Influence of HOV Lane Access on HOV Lane Utilization

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Abstract: High-occupancy vehicle (HOV) lanes are employed in many cities as a traffic congestion mitigation technique. These lanes are intended to provide a travel time benefit to carpools and buses, providing an incentive to choose those modes. The time and frustration involved in finding and using HOV lane access points may act as a deterrent to HOV lane use. Thus, proper planning of HOV lane access may be able to improve convenience for potential users, increasing HOV lane utilization. This paper investigated the possible relationship between the time required to access the HOV lane and travelers’ choice of HOV lane as their mode. Additionally, the distance to HOV lane access points and the type of access point were examined for their influence on HOV lane use rates. It was concluded that neither the type of HOV lane access point (for example, a T-ramp versus a slip ramp) nor the added time necessary to access the HOV lane were significant factors in HOV lane use rates. Instead, the convenience of carpool formation and the convenience of HOV lane access to traveler’s origins and destinations were found to be the most important factors in HOV lane use rates.

DOI: 10.1061/(ASCE)/TE.1943-5436.0000172

CE Database subject headings: High occupancy vehicles; Traffic management.

Author keywords: HOV lane; Access; GIS, HOV mode choice.

Introduction

Background

High-occupancy vehicle (HOV) lanes have been successfully used as a congestion mitigation technique in several metropolitan areas in the United States (Fuhs and Obenberger 2002). These lanes have provided rapid movement for high numbers of person trips during daily commutes and have encouraged greater carpooling in many communities even as nationwide vehicle occupancy is on the decline (Christiansen 1990; Poole and Orski 2003). This said, the public perception of HOV lanes tends to be that they are underutilized, and that the capacity they provide should be converted to use for all vehicle classes. This attitude has been best demonstrated in New Jersey on Interstates 80 and 287. Public outcry over underutilization of those lanes resulted in their redesignation as general purpose lanes (GPLs) in 1998 (Texas Transportation Institute 2000).

Underutilization was noticed early in the development of the HOV lane system in Houston. Originally, these lanes were built by the transit agency to facilitate express bus service on congested corridors and are separated by a barrier from the GPLs. However, it was realized that by only allowing buses and authorized vanpools on the lane, the majority of the capacity was wasted. Thus, Houston’s HOV lanes were opened to carpools, greatly increasing their utilization (Turnbull 2003).

Despite the relaxation in occupancy requirements in Houston, the HOV lanes are still operating well below capacity during off-peak periods. Factors influencing this include the fact that carpooling can be inconvenient, and that the travel time savings and reliability offered by the HOV lane do not outweigh the inconvenience of carpooling for many travelers. The convenience of HOV lane access points may play a role in HOV lane utilization. In fact, several factors have been indicated as being important influences on HOV mode choice, including accessibility of HOV facilities, travel time savings, and availability of transit to travelers. The question is how important is HOV lane accessibility on HOV lane utilization.

Literature Review

Aronson and Homburger manually linked carpool and transit users’ origins and destinations and used the survey respondents’ reported travel time, distance, and cost savings to determine the benefits of park and rides in the San Francisco and Los Angeles areas. Additionally, they identified many factors affecting park-and-ride lot utilization and resulting carpool and transit use. Foremost, they indicated that accessibility was important to park-and-ride lot use due to the need to minimize the delay users incurred to maximize utilization (Aronson and Homburger 1983).

They found no strong correlation between the increased carpooling and the associated decrease in vehicle miles traveled and the location or design of park and rides (Aronson and Homburger 1983). This finding can be extended to HOV lane access points in the Houston area because many are located within park-and-ride lots or transit centers. However, it contrasts with our understanding of mode choice behavior, which would imply that a well placed park and ride would have greater use than one which was less accessible.

Kumar and Goss indicated that when bus stops were within a quarter mile of the traveler’s origin and destination and headways were in the 5–10-min range, that transit mode share would reach

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Note: This manuscript was submitted on October 29, 2008; approved on April 20, 2010; published online on June 9, 2010. Discussion period open until April 1, 2011; separate discussions must be submitted for individual papers. This paper is part of the Journal of Transportation Engineering, Vol. 136, No. 11, November 1, 2010. ©ASCE, ISSN 0733-947X/2010/11-1030–1038/$25.00.
as high as 50% (Kumar and Goss 1977). Notable in this study was the indication that accessibility was a major factor in choosing a mode, other than driving alone.

