-5	1.60
Washington, D.C., Shirley Highway	2.28

'This is the total person volume (freeway plus HOV) divided by the total vehicle volume (freeway plus HOV)

Source: Reference 8 and Texas Transportation Institute.

Bus Use of HOV Lanes

Bus transit use is allowed on all HOV facilities. Offering high-speed and reliable travel times to buses on HOV facilities creates a variety of benefits for transit operators and patrons.

Impacts on Bus Transit Operating Costs. By allowing buses to operate at faster and more predictable speeds, bus productivity increases, thereby reducing operating costs. The evaluation (14) of the Shirley Highway HOV facility in Washington, D.C. noted that the utilization of vehicles and labor improved on the routes that used the busway. An analysis (16) of the East Busway in Pittsburgh found that bus routes using the busway had lower costs per passenger trip and per passenger mile than did other routes. While the aggregate operating cost data necessary to compare HOV projects with light rail are not good, analyses in Pittsburgh (11) have led to a general belief in that city that bus transit operating costs on the busway are not higher than light rail costs, and may well be lower. Similar conclusions were drawn in Ottawa, Canada (17).

Ridership Increases. Providing buses with a travel speed advantage and a reliable travel time generates more bus riders. Following the opening of the Shirley Highway Busway, the bus market share in the corridor approaching the District increased from 27 % to 40 % ; patronage on express buses during the a.m. peak period increased from 4200 in June 1969 to 16,100 in November 1974 (12.) Similarly, on the San Bernardino Busway in Los Angeles, a.m. peak-period bus ridership increased from about 1000 passengers to about 11,000 passengers during the first 29 months of operation (13). In Santa Clara County, California, ridership on the express routes using the HOV lanes increased 46% following the opening of those lanes (18); ridership dropped 26% on other routes during the same time period. In Houston (12), in comparing pre-transitway conditions to current conditions, peak-hour bus ridership has typically increased by more than 200%; in corridors not having transitways, bus ridership has remained largely unchanged. Clearly, proper application of HOV lanes can increase bus ridership.

A New Type of Bus Rider. Persons choosing to ride buses on HOV facilities tend to be young, educated, white-collar professionals. They are generally choice riders; that is, they have an auto available for the trip- but choose to ride a bus. In some urban areas, this represents significant transit penetration into new markets. Also, surveys (Table 3) suggest that the bus service is successful both in attracting riders from single-occupant autos and in serving new trips, many of which would otherwise have been made by single-occupant autos.

Table 3. Previous Mode of Travel for Bus Riders Using HOV Facilities

Previous Mode	HOV Project		
	Houston		Los Angeles San Bernardino
	Katy	North	
Drove Alone	37%	35%	50%
Carpooled or Vanpooled	17%	17%	24%
Rode a Bus	20%	22%	10%
New Trip	29%	26%	12%
Other		—	4%

Source: Reference 12, 13,

Schedule Adherence, Safety, and Other Operating Improvements. HOV lanes provide improvements in bus operating speeds and schedule adherence. For example, prior to opening the Shirley Busway, 33% of express buses arrived on time at their first stop in the District; after the Busway opened, 92% of buses arrived on time (14). Bus drivers in Pittsburgh have noted they prefer operating buses on the busways (15). Declines in bus accident rates were found in both Pittsburgh (15) and Houston (12), where the accident rates on the HOV facilities are roughly two-thirds those that are experienced on the general-purpose mainlanes. Since buses can use the existing street systems for collection and distribution, the need for transfers is also minimized.

Carpool Use of HOV Lanes

In addition to serving bus trips at high speeds, carpools and vanpools are also users of most HOV facilities; in fact, on the HOV facilities that allow carpool use, generally more than 60% of the total HOV person trips are in carpools (Table 4).

Table 4. Percent of HOV Person Trips in Carpools rnd Vanpools

HOV Project	Percent of Peak-Hour HOV Person Trips in Carpools and Vanpools
Houston, Katy Transitway	59%
Houston, Gulf Tnnsihvay	66%
Los Angeles, San Bernardino Busway	61%
Minneapolis. I-394	67%
San Diego, I-l5	88%
San Francisco, Oakland Bay Bridge	70%
Seattle, I-5	30%
Washington D.C., I-395	63%

Source: Reference 8, 12.

