Status and Effectiveness of the Houston High-Occupancy-Vehicle Lane System, 1988

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The Houston high-occupancy-vehicle (HOV) lane system is evaluated through calendar year 1988. Locally, these HOV lanes are referred to as transitways. These facilities are being built primarily as a means to help cope with the congestion problems in the Houston area. By the end of 1988, 36.6 mi of transitways were in operation on four Houston freeways. Transitways are generally located in the median of the freeway, are 20 ft wide, are reversible, and are separated from the freeway mixed-flow lanes by concrete median barriers. Ultimately, 95.5 mi of transitways will be constructed at a cost approaching $700 million. Surveys indicate that development of these transitways has public support. The primary objective of the Houston transitways is assumed to be to increase, in a cost-effective manner, the person-movement capacity of a freeway and to do it in a manner that does not unduly affect the operation of the freeway's general-purpose mixed-flow lanes. Transitway design and operation in Houston have not unduly impacted the general-purpose freeway lanes. Data indicate that the transitways can significantly increase peak-period person movement and average vehicle occupancy. New bus riders and carpools are generated by the facilities. For a transitway with a Houston-type design to be successful and cost-effective, it may need to offer a peak-hour travel time savings of at least 6 to 8 min compared with operation in the freeway mixed-flow lanes. The transitway also needs to move over 10,000 person-trips per day.

In Houston, in the early 1970s, increases in travel demand, expressed as freeway vehicle-miles of travel (VMT), began to exceed increases in roadway supply, expressed as lane-miles of freeway. Since 1970, VMT per freeway lane-mile has increased by approximately 100 percent. As a result, congestion also increased significantly and a 1984 FHWA study (*1*) found that Houston had some of the most, if not the most, congested freeway facilities in the nation. Monitoring of overall urban congestion in major Texas cities has clearly indicated that mobility levels in Houston have become undesirable (*2*). However, at the same time, congestion in Houston has been moderating in recent years. Nevertheless, the congestion problem in Houston is serious and continues to require attention.

In response to this congestion problem, a variety of actions are being taken. One involves the implementation on the urban freeways of a system of priority lanes for high-occupancy vehicles. Locally, these high-occupancy-vehicle (HOV) lanes are commonly referred to as transitways and are being jointly developed by the Texas State Department of Highways and Public Transportation and the Metropolitan Transit Authority of Harris County (Metro).

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As part of an ongoing research effort, a comprehensive evaluation of these transitway facilities is being performed. Evaluations are being conducted using two approaches. First, before and after trend line data being collected for each freeway on which a transitway is being developed provide a means for identifying changes that occur in those corridors. Second, similar data are being collected in corridors that do not have transitways. These control corridors help to isolate the specific impacts of the transitways.

Data relative to transitway and freeway operations and effectiveness in Houston are presented and evaluated through December 1988. Data are presented for all four operating transitways.

OVERVIEW OF THE HOUSTON TRANSITWAY SYSTEM

A commitment has been made to develop approximately 96 mi of freeway transitway in the Houston area (Figure 1). As of December 1988, four separate transitway facilities had been opened with a total of 36.6 mi of transitway in operation. Daily operation and enforcement of these facilities are the responsibility of the Metropolitan Transit Authority (Metro). Selected characteristics of the operating transitways are presented in Table 1.

Although some sections of two-direction transitway are being developed, the typical Houston transitway is located in the freeway median, is approximately 20 ft wide, is reversible, and is separated from the general-purpose freeway main lanes by concrete median barriers. In some locations, transitway implementation was accomplished by narrowing freeway main lanes and inside shoulder width.

Access to the median transitways is provided in a variety of manners. At some locations, slip ramps are used to provide access and egress to and from the inside freeway lane. Openings in the barriers allow direct access to the transitway. Although slip ramps are relatively inexpensive, they have a variety of operational disadvantages. As a consequence, most access to these median transitways is being provided by grade-separated interchanges of various designs. With these designs, the transitway becomes elevated in the freeway median and grade-separated ramps provide connections to surface streets, park-and-ride lots, bus transfer centers, etc. These grade-separated interchanges are typically constructed at a cost in the range of $2 to $5 million each.