The assertion of Aronson and Homburger (1983) that the effect of the location of park and ride sites has little effect on utilization is supported by Hall (1997). Hall’s study focused on the effect of the spacing of highways and arterials on relative use and vehicle miles traveled using a theoretical framework of minimizing net travel time. The study showed that frequently spaced but lower capacity roadways could reduce overall network travel when compared to infrequent but very high capacity roadways due to the reduced need for backtracking. Additionally, the study found that express highways with infrequent access would likely be able to attract 50% or more of highway travel (Hall 1997). This demonstrates that frequent access to an express route is not necessary. These findings can logically be extended to HOV lanes, which function similar to express highways for HOVs due to their access and occupancy restrictions. However, none of this clearly demonstrates the impact of HOV accessibility on mode choice.

**Problem Statement**

Despite the research done in the area of HOV and high-occupancy/toll (HOT) lanes, little is known about the influence of access locations on lane utilization. Understanding the interaction between the roadway network where HOV or HOT lanes are located and the optimal locations for access to these lanes may be important in maximizing the use of these expensive infrastructure investments. Efficient access locations are important for HOV lane operation since access points must compliment and facilitate express bus service in order to maximize the benefits derived from the lanes. Access is also important for HOT lanes, where customers paying to use the lane will only do so if the HOT lane is an attractive alternative to congested GPLs. (For simplicity, the paper will refer to HOV access but this includes HOT lane access as well.)

The problem of access is multifaceted, particularly when the lane is barrier separated from the GPLs. The number of access points must be limited to as few as practical in order to maximize the travel time savings on the HOV or HOT lane. However, access points spaced too infrequently could eliminate the travel time benefit of the HOV or HOT lane by requiring travelers to deviate from their shortest time path to a longer and less convenient route just to access the HOV lane.

**Research Objectives**

The goal of this paper was to investigate the effects of HOV lane access on HOV lane use. The specific objectives included the following:

- Determine HOV lane use rates by proximity of origins and destinations to access points;
- Determine HOV lane use rates by the difference between HOV lane access time and GPL access time (added HOV lane access time) for people’s routes;
- Determine HOV use rates by the ratio of added HOV lane access time to total trip time; and
- Determine how HOV lane access type affects HOV lane use rates.

This paper, by exploring factors not well understood to transportation researchers and practitioners, enhances the understanding of factors affecting travelers’ choice to use HOV lanes and thus could allow professionals to implement designs which encourage greater HOV lane use.

**Data Collection and Reduction**

**Data Collection**

**Surveys**

One of the surveys used for this paper was administered to a wide array of travelers on the Katy (I-10) and Northwest Freeways (U.S. 290) in the Houston area. Traveler groups included transit users, casual carpoolers, freeway mainlane travelers, and HOV lane travelers. This survey was administered primarily to determine respondent reactions to various HOT lane pricing and occupancy scenarios (Burris and Xu 2006). Surveys were mailed to freeway mainlane and HOV lane travelers. To determine where to mail surveys to reach the target user groups, video cameras were placed along the Katy and Northwest Freeway corridors to record the license plate numbers of travelers along those roadways. In 75 h of video, 19,260 readable license plates were observed. After removing plates registered to businesses, duplicates, plates with no address on file with the Texas Department of Public Safety, and plates from states other than Texas, approximately 14,000 travelers in the corridors of interest were identified, and surveys were mailed to their addresses. The total response rate was 23.0% (Burris and Xu 2006; Winn 2005; Xu 2005).

The other survey used was administered primarily online to travelers in both Houston and Dallas. This survey focused on the characteristics of respondents’ trips, socioeconomic characteristics of respondents, respondents’ attitudes toward the concept of managed lanes, and their reactions to different toll and occupancy scenarios for managed lanes. To boost the response rate in underrepresented groups, specifically low income Hispanics and African-Americans, the surveys were also administered on laptop computers and in paper form at Department of Public Safety drivers’ license offices, libraries, and a community center in Houston. A total of 2,036 surveys were completed in the Dallas area and 2,575 in the Houston area for a total of 4,611 (Mahlawat 2007).