Carpool use of HOV lanes offers advantages. Allowing carpools to use HOV lanes requires only a marginal expenditure of funds (additional signing, enforcement, etc.). As a result, it is a means of greatly increasing facility usage at a very small cost and lowering public operating cost per passenger. Carpools can be formed to serve trips that originate and/or terminate where bus transit service is either not available or not convenient. Also of considerable importance is the ability of carpools to serve trip patterns, particularly suburb-to-suburb, that are often difficult to serve with conventional, fixed-route transit. Data from the Katy Transitway corridor in Houston show that, in comparing conditions before the transitway was implemented to current conditions, the volume of carpools destined to the major suburban activity centers increased by 260% (12).

Encouraging formation of new carpools is one intent of the HOV lane, and data suggest this has taken place. During the first year that carpools were allowed on the San Bernardino Busway in Los Angeles, a 157% increase in a.m. peak-period carpools occurred (13). Houston has also seen large increases in carpooling as a result of the transitways (l2). The volume of 2+ carpools in the peak hour has increased by between 100% and 225% on the freeways with transitways; the corresponding carpool volumes on freeways without transitways have actually declined by 13 % . The Houston data suggest that, of those persons now carpooling on the HOV lanes, 45% previously drove alone. Clearly, when properly implemented, HOV facilities provide an incentive that encourages more people to carpool.

Air Quality Impacts

The significance of urban air quality problems has been referred to in an earlier section. The new federal Clean Air Act will require more than 100 cities currently not meeting federal air quality standards to develop pollution control strategies to bring these areas into compliance within 17 years.

Increasing the average number of persons per vehicle in order to at least curtail growth in vehicle-miles of travel will be pursued in many urban areas (19). Since successful HOV projects generate more carpoolers and bus riders, they can be an effective means for increasing the number of persons per vehicle.

As an example of the impact this can have on roadway emissions, early studies (13) of the San Bernardino Busway estimated that the busway resulted in about a 5 % reduction in carbon monoxide (CO) emissions and a 15% reduction in hydrocarbon (HC) emissions. In Houston (12), quantitative analyses have been undertaken to estimate the effectiveness of HOV facilities in improving air quality. Using the existing demand on both the Katy (I-10) Freeway and Transitway, computer simulation was used to compare the following alternatives: 1) existing condition, 3 directional general-purpose lane plus one transitway lane, which depicts the condition that existed after the reversible HOV lane was added to the freeway; 2) four directional general-purpose lanes, which depicts the condition that would have existed had the additional lane been added as a general-purpose lane rather than as an HOV lane; and 3) three directional general-purpose lanes, which depicts the condition that would exist had no lane additions been added to the freeway (do nothing alternative). At today's level of usage, the alternative that includes an HOV lane is providing meaningful air quality benefits (Figure 7). These findings will become more impressive in future years as demand increases, since the HOV alternative still has capacity to serve more person movement, while the alternatives that provide general-purpose freeway lanes have no unused capacity.

