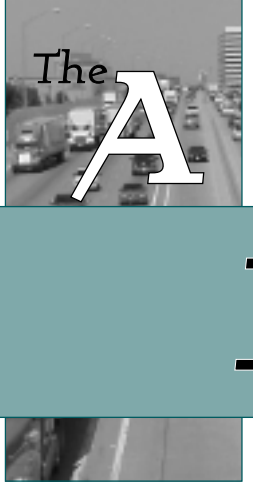

HOV



The ABC's of HOV

The Texas Experience

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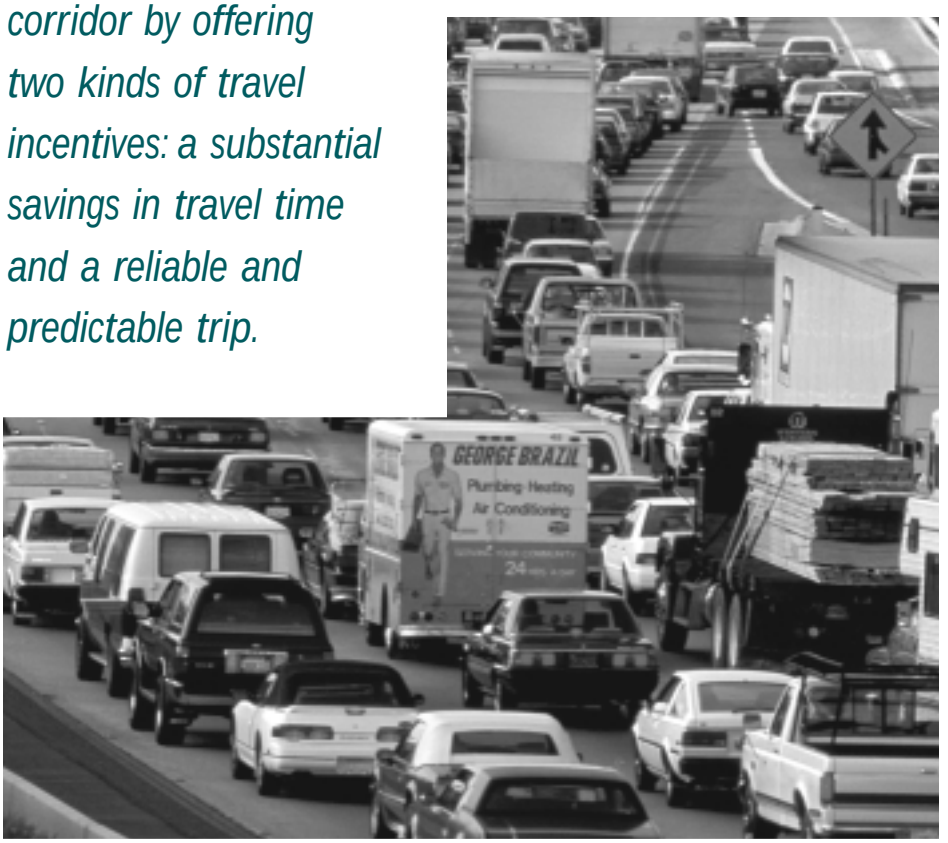
The primary purpose of an HOV lane is to increase the total number of people moved through a corridor by offering two kinds of travel incentives: a substantial savings in travel time and a reliable and predictable trip.



- That Metropolitan Planning Organizations, TxDOT and the transit authorities continue plans to consider HOV lanes for freeway corridors that are already congested or projected to be congested. Freeways with average daily traffic per lane of 25,000 should be carefully examined for potential HOV lane benefits.

- That all entities recognize the crucial role of transit in making effective and efficient use of HOV lanes, and avoid those that would be carpool-only HOV lanes.

- That all entities recognize the unique nature of each corridor, and plan and implement HOV lanes only after thorough analysis has shown that a particular HOV lane will meet the objectives and satisfy the constraints outlined in this report.

- That HOV lane planners carefully balance the support facilities associated with an HOV lane and the number of additional people who will take advantage of the HOV lane to assure that the HOV lane warrants the magnitude of support costs.

- That all entities recognize that the intent of HOV lanes is to increase the person-movement capability of a corridor, not reduce the congestion of single-occupant vehicles.

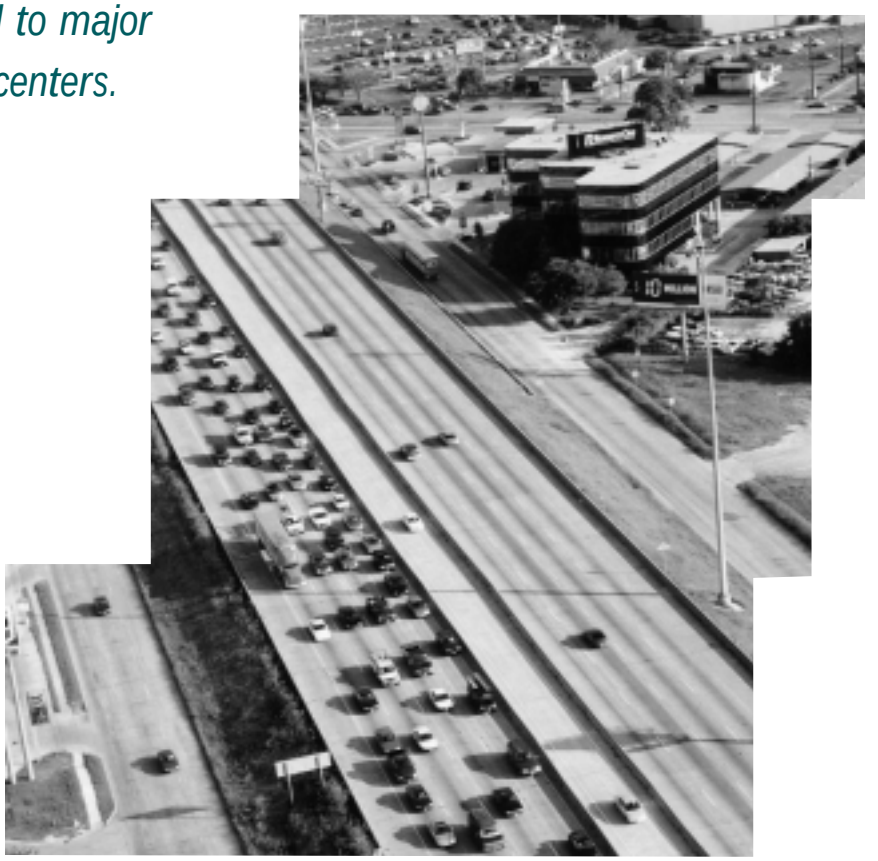
- That an evaluation plan and schedule for any implemented HOV lane should be developed along with the planning of the HOV lane. That evaluation plan should identify the measures of effectiveness to be used and the data to be collected as a routine process of ongoing evaluation.

- That TxDOT continue some level of HOV lane evaluation to track new HOV lane designs employed in Dallas and impacts of growing HOV lane use in Houston.

- That TxDOT support future research into the following unknowns:

  - How important is trip time reliability in attracting users to HOV lanes?
  - Can hardware/software be developed to automate HOV lane evaluation data collection and HOV lane enforcement?
  - Under what circumstances will HOV lanes succeed without transit?
  - Can a comprehensive analysis package including both system analysis and cost-effectiveness analysis be developed for use by planners?
  - What are the impacts of converting HOV lanes to other special uses (including HOT lanes)?
  - What are the best institutional arrangements for operating and enforcing HOV lanes (including how costs are covered)?
  - What are the implications of HOV lanes and light-rail transit in the same corridor– do they compete, or complement?