For the purposes of this paper, the responses from Dallas were not included. Only those respondents who used either the Katy or Northwest Freeways were examined in this paper. Many of the questions asked, especially regarding socioeconomic characteristics, travel characteristics, and the rationale behind traveler mode choice, were similar in both surveys. The combined results from the two surveys were analyzed in this paper.

**Complicated HOV Lane Access**

Access to the barrier separated HOV lanes can be complicated and time consuming. While slip ramps allow direct access between freeway mainlanes to the HOV lane (primarily at the ends of the HOV lane), neighborhood oriented access through park-and-ride and transit facilities takes far longer to use, as shown in Fig. 1. Furthermore, these access points may require substantial route deviation for travelers.

A particularly complex access point is the Northwest Transit Center located at the intersection of the Katy Freeway and I-610 (see Fig. 1). This access point is near the downtown end of the Katy Freeway HOV lane and is the downtown end of the Northwest Freeway HOV lane.
The Northwest Transit Center has direct ramp access to the Northwest HOV lane, ramp access to the Katy HOV lane separated by one traffic signal, and is located at the intersection of two major streets. These streets, however, have no nearby access to the freeway main lanes. Navigating this transit center is a time-consuming process as well; it takes approximately 1 min and 40 s to travel from the intersection of Old Katy Road and Post Oak Road, which is shown in the upper left corner of the schematic, to the HOV lane. These travel time issues may decrease the appeal of carpooling and transit use for travelers who would be served by this facility.

**HOV Lane Access Times**

The times for HOV access were determined for HOV lane access points along the Northwest and Katy Freeways. This was accomplished by observing vehicles using the HOV access points or by actually driving the access points. The access times for the access points were entered into the geographic information system (GIS) for those links. These access times were consistent in the peak and off-peak periods, as there is no congestion in the park-and-ride facilities.

**ArcGIS Network Creation**

Next, the data were manipulated for use in ArcGIS version 9.2, a GIS software package (ESRI 2008). ArcGIS includes a network analysis extension, which allows networks to be created based on map data and other characteristics. This extension includes tools for creating routes on a network between geocoded or manually input points, and for determining the service area of a feature, such as the locations which lie within a certain network distance or travel time of a location. In this study, the service area tool was used to determine the travel time from respondents’ origins to the nearest HOV and GPL entrance points and the travel time to their destinations from the nearest exit points. The basis of the analysis was county level road network maps in the form of TIGER line files from the United States Census Bureau.

Roadway functional classification was included as a parameter of the roadway network. The classes used were HOV lane, freeway, major arterial, and other roads. These classifications aided the network analyst extension in determining routes based on the common driver behavior of favoring higher functional classification roadways.

To facilitate travel time based network routing in later steps, peak, shoulder, and off-peak travel times for each link were added to the attribute table. Freeways and HOV lanes were assigned travel times based on the speeds for each travel period as observed by Houston’s Transtar Traffic Management System. HOV ramp travel times were directly observed and thus entered directly (as noted above). Speeds for arterials were assumed to be 35 mph in the shoulder and off-peak periods and were assumed to drop to 30 mph in the peak periods. Speeds on other roads were assumed to be 20 mph all day. Using assumed speeds rather than observed speeds for the lower-classification roads will not have a substantial impact on the results of the comparisons between HOV and GPL users. The critical portion of respondents’ trips being compared (access to the HOV lane versus the GPLs and speeds on the HOV and GPLs) uses travel times based on observed speeds. The travel times to the GPL or HOV access points will be similar and be impacted minimally by the assumed surface street speeds. From this map, which now included HOV lanes, travel time information, and functional classification information, a network was constructed using ArcGIS’ network analyst extension. This network included impedance values for peak, shoulder, and off-peak travel times, travel distance, and functional classification for the roads in the Houston area.

**Data Combination and Reduction**

**Survey Data**

The surveys were combined, relevant data were extracted, and errors were removed. This effort included the following steps:

- Identifying similar data categories between the surveys;
- Converting the data in similar categories to a consistent format;
- Consolidating the surveys into one database;
- Removing respondents who did not indicate use of U.S.-290 or I-10 Katy, the corridors of interest; and
- Quality control—checking the data for erroneous or missing values.