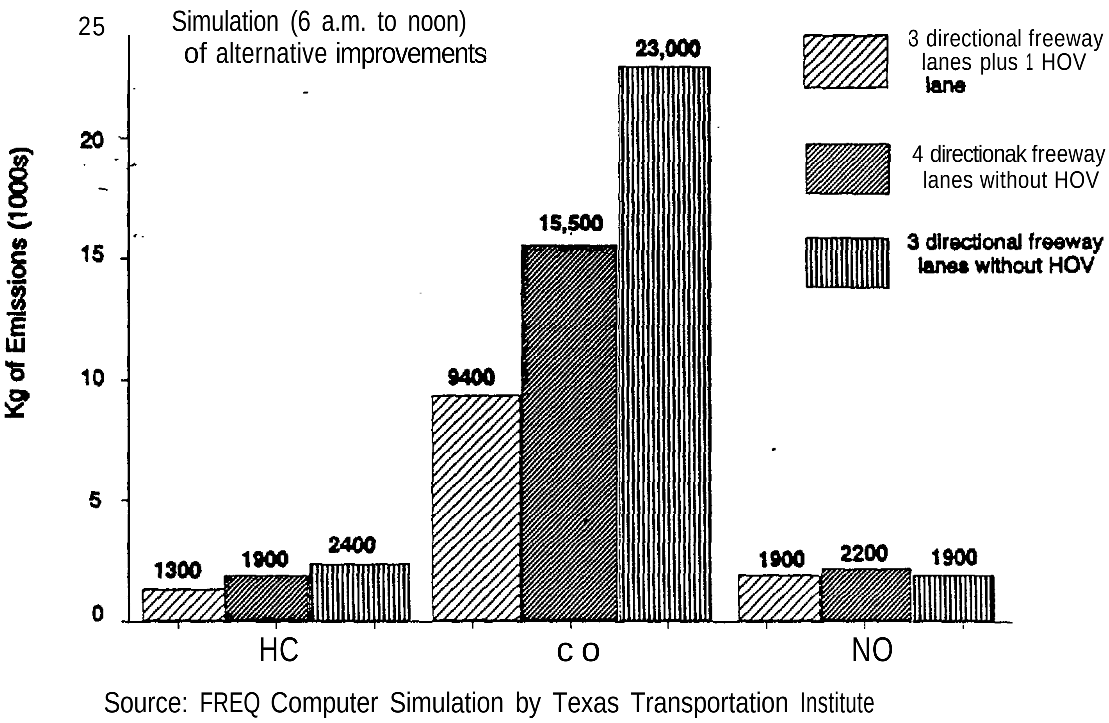
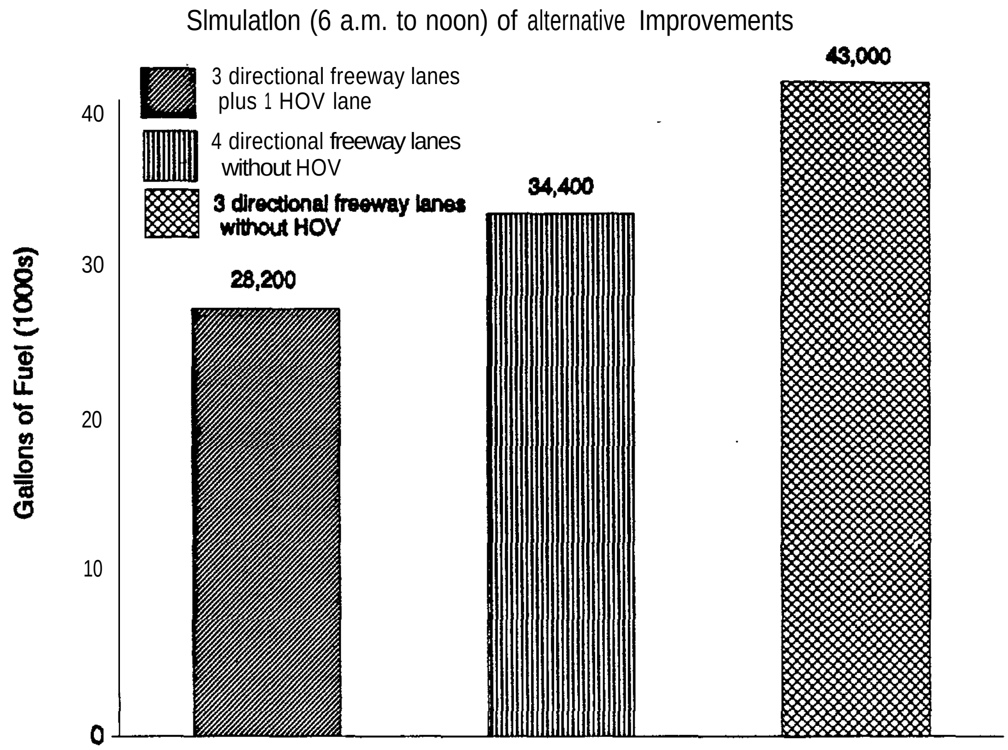