HOV facilities are one element in a complex transportation system. They serve a particular market that consists primarily of long, dispersed trips oriented to major activity centers.



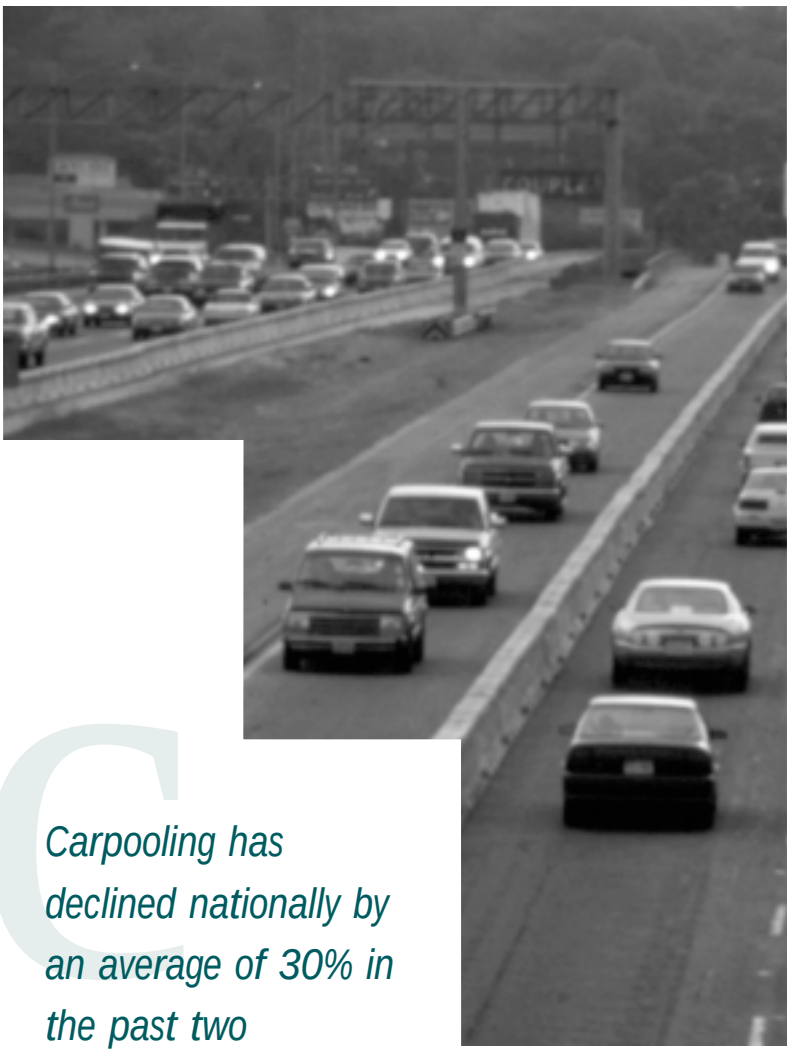
Chapter 1

INTRODUCTION

The implementation of High Occupancy Vehicle (HOV) lanes is a very important decision. Done right they offer a great opportunity for improving person-movement in a corridor. Done the wrong way or in the wrong place, they can be a significant public relations disaster. This report attempts to identify some of the key policy level questions that do (or should) arise from the consideration of HOV lanes and to shed light on the some of the answers to these questions.

The intent of this report is to provide the reader with a nontechnical introduction into the Texas experience with high occupancy vehicle lanes. It is a companion report to Research Report 1353-6F, which is the final technical report of this series. That report includes all of the results of the long-term evaluations conducted over most of the last decade. This series of reports is sponsored by the Texas Department of Transportation (TxDOT). Significant additional research benefit was gained in projects sponsored by the Metropolitan Transit Authority of Harris County (METRO) and the Dallas Area Rapid Transit (DART).

The researchers divided this summary report into three sections. The first section is a basic introduction to HOV lanes, including what they are, how they work, and typical reasons for considering HOV lanes. Following the initial section is a detailed discussion that sheds some light on the question of: "Is this type of improvement the right thing to do?" That discussion describes the findings of the Texas research on some of the key questions that are typically asked when a community is considering an HOV lane. The final section of the report deals with how to know if an operating HOV lane is meeting expectations. It identifies measurable objectives and constraints that will provide important ongoing evaluation and feedback.



Carpooling has declined nationally by an average of 30% in the past two decades. Yet on Texas freeway corridors with mature HOV lanes, there has been an increase in carpooling of 100% or greater during the same time period.

Chapter 2

HOV LANES 101

What Is an HOV Lane?

An HOV lane is a separate lane that is restricted to vehicles occupied by two or more people. HOV lanes usually include carpools, vanpools and buses. HOV lanes can be used on freeways or arterial streets, though the HOV lanes evaluated in this research project were all on freeways.

How Do They Work?

HOV lanes are typically located in highly congested areas, usually in or adjacent to the median of the freeway. The high occupancy vehicles enter the lane at designated points and travel along the lane at speeds usually much faster than adjacent general purpose lanes.

What Is The Purpose of an HOV Lane?

The primary purpose of HOV lanes is to increase the total number of persons moved in the freeway corridor. The faster travel time attracts users who can give up some flexibility to join a carpool or ride a bus. In exchange for this reduced flexibility, they save considerable time. Because the lane carries only vehicles with a higher number of occupants than the typical freeway lane, the HOV lane will move significantly more people during congested hours, even if the number of vehicles is lower than on a general purpose lane.

Are HOV Lanes And Carpool Lanes The Same Thing?

Carpools are a type of HOV, and therefore, carpool lanes are a subset of HOV lanes. However, in Texas, HOV lanes have nearly always been populated with transit vehicles and vanpools, in addition to carpools. In fact, the research has showed that bus riders make up an average of 32 percent of the typical peak period HOV lane ridership in Houston. In many other states, HOV lanes are actually carpool lanes that are rarely, if ever, visited by buses. Total person-movement is typically lower in those true carpool lanes, suggesting that inclusion of transit is very important to achieve goals of high person-movement.

What Do HOV Lanes Do?

The most common objectives for HOV lanes are:

- to increase the number of persons per vehicle (average vehicle occupancy),
- to preserve the person-movement capacity of the roadway, and
- to enhance bus operations (speed and schedule reliability).

The Texas experience is that HOV lanes are most effective when the primary motive is to move people (versus reduce congestion or improve air quality). The Texas HOV lanes have allowed the freeway corridors to increase the number of people per vehicle, in contrast to the national decline in the number of people in carpools and buses. The HOV operations practiced in Texas maintain a high level of service on the HOV lane, thereby assuring HOV lane travelers of a reliable and shorter trip through the congested corridor. Thus HOV lanes attract travelers that are seeking short, reliable travel time, and account for a very significant proportion of the people moved. As will be shown later, HOV lanes can carry up to 40 percent of the total people in the corridor during the peak hour.

What Are The Types of HOV Lanes in Texas?

HOV lanes are intended to maximize the person-carrying capacity of the roadway by giving a priority or incentive to higher occupancy vehicles. There are several types of HOV lanes:

- Reversible HOV lanes, such as all of the current HOV lanes in Houston, are typically single-lane facilities and separated from the mixed flow lanes by concrete barriers (see Figure 1).
- Contraflow HOV lanes, like the East RL Thornton HOV lane in Dallas, are found where low traffic demand in the off-peak direction will allow for that lane to be "borrowed" for an HOV lane during the peak; the contraflow lane is separated from oncoming traffic by movable concrete barriers (see Figure 2).
- Concurrent flow lanes, such as those on the Stemmons and LBJ Freeways in Dallas, are lanes added in the same direction of travel as the general purpose lanes and are not physically separated from mixed flow traffic. They typically use distinctive paint striping to separate the HOV lane from mixed flow (see Figure 3).