Initially, there were a total of 8,139 respondents in the combined data set. Then, after limiting the data set to travelers who listed both their origin and destination location and who indicated travel on the Katy or Northwest Freeways, our corridors of interest, the number of respondents was reduced to 4,321, 53.1% of the original data set.

The data set was reduced further based on the ability to geocode the respondents’ reported origins and destinations and the ability to connect the reported origins to the corresponding destinations. Geocoding is the process of locating the trip origins and destinations listed by the survey respondents on the map. There were 1,609 respondents whose origin and destination could be geocoded, a route found from the origin to the destination, and who traveled in the peak direction. This represented 37.0% of the survey respondents who indicated that they traveled on the freeways of interest. These 1,609 respondents are examined in the subsequent sections.

**Data Analysis and Results**

**Data Analysis**

Factors such as proximity to HOV lane access, the added travel time necessary to use the HOV lane access points, and the ramps and type of ramps were examined to determine which factors, if any, may have influenced travelers’ use of HOV lanes.

Travelers’ least-time path from origin to destination was determined with GIS software. HOV lane access points were part of...
the GIS model, allowing the travel time a traveler would have to
deviate from their least-time path to be determined. From this,
HOV lane ingress and egress times were calculated and summed
to determine the total HOV lane access time.

Based on vehicle occupancy and volume counts conducted on
I-10 Katy and U.S.-290 in 2003, the proportion of person trips
made by GPL and HOV lane in the corridors was calculated.
Overall, 78.3% of person trips were made in the GPLs, whereas
21.7% were made in the HOV lane. Unfortunately, this ratio of
person trips did not correspond with the ratio of survey respon-
dents using each type of lane. Of the routed survey respondents,
only 57.6% used the GPLs, whereas 42.4% used the HOV lane.
This discrepancy is most likely explained by the much higher
response rate among surveys administered on transit buses or to
those travelers who use the HOT lanes, which are located on the HOV lanes, could be
directly targeted in the surveys because their addresses were part
of the HOT lane registration information.

The inconsistency between the survey data respondents’ mode
share and the mode share observed in the field was accounted for
using poststratification. Poststratification corrects for differences
between known proportions of strata and the proportions reflected
in a sample using weighting. Poststratification is considered ap-
plicable and accurate when the population proportions are known,
when there are more than 20 members of the sample in each
stratum, and the effects of errors in the weights can be ignored
(Cochran 1953). In this analysis, the two strata are GPL and HOV
lane users, and average daily traffic and average vehicle oc-
cupancy are known for both I-10 Katy and U.S.-290, giving the
population characteristics. The sample sizes were sufficiently
large with 926 of the routed survey respondents using the GPLs
and 683 using the HOV lane.

The weighting factor was the ratio of the true proportion to the
surveyed proportion of HOV and GPL users. The weighting factor
for respondents indicating HOV lane use was 0.51, while the
weighting factor for respondents indicating GPL use was 1.36. All
results presented in the following sections are weighted.

**Results**

**Spatial Proximity to HOV Lane Access**

The first factor examined was the proximity of the survey respon-
dents’ origins and destinations to the HOV lane access points. The
proximity of survey respondents to HOV lane access points was
used to determine how HOV lane use rates varied with distance
from respondents’ origins and destinations to HOV lane access
points. These rates were then used to construct isographs depict-
ing the spatial distribution of HOV lane use rates with respect to
distance to the access point. The ratio of respondents who indi-
cated that they used the HOV lane to total respondents, called the
HOV lane use rate, was determined for various distances from the
HOV lane access points. This analysis used a straight-line dis-
tance, rather than a network distance. The isograph for HOV use
rate in the spatial stratifications is shown in Fig. 2.

There was no clear trend in HOV lane use rates with respect to
distance to the HOV lane access points. This was not necessarily
surprising, as distance neglects differences in travel time due to
network characteristics, such as higher speed or congested road-
ways.