Figure 7. Estimated Impact of HOV Improvements on Air Quality, Katy Freeway (I-10) and Transitway, Houston

Energy Impacts

As the average number of persons per vehicle increases, vehicle-miles of travel decrease and so does fuel consumption. A 1975 analysis (13) of the San Bernardino Busway in Los Angeles estimated that this HOV lane lowered gasoline consumption by 5400 to 6500 gallons per day. In 1973, the Shirley Highway HOV project was estimated (14) to result in a savings of roughly 7400 gallons of gasoline each day. The same analysis that was discussed in the "Air Quality" section was also performed to help quantify the impacts an HOV lane can have on energy consumption (Figure 8). Again, the findings indicate that, at today's level of usage, the alternative that includes an HOV lane is resulting in significant reductions in energy consumption relative to alternatives that provide only general-purpose freeway lanes.



Source: FREQ Computer Simulatlon by Texas Transportation Institute

Figure 8. Estimated Impact of HOV Improvements on Energy Consumption, Katy Freeway (I-10) and Transitway, Houston

Compatibility With the IVHS Program

A major Intelligent Vehicle and Highway System (IVHS) program is now being pursued by both the Federal Highway Administration and the Urban Mass Transportation Administration. The general purpose of this program is to use the transportation infrastructure more efficiently through the implementation of new technologies and state-of-the-art practices (20).

It appears that HOV facilities are complementary to, and compatible with, the IVHS program in both the short-run and the longer-run. Examples of coordination between HOV facilities and the emerging IVHS program already exist. During off-peak periods, the California

Department of Transportation is utilizing the I-15 HOV facility in San Diego to test a variety of IVHS vehicle guidance technologies. The controlled nature of many HOV facilities will make them logical candidates for the future testing of vehicle control and navigation systems. In addition, it is becoming apparent that HOV projects can be an integral part of short-run IVHS programs. Houston is currently developing a project that will provide the commuter with in-home; real-time information related to HOV travel time advantages as well as current information on how to use the bus system; the intent is to use IVHS technology as a means of increasing use of HOV facilities.

Inclusion in National Transportation Policy

The information in this *Paper* helps to explain why more consideration continues to be given to developing high-occupancy vehicle facility systems. The role of HOV facilities was further recognized as part of the formulation of the recent National Transportation Policy (2l). In more than one instance, that policy, as noted below, explicitly points out the need for developing HOV facilities.

- "Americans recognize the values of the investment the Nation has made in transportation facilities and vehicles, and the importance of getting the most from that investment before spending to create new capacity. Throughout America, people have ideas for ways their communities, transportation operators, and transportation users could get better use of the existing transportation system -- for example, by using suburban shopping center lots for park-and-ride commuting, adopting flexible work hour schedules, synchronizing traffic signals for more efficient traffic flow, improving transit schedules and encouraging greater transit ridership, giving preference to high-occupancy vehicles in highway and air transportation . . . " (pg. 23).

- "To use the Nation's resources most effectively, we must take better advantage of our transportation infrastructure and services ... **A** number of techniques already available can enhance the ability of those facilities to meet transportation demand. We can make significant progress in utilization of our transportation system by increasing use of higher occupancy vehicles and modes. " (pg. 46).

Public [redacted]ent

High-occupancy vehicle improvements, by their nature, impose restrictions on how the roadway system can be used. A special lane(s) has been developed on which not everyone is able to drive. For this reason alone, HOV facilities will generate some questions from the public, and this should be expected. Specific criticism of priority HOV facilities tends to address two related areas. First, the HOV lane may be perceived to be underutilized; the relatively low vehicular volume using HOV lanes leads to a perception by some that the priority lane is not well used. Second, a feeling may exist that the overall roadway facility would operate better if all traffic were allowed to use the HOV lane; that is, the lane added to the freeway should have been designated as a general-purpose lane rather than as a restricted HOV lane. It should be noted that other types of transportation improvements that place restrictions on how the roadway is used, such as freeway ramp metering, also generate this kind of public scrutiny.