Why Do Cities Build HOV Lanes?

Figure 1. Reversible HOV Lane

Communities may build HOV lanes for several different reasons. Making the most of the existing infrastructure is one important goal. This research has shown that HOV lanes provide a highly efficient use of a lane of freeway, consistently moving more peak hour travelers than one or more regular freeway lanes. This movement is one way of slowing the impact of worsening congestion.

Another reason is to create a travel alternative for people who have some flexibility. If a traveler can do without the personal flexibility of having a vehicle at their disposal during the day, then that traveler can gain significant time savings for the peak commutes. Furthermore, potentially each traveler removed from the general purpose lanes improves conditions for those who do not have the same flexibility.

What Is The Role of HOV Lanes?

Figure 2. Contraflow HOV Lane

The role of HOV lanes in the transportation network is important, but often misconstrued. More than anything else, HOV lanes are effective in moving people and improving personal mobility. While other objectives, such as reducing vehicle congestion or improving air quality, may be achieved through the application of an HOV lane, the evidence so far does not support those objectives to the same degree as moving people. Many of the arguments against HOV lanes stem from unsupported expectations, rather than the failure of HOV lanes to perform. HOV lanes are one element in a complex transportation system. Each element — freeway lanes, arterial streets, traffic control, transit, bicycle/pedestrian, and HOV lanes — plays a significant and mutually-supporting role.

What Are Realistic Expectations of HOV Lanes?

Over the last few years, TTI researchers, working with research sponsors TxDOT, METRO, and DART, developed a set of working objectives for HOV lanes. These reflect realistic reasons why a community

would want to consider an HOV lane in a corridor. Those objectives are directed at the following:

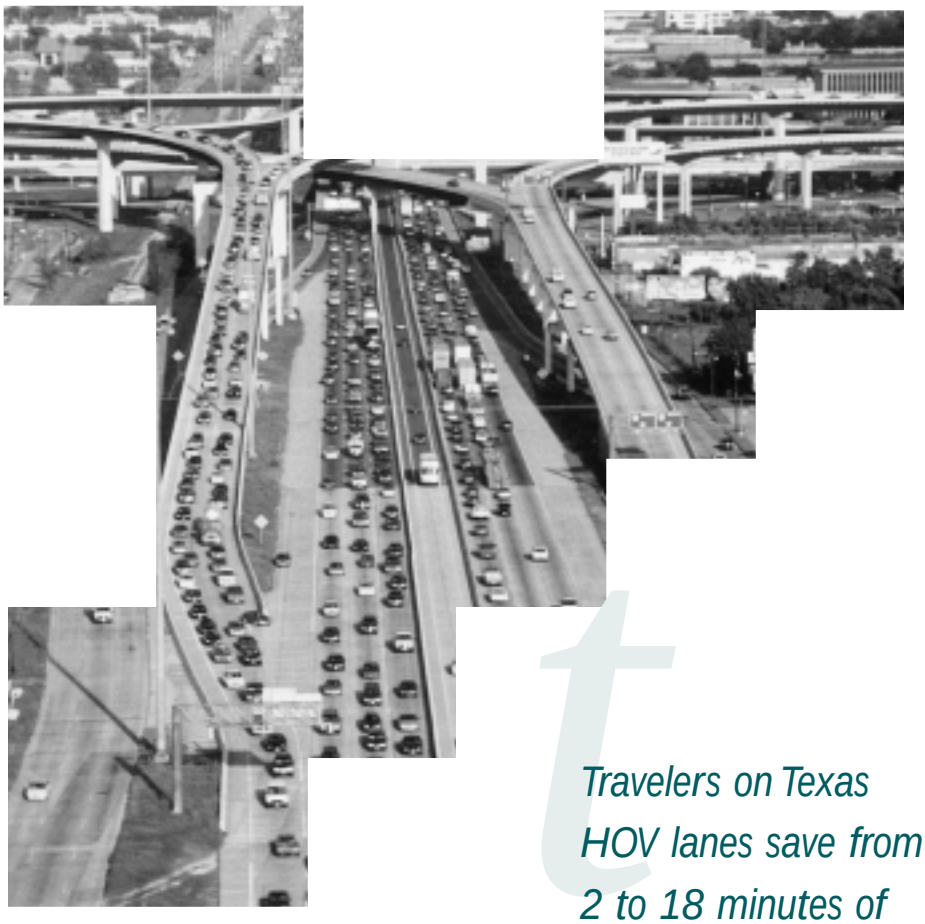
- moving people,
- benefitting transit, and
- improving overall roadway efficiency.

In addition to those objectives, the authors contend that there are some constraints that one should recognize in the planning and implementation of HOV lanes. If the HOV lane violates one of these constraints, the project is in need of careful re-examination. Those constraints include:

- no adverse impact on general purpose lanes,
- projected cost-effectiveness,
- public acceptability, and
- environmentally beneficial or neutral.

Most of these objectives would or should apply to any HOV lane. The research report documents the degree to which HOV lanes in Texas individually and collectively meet these objectives. Chapter Four of this report summarizes the objectives, constraints and the measures applied.

Figure 3. Concurrent Flow HOV Lane



Travelers on Texas HOV lanes save from 2 to 18 minutes of travel time in the morning peak rush hour.

CHAPTER THREE

WILL (MY) HOV LANES BE SUCCESSFUL?

Communities are usually interested in assuring that HOV lanes will be "successful." The research conducted here and elsewhere continues to confirm that there is no formula that guarantees success, but the research has identified many of the factors that appear to influence, if not predict, success for an HOV lane. This section of the report identifies many of the characteristics of the HOV lanes in Texas, and identifies factors that appear to have an important role in "success."

Under What Conditions Are HOV Lanes Most Likely to Be Successful?

NCHRP Report 414, *The HOV Systems Manual* (1), is an excellent source for evaluating the potential applicability of an HOV lane to a particular corridor. That manual contains numerous screening criteria that should be applied at the sketch planning level. Figure 4 shows a selection of the key screening criteria.

- Congestion Levels — Recurring peak hour speeds of 30 mph or less
- Travel Patterns — Work trips to densely developed activity centers
- Current Bus and Carpool Volumes — A corridor with high levels of current HOVs usually represents a better candidate. The Manual includes minimum "threshold" values for various kinds of HOV facilities (400-800 existing carpools/buses per hour for HOV lanes similar to those in Texas).
- Travel Time Savings and Trip Reliability — An HOV lane should save at least one minute per mile, with overall savings of at least five minutes, and preferably more than eight minutes.
- Trip Distance — Corridors with long trips are more likely to attract substantial HOV traffic.
- Support Facilities and Services — Facilities such as park-and-ride lots, direct access ramps and enforcement areas, and services such as transit and rideshare contribute significantly to the success of HOV lanes.

Figure 4. Screening Criteria Recommended by NCHRP Report 414 – The HOV Systems Manual

While some theoretical research has suggested that main lane delays of at least 20 minutes per vehicle are necessary to justify an HOV lane over a general purpose lane (2), the experience in Texas has been freeways with as little at 10 minutes delay can have very successful HOV lanes. Previous research has shown a positive relationship between ridership and travel time savings (3), suggesting that as congestion grows, the traveler's willingness to carpool or ride the bus on the HOV lane, and thus save time, also grows.