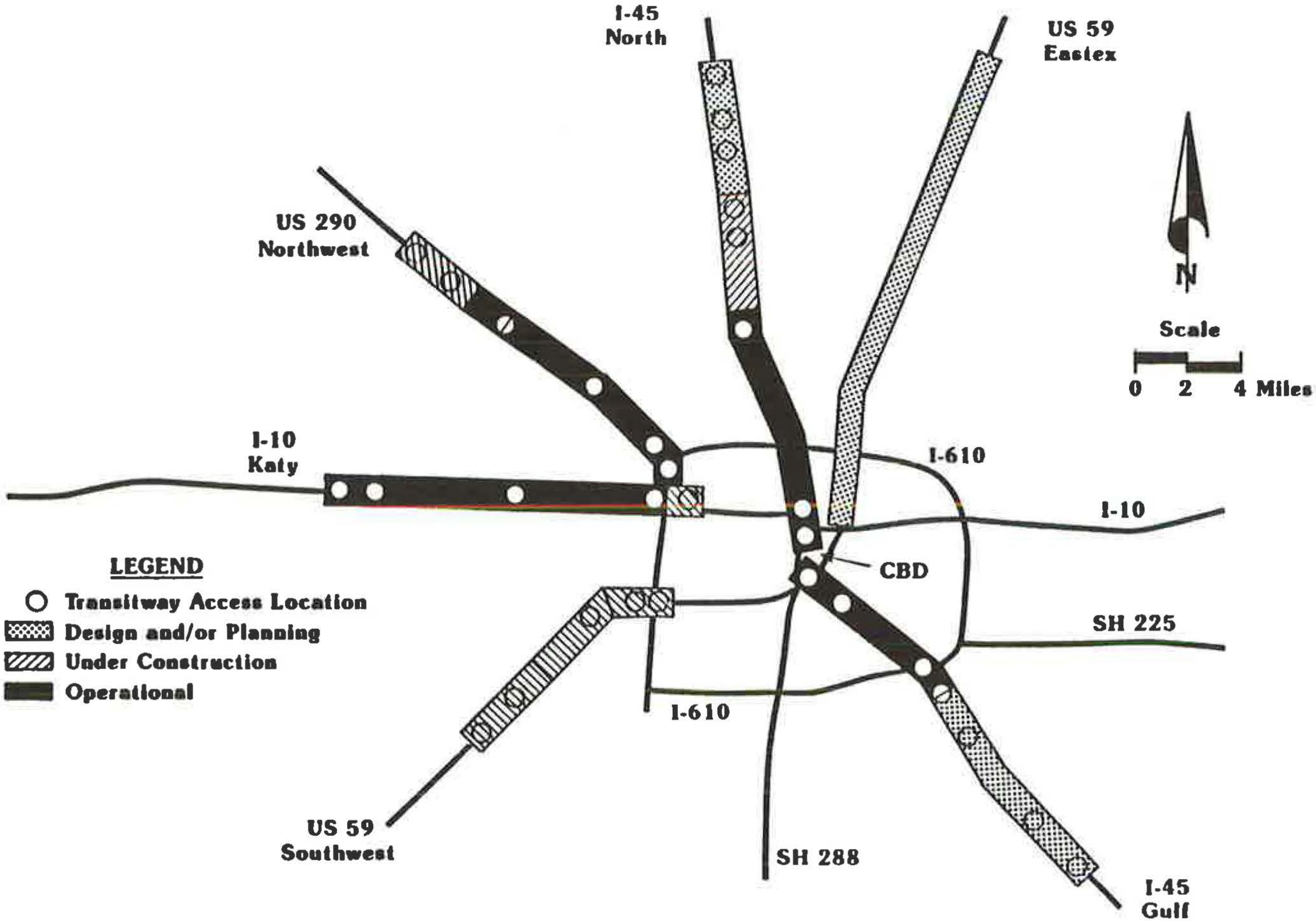

FIGURE 1 Status of Houston transitway development, March 1989.

The estimated capital cost of the entire 96 mi system is approximately $689 million, or about $7.2 million/mi. The 36.6 mi of facility in operation have been built for a construction cost of approximately $132 million, or $3.6 million/mi. For the five committed transitways, approximately 80 percent of the cost is being funded using transit dollars, with the remaining cost being funded with highway monies. In addition, the highway right-of-way in the median is being made available for these transitway projects.

Daily operation and enforcement of the transitways are a Metro responsibility, which is costing approximately $250,000/year per transitway.

Public Attitudes Regarding the Development of the Houston Transitway System

Because the transitway system being developed in Houston is somewhat unique and will involve an expenditure of approximately $700 million, public attitudes pertaining to transitway development have been an area of continued interest. Over the years, motorists using the general-purpose freeway main lanes have been surveyed to identify their attitudes concerning these priority lane projects. Surveys have been performed both on freeways that have transitways (Katy and North) and on a freeway (Eastex) that does not currently have a transitway. A primary issue addressed in these surveys was whether the transitways were perceived by the public to be good transportation improvements.

Acceptance of the transitway as effective improvements appears to have grown over time. When asked in 1986 and 1988 if the transitways were good transportation improvements, responses from both the Katy and North corridors were generally 63 percent yes, 21 percent no, and 16 percent not sure. In a corridor (Eastex) that does not currently have a transitway, the responses were 58 percent yes, 15 percent no, and 27 percent not sure. It should be emphasized that these responses are those of the motorists using the highly congested mixed-flow freeway lanes. Although these individuals may perceive that they are receiving relatively few direct benefits from transitway development, nevertheless, in their opinion the transitways are good transportation improvements.

Transitway Use and Travel Time Savings

Total daily person-trips served by the Houston transitway system in December 1988 exceeded 40,000, a 23.5 percent increase over 1987 (Table 2). As would be expected, the transitway lanes move a relatively high percentage of peak-hour person-movement in a relatively small percentage of total vehicles (Figure 2). The single transitway lane on both the North and Katy Freeways accommodates between 35 and 45 percent of the total peak-hour, peak-direction person-volume.

TABLE 1 STATUS OF OPERATING TRANSITWAYS, DECEMBER 1988

Transitway	Date First Phase Opened	Miles in Operation	Vehicles Allowed to Use Transitway	Hours of Weekday[1] Operation
Katy (I-10)	October 1984	11.5	3+ vehicles from 6:45 to 8:15 a.m. 2+ during other operating hours	4 a.m. to 1 p.m. inbound 2 p.m. to 10 p.m. outbound
North (I-45)	November 1984[2]	9.1	Authorized buses and vanpools[3]	5:45 to 8:45 a.m. inbound 3:30 to 7:00 p.m. outbound
Northwest (US 290)	August 1988	9.5	2+ vehicles	4 a.m. to 1 p.m. inbound 2 p.m. to 10 p.m. outbound
Gulf (I-45)	May 1988	6.5	2+ vehicles	4 a.m. to 1 p.m. inbound 2 p.m. to 10 p.m. outbound
TOTAL		36.6		

[1]The transitways are presently closed on weekends.

[2]A contraflow lane was implemented on the North Freeway in August 1979. It was replaced with a barrier-separated reversible lane in November 1984.

[3]Due to construction in the corridor, only buses and vans authorized by Metro are presently allowed to use the transitway.

However, the ridership increase between 1987 and 1988 presented in Table 2 occurred because two new transitways opened during 1988. Daily use of both transitways that were operational in 1987 declined in 1988 when compared to 1987. Daily ridership per mile of transitway declined from 1,583 in 1987 to 1,101 in 1988, a decrease of 30.4 percent.

An examination of transitway operations suggests that at least three factors are helpful in explaining ridership levels on an HOV facility.

Length of Transitway Operation

Even successful HOV projects have experienced rapidly increasing ridership during the first several years of operation. Ridership data (*3*) from the North and Katy transitways in Houston, the San Bernardino Busway in Los Angeles, and the Shirley Highway in the Washington, D.C., area show that, over the first 3 years of operation, all experienced ridership increases more than 200 percent. Apparently, mode choice changes continue to occur over a period of several years. Both the North and Katy transitways have experienced this growth period. However, at the end of 1988 both the Northwest and Gulf transitways had been operational for less than 8 months.