Tests for homogeneity of proportions were used to evaluate
whether significant differences exist between HOV lane use percentages by proximity to access and egress points. This test
is synonymous with the chi-square goodness-of-fit test (Mont-
gomery and Runger 2006). Eqs. (1)–(3) were used to determine
the test statistic. The null hypothesis was that the proportions
being compared were equal, while the alternative hypothesis was
that they were not equal

$$z_o = \frac{\hat{p}_1 - \hat{p}_2}{\sqrt{\hat{p}(1-\hat{p})\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

where
In these equations, $x_i =$ number of respondents in the stratum who indicated HOV lane use, while $n_i =$ total number of respondents in the stratum. The subscripts 1 and 2 represent different strata. Significance at the 95% level was desired. Thus, $p$-values less than 0.05 indicate that the null hypothesis is rejected, and that statistically significant differences exist (see Table 1). Otherwise, the null hypothesis is not rejected, and it cannot be concluded that significant differences exist.

The test for homogeneity of proportions indicated, for example, that the percent of respondents living from 1 to 2 and from 2 to 3 miles of the HOV lane ingress points that use the HOV lane (the HOV lane use rate) was significantly different from the 5–7-mile strata, but it was not significantly different from the other strata.

The same analyses were conducted on the distance from the HOV lane egress point to the respondent’s final destination. Fig. 3 is the isograph depicting travelers’ distance from their egress.

Notable in this isograph is the fact that the 5–7-mile stratum has almost twice the HOV lane use rate of any other strata. This stratum encompasses the downtown Houston region, where job concentration is high. Approximately 84% of the morning travelers were on commute trips, so it would be expected that a region with high employment concentration would encourage greater carpooling. This large difference is also reflected in the tests for homogeneity of proportions on HOV lane use rate by proximity to egress points. The percent of respondents traveling to destinations 5–7 miles from the nearest HOV lane access point was significantly different from all other strata. No significant differences could be demonstrated between the other strata.

Additionally, a test for homogeneity of proportions was conducted on the sum of the distance from the respondents’ origins to the nearest ingress point and from their destination to the nearest egress point. Few statistically significant differences exist between the total distance strata.

### Added Access Time

The HOV lane use rate was also examined with respect to the added ingress and egress times necessary to use the HOV lane access points rather than the GPL access points. It was possible (but rare) for users to have a negative added access time, indicating that accessing the HOV lane was less time consuming than accessing the GPLs.

An example of the HOV ingress time isograph during the peak period is provided in Fig. 4. Similar graphs were generated for HOV lane egress time and GPL ingress and egress times in the peak, off-peak, and shoulder periods, and all were used in the added access time analysis.
To determine the added access time, the least travel time necessary to reach the GPL and HOV lane entrances from the survey respondents’ origins was determined. Likewise, the least travel time necessary to reach the respondents’ destinations from the GPL and HOV lane exits was determined. The GPL access times were subtracted from the HOV lane access times to determine the added ingress and egress times. These times were then added together to determine the HOV lane added access time. Table 2 includes these times aggregated into logical time bins, which assured sufficient data in each group to draw meaningful conclusions.

Interestingly, HOV lane use rates seemed to generally increase as added travel time to access the HOV lane increased, the opposite of the expected result. The stratum with the most time saved

Table 2. Tests for Homogeneity of Proportions on HOV Use Rate by Added Travel Time to Access HOV Lane

<table>
<thead>
<tr>
<th>Added travel time (min)</th>
<th>HOV lane use rate</th>
<th>Added travel time (min)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>−3 to −2</td>
<td>13.5</td>
<td>−3 to −2</td>
<td>0.53</td>
</tr>
<tr>
<td>0</td>
<td>18.1</td>
<td>0</td>
<td>0.94</td>
</tr>
<tr>
<td>0–2</td>
<td>18.4</td>
<td>1–2</td>
<td>0.45</td>
</tr>
<tr>
<td>0–3</td>
<td>22.2</td>
<td>0.01a</td>
<td>0.13</td>
</tr>
<tr>
<td>0–4</td>
<td>28.4</td>
<td>0.07</td>
<td>0.13</td>
</tr>
<tr>
<td>0–5</td>
<td>18.7</td>
<td>0.38</td>
<td>0.03a</td>
</tr>
<tr>
<td>0–6</td>
<td>18.8</td>
<td>0.96</td>
<td>0.98</td>
</tr>
<tr>
<td>0–7</td>
<td>21.9</td>
<td>0.87</td>
<td>0.48</td>
</tr>
<tr>
<td>0–8</td>
<td>27.5</td>
<td>0.52</td>
<td>0.17</td>
</tr>
<tr>
<td>0–9</td>
<td>29.3</td>
<td>0.17</td>
<td>0.48</td>
</tr>
<tr>
<td>0–10</td>
<td>16.9</td>
<td>0.31</td>
<td>0.10</td>
</tr>
<tr>
<td>0–12</td>
<td>15.5</td>
<td>0.31</td>
<td>0.10</td>
</tr>
<tr>
<td>0–14–18</td>
<td>31.6</td>
<td>0.31</td>
<td>0.31</td>
</tr>
</tbody>
</table>