HOV demand has grown in all congested corridors in Texas, so much so that for two HOV lanes the minimum eligible carpool size has been increased from 2+ to 3+ in the peak hours to keep the number of vehicles manageable. Even with the occupancy restrictions, these heavily used HOV lanes carry as much as 40 percent of the people moved on the freeway. Also, surveys have shown that willingness to form new carpools and ride the bus increases after the opening of an HOV lane.

Who Uses HOV Lanes?

The HOV facilities attract young, educated, white-collar professionals to ride transit. The bus serves long-distance commute trips, primarily to downtown. These individuals are using the HOV lanes to save time, avoid driving in congested traffic, have time to relax, and have a reliable trip time. The bus patrons are transit users by choice, with over 85 percent having an auto available for the trip in Houston and

approximately 70 percent having an auto available in the East R.L. Thornton corridor in Dallas. Over 60 percent of the bus passengers have all or part of their bus fare paid by their employer.

Carpoolers also tend to be young, educated, white-collar professionals. They are also using the HOV lane for a long-distance commute trip, but find the lane to be more effective at serving their dispersed trip destinations, such as suburban office complexes. Over 60 percent of the carpools are made up of family members. Another 20 percent of the carpools on Houston HOV lanes form at either a park-and-ride or a park-and-pool lot.

Who Benefits From HOV Lanes?

In general, the carpoolers, vanpoolers and bus patrons who use the HOV lane are the primary beneficiaries. However, to the degree that the HOV lane removes traffic from the general purpose lanes, the nonusers also benefit, by making the peak period shorter.

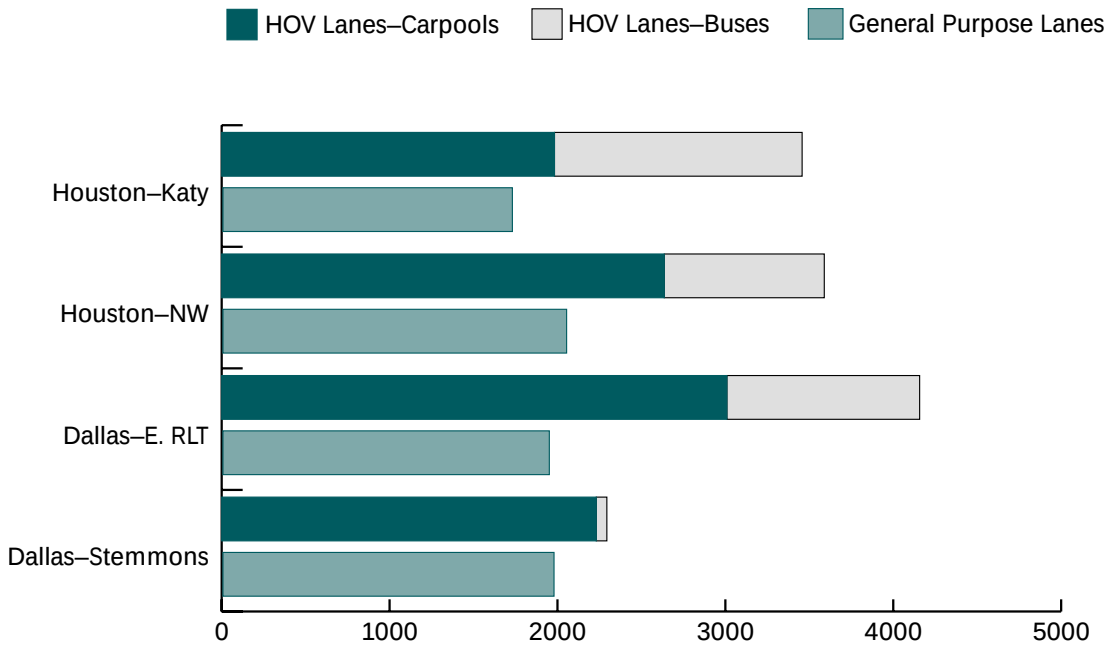


Figure 5. Number of People Moved on the HOV Lane During the Morning Peak Hour

The Texas research has shown that the inclusion of buses is very important in the effectiveness of an HOV lane. Bus passengers account for an average of 30 percent of peak period HOV lane travelers in Texas in the most recent data available.

Some have contended that eligibility to use an HOV lane should be limited to buses and emergency vehicles. The underlying philosophy of these proponents is that by providing bus service only, there will be a significant shift to buses. The practical aspect of that philosophy has not been as fruitful. The early years of operation on the Katy HOV lane in Houston were limited to buses and official vanpools. Yet significant person-movement in the HOV lane began only when carpools were allowed.

One way of looking at this is to examine how well the HOV lane performs compared to the adjacent general purpose lanes. If an HOV lane represents 1/4 (25 percent) of the inbound lanes on a freeway, then it should carry at least 25 percent of the total persons (either bus riders or carpoolers) moving inbound. If it does not, then it is inefficient. Figure 5 shows how the Texas HOV lanes compare to their adjacent general purpose lanes. It also shows that, in all but the

City	HOV Facility	Benefit-to-Cost Ratio for HOV Lane	Benefit-to-Cost Ratio for Two General-Purpose Lanes	Additional Dollar Value of Benefit Gained per Dollar Expended on HOV Lane
Houston (reversible)	Katy	15:1	9:1	$6
	Gulf	9:1	4:1	$5
	Southwest	8:1	5:1	$3
	Northwest	7:1	6:1	$1
	North	6:1	4:1	$2
Dallas	East R.L. Thornton (contraflow)	28:1	10:1	$18
	Stemmons (concurrent flow)	48:1	43:1	$5

Table 1. Comparison of Benefit-to-Cost Ratios for Texas HOV Lanes versus a General-Purpose Lane Alternative

Stemmons concurrent flow HOV lanes in Dallas, bus ridership is a very important contribution to the total person movement.

Isn't Money Better Spent on New Freeway Lanes?

Sometimes. HOV lanes are valuable tools to be used where appropriate. Each freeway corridor requires a separate, unique analysis to determine whether an HOV lane is appropriate. The benefits and costs of the six established HOV lanes in Texas were compared to adding two freeway lanes on each of those freeways instead of an HOV lane. In all cases the benefit/cost ratio for the HOV lane was greater than the general purpose lane (Table 1). However, if there isn't significant congestion for at least one hour every morning and evening, and a significant jobs base beyond the end of the HOV lane, then it will be difficult to attract riders to carpools and buses in the HOV lane. In essence, each corridor is different and warrants an in-depth examination before a determination of HOV lane suitability can be made.

How Do We Avoid The "Empty Lane" Syndrome?

Motorists in highly congested corridors have expressed frustration with seeing HOV lanes that "...have nobody in them." This frustration can result in strong negative public sentiment and even in pressure to convert the HOV lane to a general purpose lane. The keys to avoiding the "empty lane syndrome" are effective planning and operation. Effective planning should result in HOV lane construction only in those corridors for which HOV lanes are suitable improvements. It will also provide for those connections to park-and-ride and other facilities that can play a significant role in HOV lane effectiveness.

There are also operational strategies that may help make better overall use of an HOV lane, including the broadening of the use of the HOV lane to allow for other groups of users. Examples that could be considered include: lower occupancy vehicles or shorter or longer hours of operation. There are at least two techniques for managing the usage level for lower occupant vehicles, the most popular being the charging of a toll (see HOT lane discussion later). Because such actions may have significant ramifications, it is recommended that detailed site-specific examinations be conducted before important policy decisions are made.

A sometimes overlooked component of HOV lane planning is that of managing public expectations. HOV lanes are one element of a battery of transportation techniques and improvements that communities can consider. While HOV lanes may allow a freeway corridor to move significantly more people, the experience in Texas is that they have not

significantly reduced congestion. Therefore, it will usually be unwise to "sell" HOV lanes on the basis of reducing congestion as that may lead to public disappointment and mistrust later on. A more prudent approach may be to sell HOV lanes as a part of a larger plan to improve mobility.