Vehicle Groups Allowed to Use Transitways

As would be expected, allowing carpools to use a transitway or reducing carpool occupancy requirements will result in an increase in transitway person-volume (as long as the vehicular capacity of the transitway lane is not exceeded), which explains the trend in use of the North transitway. Vanpooling in general has been declining in Houston, which is reflected in the ridership trends of the North transitway. The opening of this transitway to carpools (which may occur in 1989) should increase North transitway use. A somewhat similar experience has been occurring on the Katy transitway. Before instituting the three-or-more-person (HOV-3) carpool requirement from 6:45 to 8:15 a.m. in October 1988, usage of that transitway had been increasing throughout 1988 and exceeded 19,000 daily trips in September 1988. The change in occupancy requirements, which was necessary to address a vehicular capacity problem on the transitway, caused an immediate 17 percent drop in a.m. peak-period transitway person-volumes. Since October, that usage has been increasing as daily volumes in March 1989 increased to 17,600, a 5 percent increase over the December level presented in Table 2. A more detailed discussion of the implications of the carpool occupancy increase on the Katy transitway has been given by Christiansen and Morris (*4*).

Essential Travel Time Savings

Provision of travel time savings is perhaps the most important single factor influencing transitway use. Simply, unless severe freeway congestion exists and the transitway offers meaningful time savings, usage of transitways will not be high. It has been postulated for several years that a priority HOV lane

TABLE 2 SUMMARY OF SELECTED HOUSTON TRANSITWAY OPERATIONAL DATA

Data	Katy[1]			North[2]			Northwest[3]	Gulf[3]	Total, 4 Transitways		
	12/87	12/88	% Change	12/87	12/88	% Change	12/88	12/88	12/87	12/88	% Change
Miles of transitway	11.5	11.5	0.0%	9.1	9.1	0.0%	9.5	6.5	20.6	36.6	+77.7%
Transitway Person Volume											
Daily	17897	16772	- 6.3%	14722	12946	- 12.1%	5283	5291	32619	40292	+ 23.5%
A.M. Peak Hour	4580	3881	-15.3%	3732	3732	- 5.0%	1821	1787	8508	11221	+ 31.9%
A.M. Peak Period	8703	7319	-15.9%	7238	6640	- 8.3%	3235	2754	15941	19948	+ 25.1%
P.M. Peak Hour	3812	3750	- 1.6%	3765	2725	- 27.6%	985	780	7577	8240	+ 8.8%
P.M. Peak Period	8129	8429	+ 3.7%	7484	6306	- 15.7%	1960	2469	15613	19164	+ 22.7%
Transitway Vehicle Volume											
Daily	5733	5079	-11.4%	697	531	- 23.8%	1844	1424	6430	8878	+ 38.1%
A.M. Peak Hour	1469	938	-36.1%	189	151	- 20.1%	668	490	1658	2247	+ 35.5%
A.M. Peak Period	2788	1862	-33.2%	329	265	- 19.5%	1164	719	3117	4010	+ 28.6%
P.M. Peak Hour	1180	1122	- 4.9%	157	125	- 20.4%	304	372	1337	1923	+ 43.8%
P.M. Peak Period	2517	2723	+ 8.2%	368	266	- 27.7%	636	632	2885	4257	+ 47.6%
Avg. Vehicle Occupancy, A.M. Peak Hour	3.12	4.14	+32.7%	20.8	24.7	+ 18.8%	2.73	3.65	5.13	4.99	- 2.7%
Transitway Travel Time Savings, Avg. Peak Hour (min.)[4]	8.5	13.8	+62.3%	7.9	6.2	- 21.5%	4.3	5.3	16.4	29.6	+ 80.0%
Annual Value of Travel Time Saved ($ millions)[5]	$2.8	$8.6	+207.1%	$6.8	$4.0	- 41.2%	$0.8	$1.4	$9.6[6]	$14.8[6]	+ 54.2%

Notes: Peak hour is defined as the hour in which person movement is the highest. As a result, it is not always the same hour. The peak period is a 3.5 hour time period for all transitways except the North, where it is 3 hours in the a.m. and 3.5 hours in the p.m.

[1] In October 1988, occupancy requirements to use the Katy Transitway between 6:45 and 8:15 a.m. were increased from 2+ to 3+. In 1987, the transitway operated from 5:45 a.m. to 8:00 p.m.; in 1988, it operated from 4 a.m. to 10 p.m.

[2] The North Transitway, due to ongoing construction in the corridor, is used only by authorized buses and vanpools and operates for fewer hours per day than do the other transitways.

[3] Neither the Gulf nor the Northwest Transitways were operational in 1987.

[4] Travel time data can vary significantly due to normal variations in traffic flow. Time shown is average of a.m. and p.m. peak hours on a non-incident day.

[5] Based on travel time savings per day factored to account for travel time savings resulting from incidents and a value of time of $9/hour. The value shown is the upper end of the estimated range of travel time savings.

Source: Texas Transportation Institute.

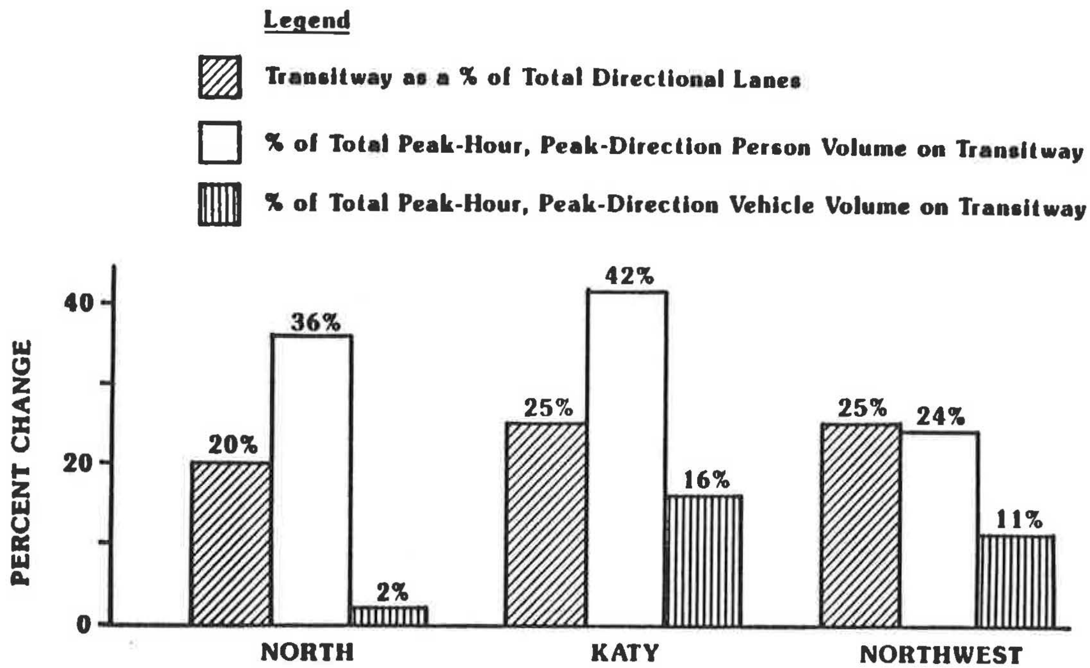

FIGURE 2 Transitway volumes as a percent of total (freeway plus transitway) a.m. peak-hour, peak-direction volumes.