\(^p \leq 0.05.\)
by using HOV lane access points had the lowest HOV lane use rate, and the second highest added travel time strata had the highest HOV lane use rate.

Tests for homogeneity of proportions were again used to determine if significant differences existed between the resulting added travel time strata. The results of this test are shown in Table 2.

In conjunction with the previous test, a paired-samples t-test was conducted to determine if significant differences existed between the mean added access time for respondents who indicated that they traveled in the HOV lane versus the GPLs. This was intended to determine if HOV lane accessibility is a potential factor in the choice to use HOV lanes.

The mean HOV lane access time for HOV lane users was 4.74 min, more than half a minute greater than the mean GPL user factor in the choice to use HOV lanes. Yet the average traveler in the GPLs had a lower average added access times than travelers in the HOV lane. Yet the average traveler in the GPLs had a lower average added access travel time than those who used the HOV lane.

The ratio of added access time to total travel time was also examined. This measure indicated which users spent a greater portion of their trip using the HOV lane access points. It was expected that users with smaller ratios would have been more likely to have used the HOV lane. For these users, the time spent accessing the HOV lanes would have been more tolerable because, compared to the rest of their trip, it represented a smaller proportion of their total trip time. This measure was an attempt to determine what proportion of travel time savings is necessary to offset the additional travel time HOV lane users incur in order to access the HOV lane, along with other factors which affect HOV lane mode choice such as the inconvenience of carpooling and the additional travel time necessary to pick up and drop off carpool partners.

The most striking conclusion that can be drawn from this table is that the Gessner slip ramp HOV use rate was significantly different from the other ramps, except for the Pinemont and the Dacona North and South ramps. Additionally, the Pinemont T-ramp HOV use rate was significantly different from the State Highway 6, Addicks Park-and-Ride, Old Katy Road, Eastern Extension, Northwest Transit Station, and Northwest Transit Center use rates. Both of these notable differences reflect differences between HOV lane use rates at intermediate access points as opposed to access points near the ends of the HOV lanes. This may indicate that more HOV lane users travel the entire length of the HOV lane rather than using only part of the HOV lane. Furthermore, this may indicate that HOV lane travel is most convenient for travelers with long trips from origins in the suburbs beyond the reach of the HOV lanes to destinations near the urban core.

Tests for homogeneity of proportions were also used to determine if significant differences existed between HOV lane use rates for the different kinds of HOV lane access point, which include slip ramps, T-ramps, and other generic ramps. No signifi-
The models were developed to examine the potential interaction of some of the HOV lane access terms discussed above, along with their relative importance to lane choice as compared to socioeconomic and trip characteristics. Variables tested in the models included the access variables as follows:

- Added travel time to access the HOV lane from each traveler’s origin;
- Added travel time to access the HOV lane from each traveler’s destination;
- Total added travel time to use the HOV lane over the GPL;
- Total added travel time to use the HOV lane divided by the total travel time; and
- Ramp type.

Plus several typical trip characteristics, including the following:

- Number of vehicle occupants;
- Trip purpose;
- Peak or off-peak travel;
- Pay for parking; and
- Number of trips per week;

Plus several typical socioeconomic variables, including the following:

- Age;
- Gender;
- Household type (single adult, married with children, etc.);
- Number of vehicles in the household;
- Occupation;
- Education level; and
- Annual household income.

The models were constructed with the GPL as the base option and HOV lane as the alternative. Many combinations of the variables listed above were examined to develop the models in Table 4. Only coefficients that were found to be significant at a 95% level of confidence \((p \leq 0.05)\) were included in the models.