Will the Installation of an HOV Lane Relieve Congestion?

Probably not. HOV lanes provide the opportunity for travelers to make a mode shift and receive substantially shorter travel times. However, for HOV lanes to have a significant and sustained impact on congestion, they would have to attract and retain a significant portion of the solo drivers into buses. For example, there are about 80 buses using the Katy HOV lane during the 3-1/2 hour peak period. To have a measurable impact on congestion, enough solo drivers to fill up 90-100 more buses (3500-4000 people) would need to convert.

There have been numerous reports and articles that have questioned the prudence of building HOV lanes versus general purpose lanes. Part of the disparity in conclusions drawn from different reports is attributable to the objective measures used to determine "success" or "effectiveness." The principal objective in all of the Texas applications has been increased person-movement, so most of the analyses have examined how well the HOV lanes have supported that objective. Demand for general purpose lane use has remained high even with significant shifts to the HOV lane. HOV lane users are generally the only group to experience lower travel times, with very little direct benefit accruing to general purpose lane users. Over the long term, land use planning can help address the delay and emissions resulting from congestion; in the short term, HOV lanes can contribute to the ability of the existing corridor to accommodate existing and growing travel demand.

A decision to implement an HOV lane should consider what potential impact the HOV lane could have on congestion. Although the market for HOV lane use is theoretically large, experience with the very mature HOV lanes in Texas has shown that there is a limit on growth in HOV lane use, even with increasing congestion. It appears that there is a relatively small portion of the traveling public that has the flexibility or willingness to rideshare, meaning that there will be a practical maximum portion of travelers that can be attracted to the HOV lane. After the first 3-4 years of service, the growth in use of the HOV lane is likely to subside. Thereafter, growth in mixed flow traffic will likely be faster than growth in HOV lane usage.

What Are the Best Ways to Provide Access to/from HOV Lanes?

HOV lane access must be balanced to maximize effective operation. Too many entry and exit points result in bottlenecks, which slow down the HOV lane and make it a less attractive alternative. Too few access points unnecessarily limit the travelers who would otherwise take advantage of it.

Depending on the type of HOV lane, there are preferred designs for access (1). Providing direct access is substantially preferred over designs that require a traveler to maneuver across several freeway lanes to merge into an HOV lane and then cross those lanes again to exit. Not only is direct access safer, but it significantly reduces the bottleneck caused on the general purpose lanes.

Who Is Responsible for Operating, Enforcing and Maintaining HOV Lanes? Who Pays for It?

There are no "cookbook" answers for either of these policy questions. These expenses can be significant; the expenses on Texas HOV lanes range from $300,000 to $600,000 per year. Capital construction costs

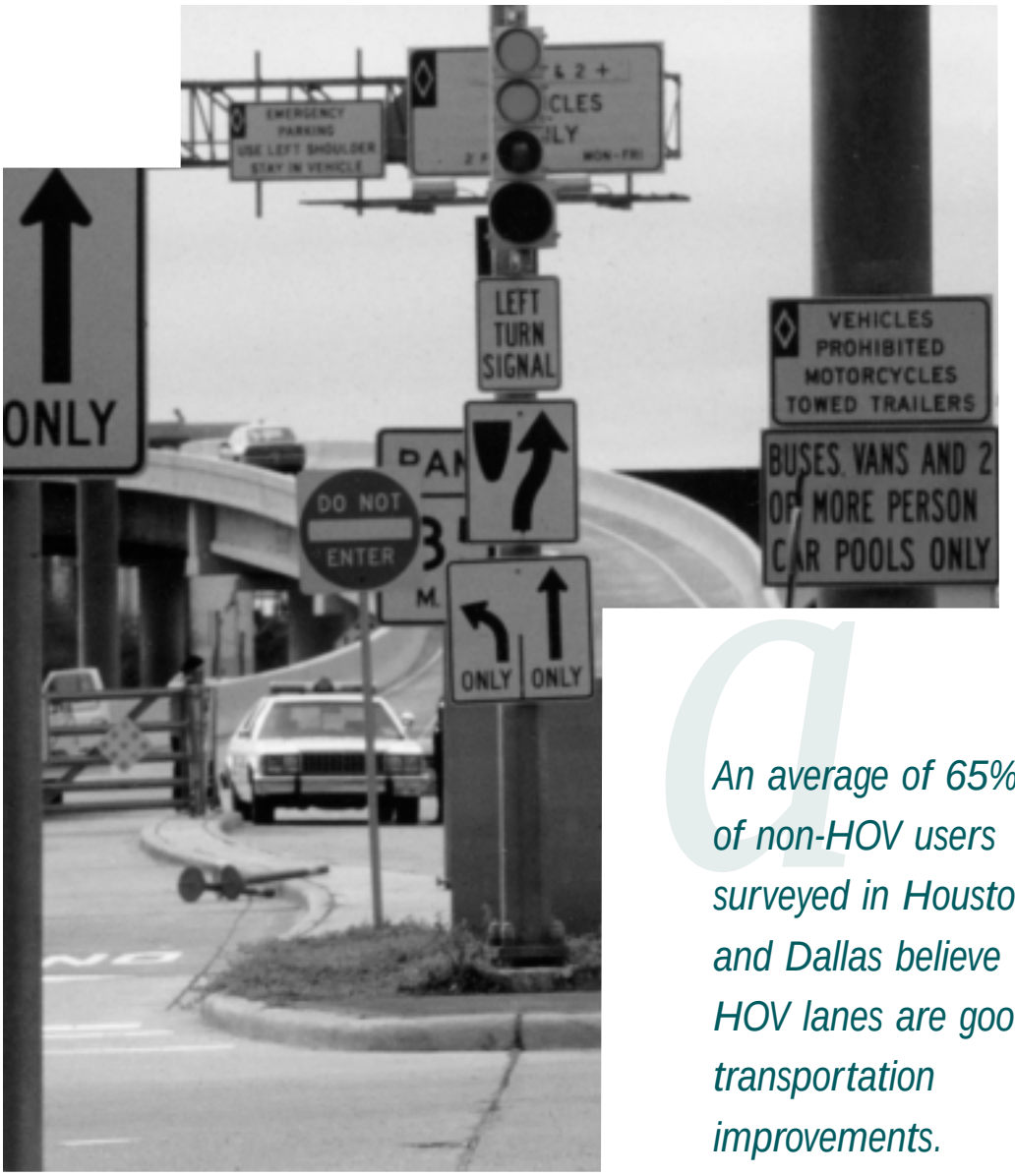
have typically been shared between TxDOT and the local transit authority, while the transit authority bears all or most of the operations and maintenance expense and staffing requirements. These are local decisions to be made based on local considerations during the planning stage.

Does the Public Look Favorably on HOV Lanes?

The public support for HOV lanes in Texas is high. The last direct measurement of public support was performed in 1994. That survey of Houston and Dallas freeway (non-HOV) users showed that more than 65 percent viewed the HOV lane on the freeway they use as a "good transportation improvement." Less than 20 percent said that the HOV lanes were not good improvements. However, freeway users and HOV lane users differed on whether the HOV lanes were sufficiently utilized. A modest majority of freeway users felt the HOV lanes are not sufficiently utilized, while an overwhelming majority of HOV lane users believe they are sufficiently utilized. Although that research is now about five years old, evidence of continued support has been demonstrated through other research (4).

What Is a HOT Lane?