must provide at least 1 min of travel time savings per mile of lane to be successful (*5*). Houston data (Figure 3), collected over several years, suggest that unless the transitway offers a travel time savings in excess of 7 to 8 min during the peak hour, use of the transitway will be marginal. This conclusion currently affects several of the Houston freeway transitways. Completion of the North Freeway main lane widening between I-610 and North Shepherd, combined with the opening of the Hardy toll road in that same corridor, has at least temporarily reduced transitway travel time savings offered by the North transitway. In 1979, when the North Freeway contraflow lane first opened, 15-min travel time savings to contraflow users were typical, but in 1988 the corresponding time savings were about 6 min. The section of the Gulf transitway currently in operation is located in a freeway segment that has recently been significantly expanded and the transitway currently offers peak-hour travel time savings of about 5 min. This marginal level of travel time savings will continue at least until the second phase of the transitway is completed. Although 9.5 mi of the Northwest transitway are operational, the geometrics and operations at the temporary terminus of this priority lane at West Little York cause severe congestion for transitway users. In fact, in the afternoon travel time savings generated on the transitway are more than negated by the congestion experienced at the terminus of the transitway. Completion of this transitway, scheduled for 1989, should eliminate this problem and result in an increase in transitway use. Until that occurs, marginal peak-hour travel time savings of about 4 to 5 min will continue to exist.

Transitway Travel Time Savings

Although transitway volumes have not been showing significant increases, the value of travel time saved by users of the transitways has increased because of the experience on the Katy Freeway. Changing the occupancy requirement to HOV-3 from 6:45 to 8:15 a.m. eliminated the delay that had been occurring on the transitway. At the same time, general freeway congestion was intensifying. Although person-volumes on the transitway declined somewhat, at least in the short run, delay incurred on the transitway declined by a much greater amount, resulting in an increase in travel time saved. The annual value of time saved by all users of the Houston transitway system in 1988 was approximately $14.8 million (Table 2). Nearly 60 percent of those savings were realized on the Katy Freeway transitway.

MEASURING THE EFFECTIVENESS OF THE TRANSITWAY SYSTEM

Before establishing criteria by which to measure the effectiveness of the transitways, the primary objectives for those transitway projects must be identified. Numerous potential objectives exist, some qualitative in nature and some that can be quantified. A 1985 survey (*6*) of HOV lane projects determined that increasing roadway capacity and reducing vehicle-miles of travel were the primary reasons for implementing HOV lanes nationwide. In Houston, the primary reason for transitway development was to increase effective roadway capacity. In the face of increasing congestion and projected freeway average daily traffic volumes in the range of 300,000 vehicles or more, travel demand simply could not be served either physically or economically just by building more additional mixed-flow freeway lanes. The transitways, with a design year volume of 7,000 to 10,000 persons/hr, could nearly double the person-movement capacity of a roadway and provide a conceptual means of serving projected travel demands. Thus, the primary objective of the Houston transitways is assumed

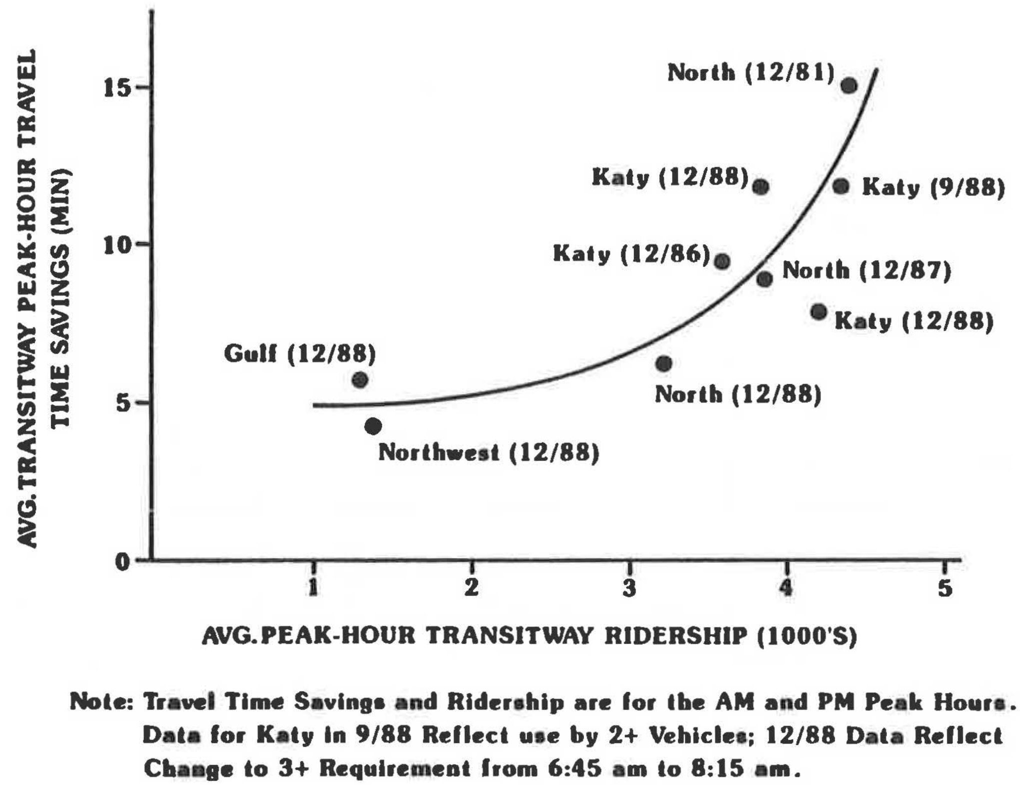

FIGURE 3 Relationship between peak-hour transitway ridership and peak-hour transitway travel time savings.

to be to increase, in a cost-effective manner, the person-movement capacity of a freeway and to do it in a manner that does not unduly impact the operation of the freeway's general-purpose, mixed-flow lanes.