Nevertheless, HOV lanes appear to have gained support in many parts of the country. The fact that so many areas are either operating or developing these projects suggests that support for HOV projects exists at the policy level where these decisions are being made. Also, many areas that have HOV lanes have chosen to build additional facilities of this type. Perhaps the quote (22) below, from a speech by the mayor of the City of Tustin, California, who is also a member of the Orange County Transportation Commission and the Orange County Transit Board, reflects an attitude that is developing in the United States concerning HOV lanes.

> "As someone who has been involved in many levels of government for many years, I am impressed at the degree of institutional cooperation our transitway program has achieved. The concept is consistent with UMTA's, FHWA's, and the Southern California Association of Governments' policies. It is being designed and built jointly with Caltrans. The impacted cities are heavily involved in terms of specific design features, and the Orange County Transportation Commission has given its policy approval at each major milestone."

Similar observations (23) were recently made by a Washington State legislator who noted that the Seattle HOV-lanes "are an innovative, energy efficient, and environmentally sound way of maximizing the capacity of freeways."

Perhaps of equal interest is that the general public in those areas where HOV facilities are being operated is also expressing support for HOV development. A survey (24) conducted in Seattle found that over 85% percent of the citizens approved of the HOV concept. A Los Angeles study (13) noted that two-thirds of the freeway users surveyed felt the San Bernardino Busway was a good use of the taxpayers' money, Freeway motorists (individuals not using the HOV lanes) in Houston (12), when asked if the transitways were good transportation improvements, responded: yes, 67%; no, 18%; not sure, 15 %. A survey (18) of single-occupant auto drivers in Santa Clara County, California, found that 89% of the respondents were aware of the HOV lane network, and 83% of those aware of the network viewed it favorably. All surveys addressing support for HOV facilities are yielding similar results.

Considerations to Enhance HOV Project Success

Although freeway HOV projects have existed in this country for only about two decades, sufficient experience with these facilities now exists to better understand their applicability and operations. This section briefly highlights some of the lessons learned through operation of HOV facilities.

Conditions Necessary to Make HOV an Attractive Alternative

Experience from across the country suggests that the following conditions should exist before serious consideration is given to a high-occupancy vehicle lane alternative. If all the conditions listed below are met, an HOV lane alternative warrants consideration.

General Support Should Exist from the Agencies Involved and the Public.

Intense, Recurring Congestion Must Exist on the Freeway General-Purpose Mainlanes HOV projects are congestion dependent. Unless severe congestion exists daily on the freeway. HOV lanes are probably not a viable alternative.

The Travel Patterns on the Freeway Should be Conducive to Being Serviced by Rideshare – Either Bus or Carpool.

The HOV Lane Design Should Allow for Safe, Efficient, and Enforceable Operation.

Other Considerations that Enhance HOV Success

When a decision is made to pursue HOV as an alternative, recognition of the following may assist in project development and implementation.

HOV Lanes Should be Implemented as New Lanes. Conceptually, an HOV lane can be created either by adding a new lane to a facility, which is then designated as an HOV lane (add a-lane approach), or by taking a lane away from general-purpose traffic and designating it as an HOV lane (take-a-lane approach). Experience indicates that the "take-a-lane" approach can be highly controversial. The best example of difficulties with the take-a-lane approach occurred on the Santa Monica Freeway in Los Angeles in 1976. The controversy that project generated caused it to be terminated and significantly set back other HOV development in the Los Angeles area. All HOV projects implemented since the Santa Monica project have been "add-a-lane" projects.