A HOT lane is an HOV lane that allows lower occupancy vehicles to have access for a toll. In order to make maximum effective use of the available space on HOV lanes, some communities have installed electronic tolling systems on one or more HOV lanes to allow them the flexibility of varying their eligibility and essentially "selling" unused capacity in the HOV lane. While this approach may improve HOV lane utilization, there are additional operational obligations and expenses and potentially some public relations challenges. Houston has experimented successfully with a peak-hour HOT lane on the Katy HOV lane. Both Houston and Dallas are considering an expansion of the HOT lane concept in long range planning for I-10 and I-635.



An average of 65% of non-HOV users surveyed in Houston and Dallas believe HOV lanes are good transportation improvements.

CHAPTER FOUR

MEASURING PERFORMANCE

Is the HOV Lane Working?

The expectation of the public and the goal of transportation professionals are that the elements of the system work as intended. For each identified objective of HOV lanes, there are several measures that can be applied to evaluate the success in meeting that objective.

Objective 1. Increase Roadway Person-Movement

(Does the corridor move more people with the HOV lane than without it?)

Of all the objectives, this one should get a resounding "yes"; if not, an HOV lane is not the right improvement. Because this objective is so critical in determining the success of an HOV lane, several measures have been developed to address it. Among the measures analyzed in the research report are:

- person-movement characteristics of HOV lane and general purpose lanes,
- comparison of the percentage of persons moved versus the percentage of vehicles (Figure 7),
- comparison of the percentage of persons moved versus the percentage of pavement used (Figure 7),
- increases in use of HOV lanes compared to overall increases in travel, and
- impact of HOV lanes on overall occupancy in the corridor (Figure 6).

Objective 2. Improve Bus Transit Operating Efficiency

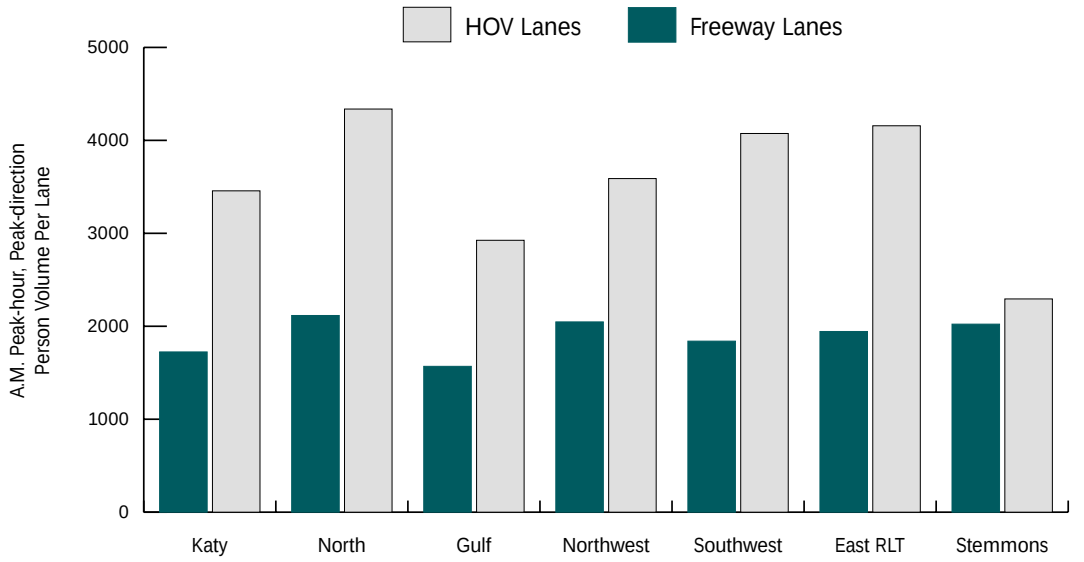
(Does it help transit?)

Although attracting carpools is crucial for public perception of HOV lane utilization, in most corridors the "bang for the buck" in person-movement comes from buses. Two measures of the benefit to transit are:

- improvement in bus operating speeds that results from the free flow, and
- improvement in bus schedule reliability.

Figure 6. Average Vehicle occupancy on Freeways with HOV Lanes

Source: Texas Transportation Institute data collection.



Objective 3. Improve Total Roadway Efficiency

(Are HOV lanes an effective use of the available pavement/right-of-way?)

Another objective of the HOV lane is to improve the efficiency of the entire roadway (freeway + HOV lane). Such a measure should consider not only the volume of people moved, but also the speed at which they move. In other words, moving 100 people at 55 mph is of more value than moving 100 people at 20 mph. Figure 8 shows the impact of the HOV lane for the seven corridors studied. The most dramatic improvements are on those freeways that had the worst congestion prior to the implementation of the HOV lane.

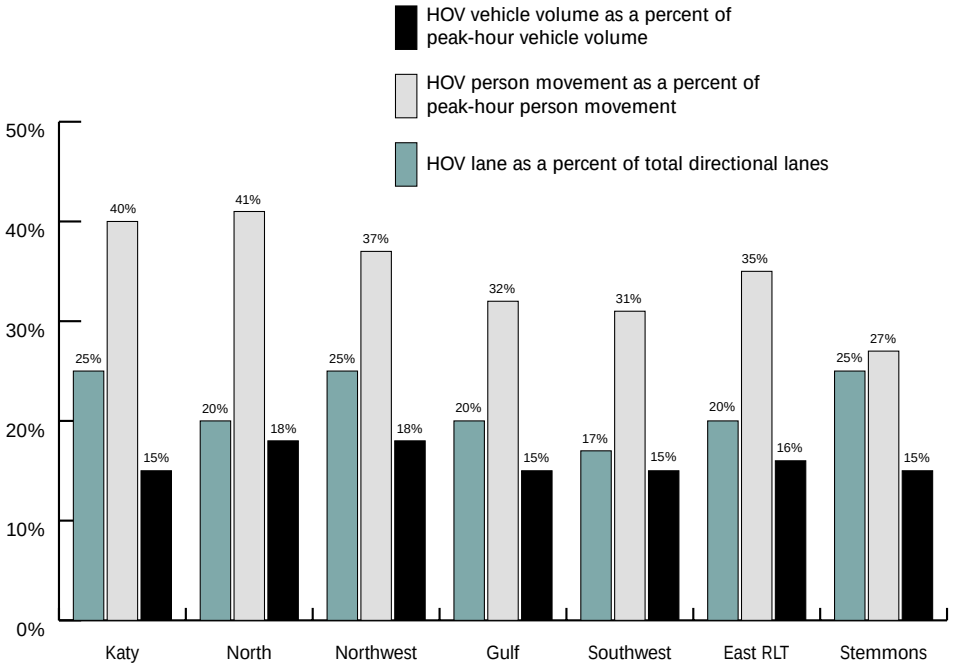


Figure 7. Comparison of Peak-hour Person Movement and Vehicle Movement

Constraint 1. No Impact on General Purpose Lanes

(Can HOV lanes be installed and operated without causing problems for other traffic?)

In the early years of HOV lane development in Texas, HOV lanes were "shoe-horned" into existing freeway medians. This practice usually led to the narrowing of existing general purpose lanes and the elimination of inside shoulders. There were no adverse safety or operational impacts of these changes.

More recently HOV lanes have been designed into the reconstruction of congested corridors, alleviating many of the original problems. However, there are still some locations where the merging of HOV lane and mixed flow lane traffic occurs. To assure that such interactions do not become a bottleneck, congestion levels, operating speeds and accident rates on the general purpose lanes adjacent to HOV lanes should be monitored on an ongoing basis.