A variety of positive benefits can be realized from the development of a successful transitway. Given the assumed primary objective of the transitways being developed in Houston, several potential measures of effectiveness can be quantified and used to help evaluate the performance of the transitway system.

Transitway Projects Should be Cost-Effective

Unless the transitway project is cost-effective, the project will not be able to successfully compete for the limited funds available. Many of the potential benefits associated with a transitway, such as air quality, energy, and regional economic effects, are difficult to quantify. However, one that can be quantified is the value of the time saved by those persons using the transitway. If the project has a benefit-cost ratio greater than 1 only on the basis of this single benefit, the project is cost-effective. This approach would suggest that the average annual value of time saved by users of the transitway over the life of the project should be at least 10 percent of the total transitway construction cost.

Percentage Increases in Peak-Hour, Peak-Direction Person-Volumes Resulting from Transitways Should at Least be Greater Than the Percentage Increase in Directional Lanes Added to the Roadway

In effect, this goal will be accomplished by increasing the average vehicle occupancy (persons per vehicle) on a roadway. Much of the increase in the average vehicle occupancy should be the result of creating new carpoolers and new bus transit riders. Previous research (*5*) has suggested that average occupancy should increase by about 10 percent for a project to be successful, with the percent of the total person-movement occurring in the HOV lanes used as the measure of success. Experience in Houston would suggest this threshold might be a conservative measure of success because a 10 to 15 percent increase in average peak-hour vehicle occupancy for the entire roadway might be a more appropriate indicator of whether a transitway is effective.

Transitways Should Not Unduly Affect the Operation of the Freeway Mixed-Flow Lanes but Should Increase the Per-Lane Efficiency of the Roadway

Transitways should not severely degrade safety or operations of the freeway main lanes. Also, the transitway should significantly increase (say, by more than 25 percent) the peak-hour, peak-direction efficiency per lane of the roadway facility. As defined in this discussion, peak-hour, per-lane efficiency is defined as the peak-hour person-volume, times average speed, divided by number of lanes.

Criterion 1: Transitway Projects Should Be Cost-Effective

Clearly, transitway development is not desirable unless cost-effective. Many of the potential benefits associated with a transitway facility, although possibly significant, are difficult to quantify without making numerous assumptions. Included in this benefit list are factors such as air quality, energy consumption, impact on regional economic development, impacts of improved bus schedule reliability, etc. Nevertheless, all of these can be potentially significant benefits.

However, one benefit that can be quantified relatively easily is the value of the time saved by users of the transitway facility. If the project is cost-effective solely on the basis of that criterion, it would be even more cost-effective if all the other potential benefits were considered. Also, if the transitway operational values associated with a cost-effective project can be identified, other measures of effectiveness are easier to establish.

Depending on the assumptions made concerning the discount rate and project life, different conclusions could be drawn concerning the level of travel time savings required to make the transitway project cost-effective solely on the basis of that criterion. However, as a rule of thumb, if the average annual value of the transitway user travel time savings is at least 10 percent of the construction cost of the project, the transitway project will be cost-effective (assuming a constant stream of benefits, a 20-year project life, and a 4 percent discount rate). In Houston, the conclusion is also based on the fact that the present value of the operating and enforcement costs is small compared with the capital cost.

Because congestion can generally be expected to increase in the future, the average annual value of time saved over the project life should be greater than the amount saved in the early years of the project. However, if the project appears cost-effective on the basis of today's level of use, the transitway should prove to be even more cost-effective as use increases. On the basis of the information presented in Table 2, the current annual value of time saved by users of the transitways as a percent of the capital cost of the transitway as currently operating is Katy, 27 percent; North, 14 percent; Gulf, 5 percent; and Northwest, 2 percent. The value of time being saved on the North and Katy transitways is significant when compared with the other two operating transitways, both of which have been in operation for less than 1 year.

Although the data and the analysis could be better, the procedure developed can be used as a means of estimating ridership levels needed for a transitway with a Houston-type design and associated cost to at least appear to be cost-effective (Figure 4). These facilities would need to serve more than 10,000 person-trips daily, which would roughly translate to serving in excess of 2,500 persons in the peak hour. Although the data supporting these conclusions are not definitive, this general finding is in agreement with previous research (*7*) pertaining to the cost-effectiveness of barrier-separated transitways, which used simulation models as a means of identifying transitway cost-effectiveness.

Criterion 2: Transitways Should Significantly Increase Roadway Person-Movement and Average Vehicle Occupancy

A primary reason for implementing transitways is to increase the person-movement capacity of the roadway during peak operating periods. Because transitways do increase the number of directional lanes, in order to be cost-effective the transitway should at least increase peak-hour person-movement by an amount greater than the increase in lanes added to the roadway caused by the transitway. If the transitway does not do this, an additional mixed-flow, general-purpose lane could be a more effective improvement. For two (Katy and North) of the three Houston transitways for which data are available, this type of increase clearly has occurred. The Katy transitway increased the number of directional lanes by 33 percent, and the a.m. peak-hour person-movement by 80 percent. The corresponding values for the North transitway are 25 and 65 percent, respectively. On the more recently opened Northwest transitway, directional lanes were increased by 33 percent and to date a.m. peak-hour person movement has increased by only 22 percent.