HOV Lanes Involve a System of Improvements. In addition to providing an exclusive lane for use by high-occupancy vehicles, successful implementation of an HOV project generally involves providing a system of improvements. Some of these complementary system improvements involve construction of physical facilities, such as park-and-ride lots, bus transfer centers, and HOV bypass ramps. Other actions do not necessarily require provision of physical facilities but can be equally important; included in this category are carpool and vanpool programs, new bus service, marketing and public relations, parking policies, and implementation of supportive transportation demand management strategies. The success and acceptance of an HOV project can be highly dependent on pursuing the appropriate package of complementary actions and strategies. Simply constructing or designating a roadway lane as a priority HOV lane does not assure project success.

HOV Projects Often Involve Multiple Agencies. Many HOV projects are constructed within highway rights-of-way. However, these facilities are often used by transit buses, and transit agencies are frequently responsible for providing some of the support facilities and services that are needed to maximize HOV lane effectiveness. Other agencies, such as those that offer enforcement support, are also needed to make a project work. Decisions have to be made regarding agency participation for funding of capital and operating costs. In planning for project implementation, responsibilities for enforcement, operations, and maintenance need to be established. Still other agencies may be involved in marketing and promotion of the project, and other agencies may set parking policies. Consequently, HOV projects are neither pure "highway" projects nor pure "transit" projects. A higher than normal level of agency cooperation is required in the planning, design, construction, operation, and enforcement of HOV projects.

Limitations Associated With the HOV Alternative

All transportation improvements have strengths and weaknesses. In considering the high-occupancy vehicle alternative, the following should be realized.

Image Value. Unlike some rail transit projects, HOV lanes are not commonly associated with a "world class" city. HOV projects do not have the same positive image value that rail projects can have.

Land Development Impacts. If higher density land development is desired, rail transit, when combined with necessary complementary policies, can result in development tending to concentrate near stations. HOV lanes in the U.S. have not had as much of an impact on land development patterns.

Public Response. It has been established that general public support for HOV lanes exists. However, since these priority lanes place restrictions on how a roadway can be used, some questioning by segments of the public is to be expected.

Congestion Associated with Collection and Distribution. HOV projects may result in large volumes of buses operating on streets in major activity centers. The extent to which this is a problem will vary between cities. When it is a significant problem, the solution (e.g., Seattle downtown bus tunnel) can be expensive.

Trips Served. HOV projects are generally most effective at serving relatively long commute trips that occur during peak periods. Rail projects tend to better serve short trips and trips that occur during off-peak periods. However, some types of HOV facilities, such as the Pittsburgh busways, offer service that closely replicates rail transit.

Ongoing Operation and Enforcement. While experience has shown that operating and enforcing properly designed HOV facilities is manageable, it is nonetheless a concern that requires ongoing attention and resources once an HOV facility opens. Houston, which provides a relatively high level of operations support and enforcement, expends approximately $250,000 per year per transitway for enforcement and operations.

Conclusions Regarding the Role of HOV Projects

A wide range of transportation improvements are being pursued in this country. While not an appropriate improvement in all corridors, high-occupancy vehicle system projects play an effective role in addressing problems associated with urban mobility and congestion; these HOV projects are often a means of helping to make the best use of the limited available transportation rights-of-way, and proper operation of HOV facilities assures that capacity is available into the future to move people.

Sufficient experience in developing and operating HOV facilities exists to understand when these priority facilities should be built, and how well they will perform. Based on this experience, the following observations help define why HOV projects will continue to be looked to as an important alternative in many urban corridors.

1. High-occupancy vehicle lanes move large numbers of commuters during peak periods. They cause individuals to choose to either ride a bus or carpool, thus increasing the average number of persons per vehicle. During peak hours, successful HOV lanes serve 2 to 4 times as many persons as does a general-purpose freeway lane, and the HOV lanes move those commuters at a much greater speed. Also, HOV lanes can effectively serve suburb-to-suburb travel; this has become the largest component of urban commuting and is not easily served well by fixed-route transit service. In an era when the opportunities to build new freeway facilities are limited, HOV lanes offer both a means to make the best use of the right-of-way and to preserve capacity to continue to satisfactorily serve future growth in person travel.

2. An intense interest currently exists in the Intelligent Vehicle and Highway System (IVHS) program. Substantial federal funding is to be directed toward this program by FHWA and UMTA. In the short- and long-run, HOV system programs can both complement, and benefit from, the IVHS program.