Constraint 2. HOV Lanes Should Be Cost-Effective

(Are HOV lanes financially prudent? How do they compare with adding freeway lanes?)

Because resources will always be limited, all transportation improvements should be able to meet the test of financial prudence. Thus, HOV lanes should produce a favorable benefit/cost relationship. Further, they should compare favorably to other improvement alternatives, specifically additional general purpose lanes. Chapter 8 in the TTI research report 1353-6 analyzes these relationships for the Texas HOV lanes in detail. Some general conclusions about the factors that drive the B/C ratios are presented.

The benefits of HOV lanes in Texas were quantified and then com-

pared to the implementation costs, which are the project construction costs and the ongoing costs for operation and enforcement of the HOV lane. The benefits of the HOV lane are the monetary value of time savings for motorists and bus riders, as well as the cost savings resulting from a reduction in fuel consumption. When comparing these benefits to the costs of implementation, the HOV lanes in Texas have cost-effectiveness ratios ranging from 6:1 to 48:1, and in each case, demonstrate greater cost-effectiveness than an alternative involving the construction of two general-purpose lanes.

Constraint 3. Maintain Public Acceptance

(Are HOV lanes understood and accepted by the public?)

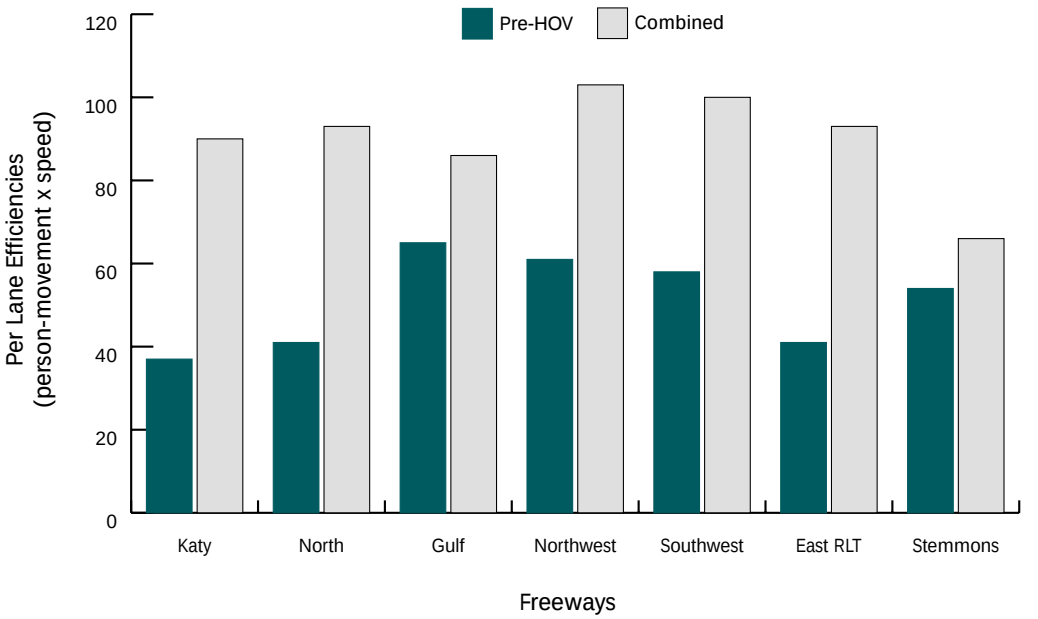
The significance of public support is best reflected in the short life of the Santa Monica Diamond Lane in Los Angeles in the mid-1970s. Although this carpool lane was actually performing reasonably well for its newness, the public outcry that stemmed from gross misunderstanding resulted in the cancellation of that project and a decade-long hiatus from carpool lane experiments in California. More recently the I-80 and the I-287 HOV lanes in New Jersey have been "decommissioned," in large part because of public outrage over low usage. HOV lanes in Texas have been carefully and slowly introduced, with little or no public backlash. Detailed research on public acceptance is presented in Research Report 1353-6F. Specific public opinion surveys from users and non-users show the public support for HOV lanes in Houston.

Constraint 4. HOV Lanes Should Have a Favorable or Neutral Impact on Air Quality and Fuel Consumption

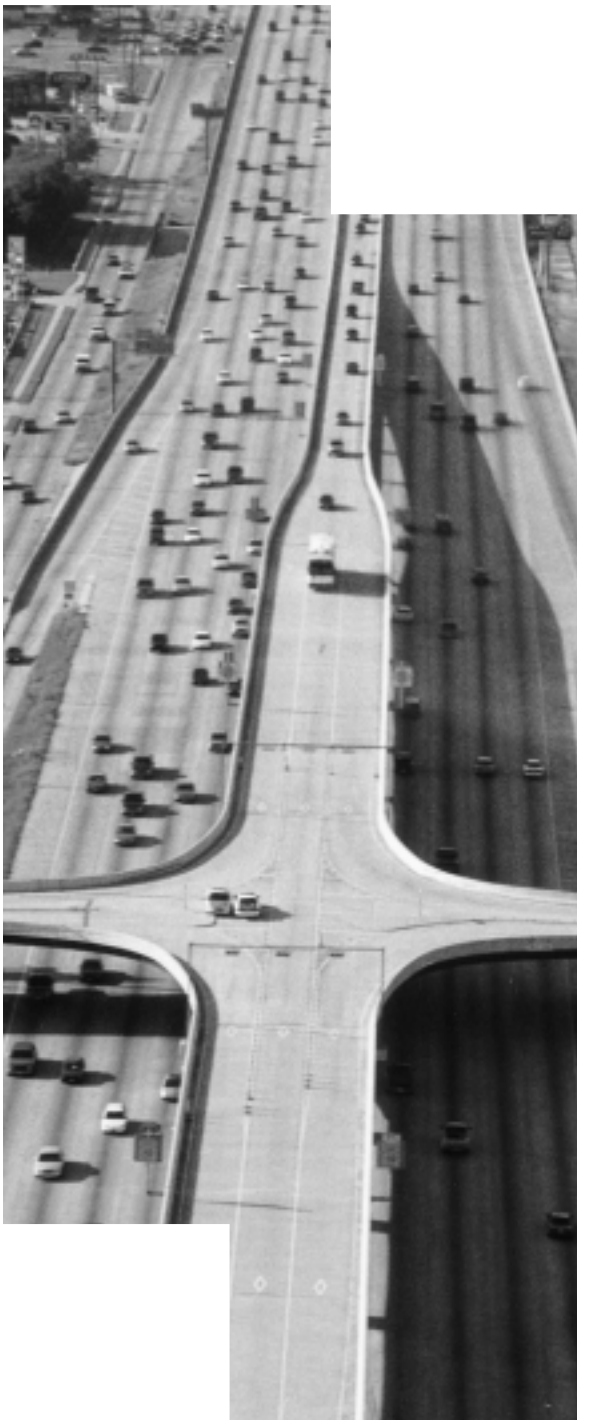
(Are HOV lanes good for the environment?)

HOV lanes should have a beneficial impact on the environment. Intuitively, increasing vehicle occupancy should result in fewer emissions and less fuel consumption. Both of those desirable outcomes may occur, but HOV lanes and associated traffic represent such a small portion of the overall travel demand, even during the peaks, that any savings are hard to isolate using currently available tools and computer models. Research Report 1353-6 provides some additional insight into the possibilities. It is important to note that in non-attainment regions, HOV lanes are the only added-capacity project type that is eligible for implementation under the Congestion Mitigation/Air Quality (CMAQ) program. This support for HOV lanes suggests that federal officials have concluded that HOV lanes can produce emissions benefits.