For the transitway to generate a disproportionately large increase in person-movement, the transitway must also increase

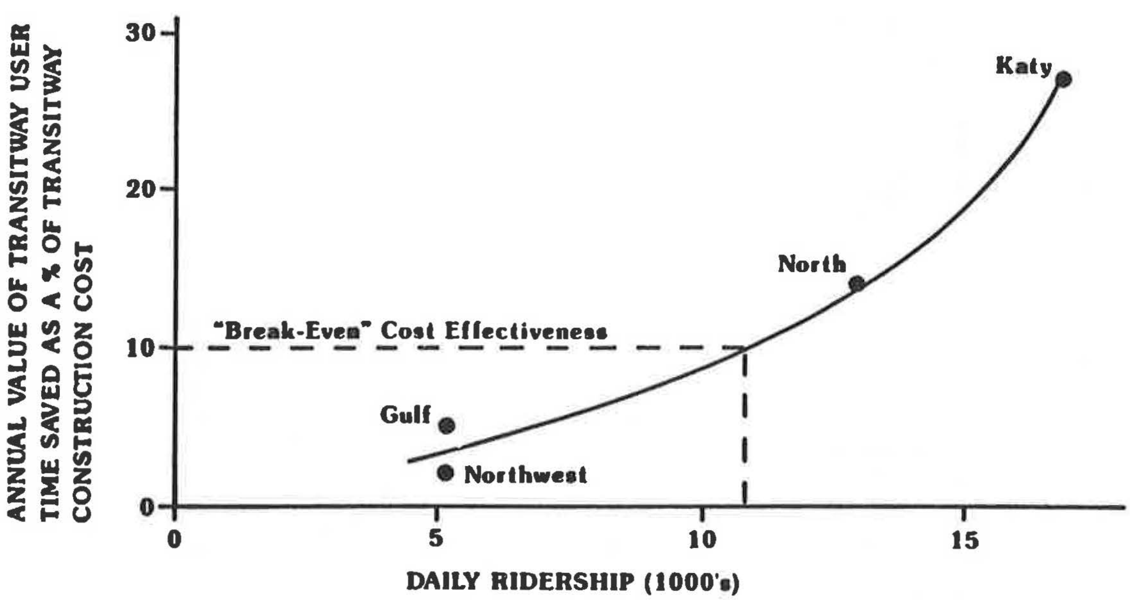

FIGURE 4 Estimated transitway ridership required for transitway to be cost-effective.

the average vehicle occupancy (persons per vehicle) characteristic of the roadway. Transitways are intended to offer a travel alternative that a significant percentage of commuters will find attractive and, therefore, will choose to either carpool or ride a bus. The result of these rideshare decisions will be that the occupancy (combined freeway and transitway volumes) for the overall roadway facility will increase.

In comparison to pretransitway conditions, a.m. peak-hour average vehicle occupancy on the North Freeway has increased by 25 percent, from 1.28 to 1.60 persons per vehicle. On the Katy Freeway, a 23 percent increase from 1.26 to 1.55 persons per vehicle has been realized. Those occupancies are unusually high for Texas freeways. To date, occupancy on the Northwest Freeway has increased by 10 percent, from 1.14 to 1.26 persons per vehicle. The fact that these increases in occupancy can be at least partially attributed to the presence of the transitway is supported by the fact that occupancy has actually declined by 9 percent on the control freeway that does not yet have a transitway (Southwest Freeway).

Carpool Component

The increase in average vehicle occupancy on a roadway should be the result of new rideshare patrons. If all the transitway accomplishes is to divert existing carpools from parallel routes to the transitway, the effectiveness of the transitway would need to be questioned.

Because carpools naturally have a fairly high turnover rate, difficulties arise from how to precisely determine how many of the carpools using a transitway are new carpools formed because of the transitway. One indicator is the previous mode of travel for the carpoolers (Figure 5). These data indicate that between 27 and 45 percent of the current carpoolers on the transitways were previously in drive-alone vehicles. The sum of drive-alone plus new trips, which is in the range of 35 to 56 percent, could be representative of new carpools.

However, because of the relatively high turnover rate of carpools, particularly for transitways that have operated for several years such as the Katy, at least some of those with a previous mode of drive-alone would have formed carpools regardless of whether a transitway were in existence. In order to try to identify this portion of the carpool component, carpoolers using the transitways were asked if they would be carpooling if there were no transitway (Table 3). On the mature Katy transitway, approximately 40 to 45 percent of the existing carpoolers previously drove alone and formed a carpool as a result of the transitway. The corresponding value for the less mature transitways appears to be in the range of 20 to 34 percent. Apparently, the transitways have been a factor in creating new carpools because the percentage of carpoolers whose previous mode was drive alone is representative of new carpools formed as a result of the transitway.

In comparing pre-transitway conditions to current conditions, the type of increase in carpooling that has been observed in freeway corridors with transitways has not occurred in the control corridor not having a transitway. Although the a.m. peak-hour volume of HOV-2 carpools (freeway plus transitway) has increased by 85 percent on the Katy and 128 percent on the Northwest Freeway, on the control freeway (Southwest) not having a transitway, the corresponding carpool volume has increased by 26 percent over the comparable time period.

Preliminary data also suggest that carpools formed in corridors with transitways may last longer than carpools in corridors without transitways. Surveys in 1986 of carpoolers using