3. Increasing the number of persons per vehicle will be one of the strategies looked to in order to bring urban areas into compliance with provisions of the Clean Air

Act. High-occupancy vehicle facilities offer one of the more successful options for cost effectively attracting new bus riders and carpoolers.

4. Increasing the number of persons per vehicle, as a minimum, reduces the rate of increase in vehicle-miles of travel, which lessens transportation energy consumption.

5. Surveys indicate that public support exists for developing HOV projects.

6. The potential role and value of HOV facilities is explicitly recognized in the recently formulated National Transportation Policy.

A role for priority HOV facility systems exists in large urban areas in this country. The HOV system approach can play a major part in addressing regional concerns relating to traffic congestion, air quality, and energy consumption. HOV facilities, which have moderate capital and operating cost requirements, can do this cost effectively.

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APPENDIX

Table A-1. General Characteristics of Operating HOV Projects in the United States

City	Number of Lanes[1]	Length (miles)	Year Implemented
Exclusive Facilities, Separate Right-of-Way			
Pittsburgh, PA			
South Busway	1 (each direction)	4.0	1977
East Busway	1 (each direction)	6.8	1983
Exclusive Facilities, Freeway Right-of-Way			
Hartford, CT I-84[2]	1 (each direction)	10.0	1989
Houston, TX			
I-45N (North)[3]	1 (reversible)	9.1[4]	1979-1984[5]
I-45S (Gulf)[6]	1 (reversible)	6.5	1988
I-10 (Katy)[7]	1 (reversible)	11.5	1984-1987
US 290 (Northwest)[8]	1[9] (reversible)	9.5	1988
Los Angeles, CA San Bernardino Fwy. Busway (I-10)	1 (each direction)	12	1973 & 1989
Minneapolis, MN I-394[10]	1 (reversible)	3.4	1985
Pittsburgh, PA I-279	2[11] (reversible)	4.1	1989
San Diego, CA I-15	2 (reversible)	8.0	1988
Washington, D.C./ Northern Virginia			
I-395 (Shirley)[12]	2 (reversible)	11	1969-1975
I-66	2 (peak direction)	10.0	1982
Concurrent Flow Facilities			
Denver, CO US 36-Boulder Turnpike	1 (eastbound only)	4.1	1986-1988
Fort Lee, NJ/New York City I-95	1 (eastbound only)	1.0	1986
Honolulu, Hawaii			
Moanalua Freeway	1 (eastbound only)	2.5	1978
H-1	1 (each direction)	7	1987
Los Angeles/Orange Co., CA			
Rt. 55 Commuter lane	1 (each direction)	11	1970
I-405 Commuter lane[13]	1 (each direction)	14	1971
Rt. 91 Commuter lane	1 (eastbound only)	8	1980

Table A-1. General Characteristics of Operating HOV Projects in the United States (continued)

City	Number of Lanes[1]	Length (miles)	Year Implemented
Concurrent Flow Facilities (con't)			
Miami, FL			
I-95	1 (each direction)	14	1976-1978
Orlando, FL			
I-4	1 (each direction)	30.0	1980
Phoenix, AZ			
I-10[14]	1 (each direction)	7.0	1987
San Francisco, CA			
I-280 (reopening 9/90)	1 (each direction)	1.6	1975
Oakland Bay Bridge	4 (peak direction)	2.3	1970
US 101[15]	1 (each direction)	7.0	1974 1986-1987
San Jose, CA			
Montague Expressway[16]	1 (each direction)	5.0	1982,1984,1988
Rt. 101	1 (each direction)	12 SB; 11 NB	1986 & 1988
San Tomas Expressway[17]	1 (each direction)	11	1982 & 1984
Rt. 237[18]	1 (each direction)	4	1984
Seattle, WA			
I-90[19]	1 (westbound only)	5.8	1988
SR 520[20]	1 (westbound only)	2.8	1973
I-5[21]	1 (each direction)	6.2 NB; 5.9 SB	1983
I-405	1 (each direction)	6	1986
Washington, D.C./ Northern Virginia			
I-95[22]	1 (each direction)	6.8	1985-1986
Contraflow Facilities			
New York City, NY			
Rt. 495	1 (inbound only)	2.5	1970
Long Island Expressway	1 (inbound only)	2.2	1971
Gowanus Expressway	1 (inbound only)	0.9	1980