Figure 8. Changes in Per Lane Efficiencies



HOV lanes move people at a rate of 87,000 per day in Houston and 88,000 per day in Dallas. They haved preserved the ability of congested corridors to move people during times of rapid population growth.



CHAPTER 5
CONCLUSIONS

Based on our collective HOV lane evaluation experience of more than a decade, the researchers who have participated in the HOV lane evaluations have drawn the following general conclusions. While these conclusions are based more on the preponderance of evidence than on an experimental design, they are well supported by the research, which has produced consistent results throughout the study period.

Person-movement

- Texas HOV lanes move a greater volume of people per lane than a general-purpose lane from 10 percent more up to 120 percent more.
- The data clearly show that the presence of an HOV lane has resulted in a meaningful increase in average vehicle occupancy. All Texas freeways with HOV lanes that were reviewed in this study have higher average vehicle occupancies than the national average, and those HOV lanes that have operated in a stable environment over time have experienced increases in average vehicle occupancy of 10 percent or more.

Carpooling

- Implementation of the HOV lanes appears to have lengthened the median life of a carpool and increased the volume of carpools. Freeways without HOV lanes have experienced a decline in carpooling. On freeway corridors that did not experience high carpooling prior to implementation of an HOV lane, the data suggest that 40 percent to 50 percent of the current HOV carpoolers formed a carpool as a result of the HOV facility.
- The HOV lanes in Texas have shown that it is possible to increase the average number of people in each vehicle. The peak-hour average in Texas HOV corridors ranges from 1.24 to 1.5, versus a national average of 1.09 in 1990. Carpooling has increased by more than 100 percent on Texas HOV lanes. This increase contrasts with a national decline of 32 percent from 1970 to 1990.

Bus Transit

- Bus transit usage is extremely important to the success of HOV lanes. The highly effective HOV lanes in Texas would be less effective if bus transit were removed.
- The presence of an HOV lane has the potential to increase bus ridership by as much as 60 percent in corridors where transit is not a predominant mode before HOV lane implementation.
- Compared to conditions that existed prior to HOV lane implementation, average bus operating speeds have increased dramatically. On average, peak-hour bus operating speeds have more than doubled, increasing on average from 25 mph to 52 mph. As a result, schedule times have been cut significantly, making bus travel a substantially more attractive alternative.

Total Roadway Efficiency

- The implementation of HOV lanes in Texas has resulted in corridor efficiency increases ranging from 30 percent to 140 percent. Total roadway efficiency is a measure that combines the number of people

using the entire facility in the peak hour with the speed at which they travel.

Impact on General-Purpose Lanes

- Construction of HOV lanes has occasionally involved narrowing traffic lanes and inside shoulders, yet these changes have not created operational problems for adjacent freeway lanes, either in terms of freeway speeds or crash rates.

Cost-Effectiveness

- The benefits offered by individual Texas HOV lanes outweigh the costs for implementation, including annual operations and enforcement costs, by margins ranging from 6:1 to 48:1. In all cases, the benefit-to-cost ratio (B/C) for the HOV lane exceeded that of a general-purpose lane alternative.
- The volume of traffic on the general-purpose lanes is the most important variable in determining the potential cost-effectiveness of an HOV lane, because high-traffic volumes slow freeway speeds, thus making the HOV lane attractive.
- Construction cost is also an important determining factor in cost-effectiveness evaluations. Support facilities such as park-and-ride lots and transit centers play an important but delicate role: they are crucial to making HOV lanes accessible and attractive, but they can be expensive and if overdone, can reduce the B/C ratio of a project.

Public Support

- Survey data suggest relatively strong public support for the HOV lane programs from both users and non-users in corridors with HOV lane improvements, although non-users generally consider the lanes to be underutilized both in terms of vehicle usage and person-movement. The issue of perceived HOV lane utilization among non-HOV users will continue to be an issue associated with the implementation of HOV lane programs.

Air Quality and Fuel Consumption

- The techniques and methods available to conduct air quality and energy savings evaluations of HOV lanes clearly need to be enhanced in order to strengthen policy arguments based on these two criteria. A simulation analysis of the Katy Freeway corridor shows that the HOV lane alternative offers favorable impacts on pollutants emitted and energy consumed.

Factors Affecting HOV Lane Utilization

- HOV lanes are effective alternatives for congested freeway corridors that meet certain "qualifying criteria," including:
  - a differential between freeway and HOV lane speeds that will generate sufficient travel time savings for the user to consider carpooling or bus transit as an attractive alternative,
  - corridor characteristics and facility design factors that include orientation to major activity centers and physical opportunities to completely "bypass" congested sections, and
  - effective integration of transit service into HOV lane operation.
- Travel time reliability, or the expectation that travel time will not vary appreciably from day to day, is a demonstrated advantage of HOV lanes. Travel time recorded over an eight-month period on the Katy Freeway general-purpose lanes had a statistical variation of six minutes, while Katy HOV lane travel times varied by less than one minute.
- The socioeconomic and demographic factors that are typically considered conducive to carpooling are fairly consistent with the HOV

corridors in Texas. By virtue of their design, the HOV lanes provide a time-saving incentive that accommodates longer travel times and greater trip lengths, which are factors considered important to the propensity to carpool. A higher percentage of lower income households in the corridor is the one factor that appears to have a greater influence on the propensity to rideshare in these corridors than other socioeconomic factors. Household size and parking costs appear to have little or no influence on carpooling in these corridors.

Summary

Table 2 summarizes the results of the research.

Table 2. Comparison of HOV Lane Objectives and HOV Lane Performance, 1997

Objectives, Measure of Effectiveness	HOV Facility						
	Katy	North	Gulf	Northwest	Southwest	East RLT	Stemmons
HOV lanes should increase person movement.							
• Does the HOV lane move a greater percentage of persons in the peak-hour than the percentage of total lane capacity it represents?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
• Has the peak-hour vehicle occupancy increased by 10% to15%?	Yes	Yes	No	Yes	No	No	No
• Have new carpools increased by at least 25% due to the HOV lane?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
• Has bus ridership increased at least 25% as a result of the HOV lane?	Yes	N/A	Yes	Yes	Yes	No	No
HOV lanes should enhance bus operations.							
• Have peak-hour bus speeds increased by 50%?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
HOV lanes should not result in an adverse impact on freeway general-purpose lane operations.							
• Have general-purpose lane speeds been impacted by the HOV lane?	No	No	No	No	No	No	No
• Has the general-purpose lane accident rate increased significantly due to the HOV lane?	No	No	No	No	No	No	No
Implementation of an HOV lane should increase the overall efficiency of the roadway.							
• Has the roadway per-lane efficiency increased by a value of at least 20 due to the HOV lane?	Yes	Yes	Yes	Yes	Yes	Yes	No
HOV lanes should be cost effective.							
• Does the value of the benefit outweigh the costs?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
• Does the HOV lane have an equal or greater benefit-to-cost ratio than a general-purpose lane alternative?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
HOV lanes should have public support.							
• Do more than 50% of the persons responding to the surveys indicate support for HOV lane development?	Yes	N/A	N/A	Yes	N/A	Yes	N/A
HOV lanes should have favorable air quality & energy impacts.							
• Has adding an HOV lane been more effective than a general-purpose lane would have been in terms of air quality and energy impacts?	Yes	N/A	N/A	N/A	N/A	N/A	N/A
Overall Assessment: Is the HOV facility effective?	Yes	Yes	Yes	Yes	Yes	Yes	Marginally

If they are well-planned, designed and operated, HOV facilities can offer travel time advantages, predictable trips, alternatives for improved personal mobility, incentives to rideshare, and more efficient use of the transportation infrastructure.

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