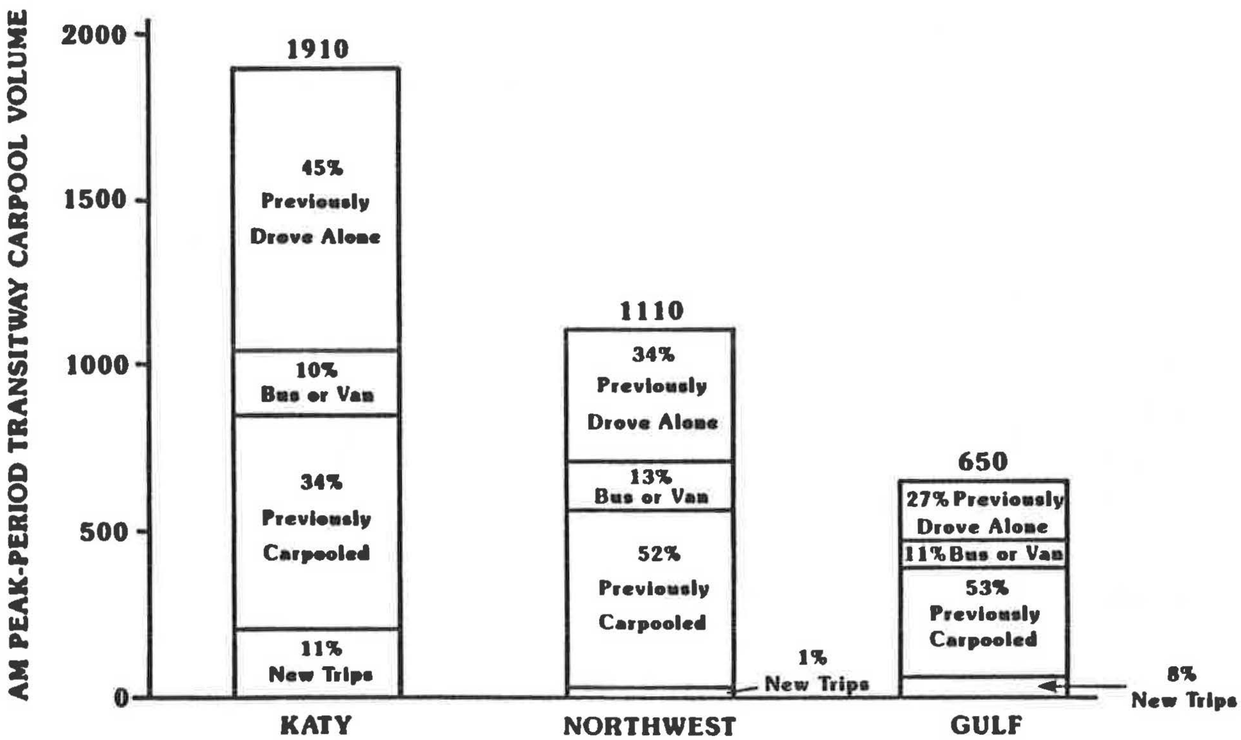

FIGURE 5 Previous mode of travel for transitway carpoolers.

TABLE 3 ESTIMATED IMPACT OF TRANSITWAYS IN FORMING NEW CARPOOLS

Transitway	Apparent % New Carpools Based on Previous Mode[1]	Would You Carpool if No Transitway			Est. % Carpools Due to Transitway[3]
		Yes	No	Not Sure	
Katy	56%	53%	35%	11%	40%-45%
Northwest	35%	70%	21%	9%	25%-34%
Gulf	35%	75%	14%	11%	20%-27%

[1]From Figure 5, the sum of "Drove Alone" plus "new trips".

[2]Transitway carpooler response to the question "If the transitway had not opened, would you be carpooling today?"

[3]It is assumed that the sum of the "no" responses plus one-half of the "not sure" responses equals the lower end of the percentage of total transitway carpools that were previously "drive alone" that formed a carpool as a result of the transitway. The upper end is the "drove alone" component from Figure 5.

the Katy transitway indicated that the average carpool on that facility had been in existence 30 months. Surveys in late 1988 on two transitways that had just opened indicated that the average carpool in those corridors had been in existence for about 20 months.

Bus Transit Component

As was the case with carpooling, available data suggest that the transitways have resulted in the creation of a large volume of new bus riders. For example, compared with pretransitway conditions, peak-hour, peak-direction bus ridership on the Katy Freeway has increased by 373 percent. Previous mode data for the North and Katy transitways suggest that fewer than 25 percent of bus riders on the transitway rode a bus before being transitway bus riders (Figure 6).

The fact that transitways generate new bus riders is further illustrated by the response to the question "If the transitway had not opened, would you be riding a bus now?" These data, presented in Table 4, suggest that approximately 50 percent of the bus riders in the Katy and North corridors are riding buses because of the existence of the transitway.

However, not all of these new riders can be attributed solely to the development of a transitway. The increased frequency of bus service being provided would, by itself, have more than doubled pretransitway bus ridership (assuming a service elasticity of 0.50). About half of the current bus riders on the Katy transitway are estimated to be new riders generated as a result of implementing the transitway. On the recently opened Northwest transitway, about all of the 23 percent increase in peak-period bus ridership can be attributed to the increase in frequency of bus service provided.

However, although a.m. peak-period bus ridership on the Katy transitway has increased by 224 percent and on the Northwest transitway has increased by 16 percent, in the control freeway corridor, not having a transitway, no change in bus ridership has occurred over the comparable time period. The same experience has occurred in observing the number of vehicles parking at bus park-and-ride lots in the corridor. Compared with pretransitway conditions, a 196 percent increase in parked cars has taken place in the Katy corridor and a 35 percent increase in the Northwest corridor. In the control corridor not having a transitway, a 1 percent increase has been observed over the comparable period of time.

Criterion 3: Transitways Should Increase the Overall Efficiency of the Roadway

Transitways can be cost-effective and can increase the person-movement capacity of a roadway. However, the transitway should not unduly affect the operation of the freeway main lanes. Transitways should also increase the overall efficiency of the roadway in which the transitway is a part. If these criteria are not realized, other potential transitway benefits such as air quality and energy impacts will not be maximized.

Impact on Freeway Main Lane Operations

Transitways, in order to be successful, must offer a significant travel time savings. As such, transitways are congestion-dependent improvements. Severe congestion must exist on the freeway for the transitway to be able to be successful by offering a significant travel time savings.

Available data suggest that the implementation of transitways with a design similar to that being used in Houston does not greatly affect the operation of the freeway main lanes, either positively or negatively. Transitways have not

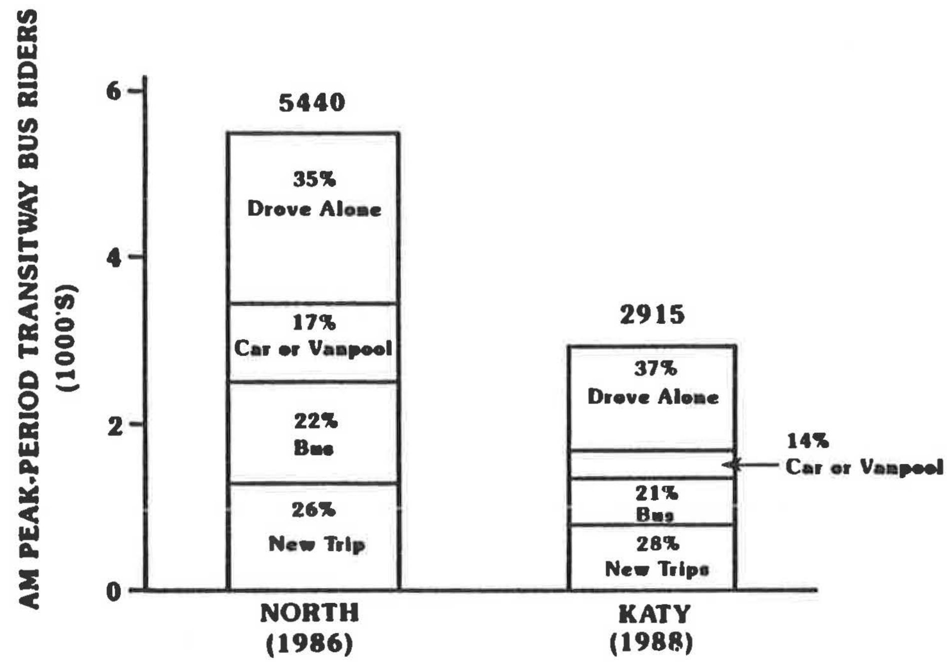

FIGURE 6 Previous mode of travel for transitway bus riders.