Notes:
1. Number of lanes reported by direction; if reversible facility, represents total number of lanes.
2. The Hartford I-84 HOV lane is listed as an exclusive HOV facility. It is separated from the mixed traffic lanes by a 15-17 foot painted buffer.
3. An additional 5 miles of the North Transitway are scheduled to open in mid-1990. The final 5.6 mile segment is scheduled to open in two phases; 2.9 miles in 1994 and 2.7 miles in 1997.
4. An additional 4.4 mile segment of the North Transitway opened in two stages in late 1989 and April, 1990. This brings the total length of the facility to 13.5 miles.
5. Between 1979 and 1984 a contraflow lane was operated on I-45N. The current exclusive facility was opened in 1985.
6. An additional 9 miles of the Gulf Transitway are scheduled to open in three phases by 1993.
7. The 1.5 mile eastern extension of the Katy Transitway was opened in January, 1990. This brings the total length of the facility to 13 miles.
8. The final 4 miles of the Northwest Transitway were opened in February, 1990. This brings the total length of the facility to 13.5 miles.
9. Approximately 2-miles of 2-lane, 2-direction HOV lanes are in operation on the Northwest Transitway at the connection to the Northwest Transit Center.
10. The I-394 HOV lane is currently an interim facility operating on a signalized arterial street. The final facility includes a combination of reversible barrier separated HOV lanes and concurrent flow diamond lanes.

Table A-1 Notes, continued

11. The two lane reversible I-379 HOV facility splits into two short, one lane segments at the southern end. One segment connects to Three Rivers Stadium and one provides access into the downtown.
12. The I-95 concurrent flow lanes in Northern Virginia connect to the exclusive HOV lanes on I-395 (Shirley Highway).
13. An additional 10 miles of the I-405 HOV lanes are schedule to open in April, 1990, bringing the total length of the HOV lanes to 24 miles.
14. An additional 10 mile segment of the I-10 HOV lanes in Phoenix opened in January, 1990. This segment is to the west of the HOV lane reported in this survey. The two facilities are separated by a short segment currently under construction.
15. The HOV lanes on US 101 in Marin County include two segments, 3 miles and 4 miles in length, separated by approximately 1 mile of mixed traffic lanes.
16. The HOV lanes on the Montague Expressway operate only in the peak direction. The outside lane is used as the HOV lane during the restricted period and is open to general traffic at other times. The Montague Expressway is a signalized expressway.
17. The San Tomas Expressway HOV lanes operate only in the peak direction. The outside lane and shoulder are used for the HOV lane during the restricted period and is open to general traffic at other times. The Montague Expressway is a signalized expressway.
18. The Rt. 237 HOV lanes operate only in the peak direction. The outside shoulder is used for the HOV lane. The section of Rt. 237 where the HOV lanes are located is a signalized expressway.
19. The I-90 HOV lane included in this survey is an interim facility. It is a contiguous concurrent flow facility on the outside lane. Currently only 5.8 miles are open in the westbound direction. The completed I-90 facility will include a 10 mile 2-lane reversible HOV facility located in the freeway median.
20. The SR 520 HOV lane is located on the outside shoulder and operates only in the westbound direction.
21. Different segments of HOV lanes are operated along I-5. The segment included in this survey is the 6-mile segment north of downtown with HOV lanes operating in both directions on the inside lane.
22. The I-95 concurrent flow lanes connect to the exclusive HOV lanes on I-395 (Shirley Highway). The lanes are located on the inside lane and revert back to general-purpose lanes when not in use as HOV lanes.

Source: Reference 8.

*U.S. GOVERNMENT PRINTING OFFICE: 1991--525-619/40694