The first of these models contained the “total added travel time to access the HOV lane” independent variable. Oddly enough, this variable had a small positive coefficient, indicating an increased likelihood of using the HOV lane as the additional time to access the lane increased. This was exactly what the pairwise statistical analysis had found. This model also showed that individuals who were married with children were more likely to travel in the HOV lane.

The second model contained the number of slip ramps used to access the HOV lane. This coefficient was positive. This was as expected since the slip ramps were considerably easier to access than the T-ramps and wish-bone ramps. The pairwise statistical analysis had not found this exact result but rather found that users who access the HOV lanes at the end points were more likely to use the HOV lanes. These end points are generally slip ramps, so the model is consistent with that result.

Many models were estimated and generally few found significant coefficients for the access variables. This again confirms the pairwise statistical analysis that generally showed that access type and time were not key variables.

### Conclusions

This study examined spatial impacts on the lane choice of travelers along two corridors that included both GPLs and HOV lanes. Survey data were used to examine travelers’ lane choice based on their origins and destinations along with HOV access point location, type, and access impediments. Logically, the proper placement and design of HOV lane access points would be expected to have an influence over the use of HOV lanes. While the proper location of HOV lane access did appear to have had impact on HOV lane use rates, the design of access had no discernible effect.

While statistically significant differences were found, no discernible trend in HOV lane use rates was found between the distance from survey respondents’ origin points and HOV lane ingress points. However, a statistically significant difference in the HOV lane use rate was found between respondents whose destination was 5–7 miles from an HOV lane egress point and the other distances to destinations. This 5–7 mile range, which includes Downtown Houston, had almost twice the HOV lane use rate of the other ranges. Downtown Houston has a high concentration of jobs, which are commuters’ destinations. High origin or destination density has been shown by previous research to be a factor which encourages carpooling (Aronson and Homburger 1983; Kumar and Goss 1977). This result supports the conclusion that placing HOV lane access close to activity centers supports carpooling, as concentrated origins or destinations make finding suitable carpool partners easier and more convenient.

The effect of the time necessary to access the HOV lane was surprising. This parameter ranged from 3 min saved to 18 min added. It was expected that as the amount of added travel time to access the HOV lane increased, the HOV lane use rate would substantially decrease. However, the rate of HOV lane use generally increased as the time necessary to access the HOV lane increased. Furthermore, the average added access time for HOV users was 4.74 min, more than half a minute greater than the mean GPL user access time of 4.22 min, significantly different from the 0.004 level. This implies that time to access the HOV lane was not a factor in HOV lane mode choice, as logically those
with lower HOV lane access times should be more likely to use the HOV lane, not less.

Finally, factors related to the HOV lane ramps themselves were explored. Ramps closer to the ends of the HOV lanes tended to have higher HOV lane use rates than intermediate ramps. Additionally, no statistically significant differences could be found between the HOV lane use rates for the different types of ramps. This indicates that the convenience of HOV lane access to a traveler’s origin and destination has an effect on HOV lane use rates, but that the design of the ramp itself has no effect.

Of the factors examined, it appears that the convenience of carpooling arrangements as well as the convenience of the HOV lane access points to traveler’s origins and destinations have the largest effect on HOV lane use. Factors relating to the time necessary to access the HOV lanes or the convenience of HOV lane ramps themselves had little impact on HOV lane use rates. This is important, as transportation practitioners tend to focus on travel time savings as a very important factor in the design of HOV lanes and their access. While travel time savings is clearly an incentive to switch to higher occupancy modes, it appears that convenient carpool arrangements and conveniently placed HOV lane access are more important factors.

Acknowledgments

The writers would like to thank the Texas Transportation Institute (TTI), the Texas Department of Transportation (TxDOT), the Metropolitan Transit Authority of Harris County, TX (METRO), the Federal Highway Administration (FHWA), and the U.S. Census Bureau for making the data used for this paper available. Financial support for the collection of the data was provided by TxDOT and FHWA, for which we are grateful. In addition to TTI, the University of Texas at Arlington provided assistance with data collection for one of the surveys used. The writers also thank Dr. Wunneburger and Dr. Quadrifoglio of Texas A&M University for their assistance in resolving technical issues encountered during the research. The contents of this paper reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or polices of the Federal Highway Administration or the Texas Department of Transportation.

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