TABLE 4 ESTIMATED IMPACT OF TRANSITWAYS IN CREATING NEW BUS RIDERS

Transitway	Would You Be Riding a Bus if no Transitway[1]			Est. % New Bus Riders Due to Transitway[2]
	Yes	No	Not Sure	
North (1986)	23%	41%	36%	59%
Katy (1988)	36%	32%	32%	48%

[1]Transit rider response to the question "If the transitway had not opened, would you be riding a bus now?"

[2]It is assumed that the sum of the "no" response plus one-half of the "not sure" responses equals the percentage of existing transitway bus riders who would be riding the bus (i.e., new riders) if there were no transitway.

greatly altered demand for the freeway main lanes because during peak periods, in comparison to pretransitway conditions, the vehicular volume per freeway main lane is essentially unchanged or has increased slightly. Although speeds on some freeways have actually increased since transitway implementation, this increase is largely attributable to factors other than the transitway. In addition, compared with pretransitway conditions, accident rates for the freeways with transitways have generally declined slightly. For example, for the control freeway (Southwest Freeway) without a transitway, accident rates have remained essentially unchanged for the comparable time periods.

Impact on Overall Roadway Efficiency

Transitways are intended to move substantial volumes of commuters at relatively fast speeds. As such, successful transitways should improve the overall efficiency of a freeway. For purposes of this discussion, peak-hour efficiency of the freeway is expressed as the product of the peak-hour person-volume times the speed at which that volume is moved. Peak-hour efficiency is expressed on a per-lane basis. In all cases for which data are available, implementation of the transitway increased the overall efficiency of the facility (Table 5). These increases in efficiency have been larger than those experienced on a freeway that does not have a transitway.

This criterion has weaknesses in that it does not directly address what would have happened to overall roadway efficiency had the new lane been used as another mixed-flow lane rather than a transitway. However, the North Freeway where, in addition to the transitway, an additional mixed-flow lane has been added provides some measure of this impact. About half of the overall increase in roadway efficiency has occurred in the main lanes (Table 5). Virtually all of the increase in the Northwest Freeway is caused by improvements in main

TABLE 5 ESTIMATED CHANGE IN PEAK-HOUR PER-LANE EFFICIENCY, BEFORE AND AFTER TRANSITWAY IMPLEMENTATION

Freeway	Pre-Transitway Freeway Efficiency	Current Freeway Efficiency	Current Combined Freeway and Transitway Efficiency	Percent Change
North	41	65	89	+117%
Katy	38	44	77	+103%
Northwest	62	88	90	+ 45%

[1]Peak-hour per lane efficiency defined on the person volume per lane times the average speed divided by 1000. Thus, it is a measure both of the volume moved and the speed at which that volume is moved.

lane operation, in line with the 35 percent increase experienced on the control freeway. For a transitway to be effective, the transitway alone should increase the efficiency of the roadway by at least about 20 percent. In both the North and Katy corridors, a meaningful increase in per-lane efficiency has occurred that can be attributed to the transitway. This result has not occurred to date in the Northwest corridor.

CONCLUSION

A 95.5-mi system of freeway transitways is being developed in Houston with 36.6 mi operating in four different freeway corridors today. Development of the system appears to have public support.

The principal objective of the Houston transitways was assumed to be to cost-effectively increase the person-movement capacity of the freeways and to do this in a manner that does not unduly affect the operation of the freeway main lanes. With this assumed objective, several performance measures have been developed.

In assessing the performance of the transitway in meeting its objectives, the following quantitative values can be used as guides.

Objective: Transitways Should Be Cost-Effective

Potential performance measure—

- Conservatively, the project will have a benefit-cost ratio >1 if the average annual value of the time saved by users of the transitway over the life of the project exceeds 10 percent of the initial construction cost of the transitway.

Objective: Increase Roadway Person-Movement

Potential performance measures—

- Daily transitway ridership should be in excess of 10,000;
- The transitway should increase peak-hour, peak-direction person-movement by an amount greater than the increase in directional lanes added to the roadway due to transitway implementation; and
- The transitway should increase the a.m. peak-hour, peak-direction average vehicle occupancy (persons-per-vehicle) for the roadway by at least 10 to 15 percent.
  —More than 25 percent of the carpools using the transitway should be new carpools created because of the transitway, and
  —More than 25 percent of the bus riders using the transitway should be new bus riders created because of the transitway.

Objective: Don't Unduly Impact Freeway Main Lane Operations

Potential performance measures—

- A statistically significant increase in either freeway congestion or freeway accident rate should not result solely from transitway implementation.
- Absolute value of the total roadway per-lane efficiency should increase by at least a factor of 20 because of implementation of the transitway (total roadway efficiency should be at least 20 times greater than freeway main lane efficiency). Efficiency is the product of person-volume times speed.

Performance measures suggest that the Katy transitway is clearly fulfilling its intended objective. Although the North transitway also appears to be effective, allowing carpools onto this facility will increase its attractiveness and should, on the basis of current carpool demand estimates, make it comparable to the Katy transitway in terms of performance. As presently operated, neither the Gulf nor the Northwest transitway can be considered to be effective. However, only the first phase of these projects is presently operating and future extensions will significantly increase potential transitway travel time savings and, thus, enhance the attractiveness of the facilities. Also, these facilities have not operated for a long period of time (less than a year) and some growth in transitway use can be expected to take place over time.

Continued monitoring of all the committed transitways will take place as part of ongoing research projects.

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