HOT LANE POLICIES AND THEIR IMPLICATIONS

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Abstract

This research examined the major changes in a corridor due to high occupancy/toll (HOT) lane implementation. This was accomplished by comparing the impacts of HOT lanes on three pairs of HOT lanes with similar design and operational characteristics. These pairwise comparisons of similar HOT lanes reduced the impact of exogenous factors and removed the issue of comparing HOT lanes that were so dissimilar it would be impossible to isolate the reasons for difference in results from the lanes.

With strict registration requirements for free high occupancy vehicle (HOV) 3+ travel on the I-95 Express Lanes (ELs) in Miami there were indications that some carpoolers switched to lower occupancy modes. Tolled access for HOV2s on I-95 and the SR-91 ELs near Los Angeles resulted in lower usage of those ELs by the HOV2s as compared to most HOV lanes where HOV2 access is free.

On the SR167 (Seattle) and I-25 (Denver) HOT lanes, exogenous factors like the price of gas and the economic recession seemed to be the primary influence on the usage of those HOT lanes. In both cases, carpool usage increased along with the price of gas. On I-25, the increasing unemployment rate coincided with a decrease in toll paying travelers. On SR 167 there were also indications of mode shifts among the transit, carpool and toll paying SOVs due to the fluctuating price of gas.

Key Words: Managed Lanes, Policy, Express Lanes, HOT Lanes.
1.0 High Occupancy/Toll (HOT) Lanes Introduction

HOT lanes are gaining interest throughout the United States as a strategy for meeting multiple performance objectives in congested urban freeway corridors. Over the past 15 years the United States has witnessed ten High-Occupancy Vehicle (HOV) lanes being converted to HOT lanes. HOT lanes allow lower occupancy vehicles (generally, single occupant vehicles) to access the carpool lanes by paying a fee while higher occupant vehicles continue to access the lanes for free. In December 1995, the nation’s first HOT lane opened. This project was the 91 Express Lanes (ELs – note that many of these HOT lanes are called Express Lanes), where carpools with three or more passengers could use the lanes for free (except during the period from 1998 to 2003 when HOV3+ travelers were required to pay half the SOV toll). This project was followed by nine HOT lanes converted from HOV lanes across the United States. These projects included (with year of conversion in parentheses) I-15 Express Lanes in San Diego, California (1996), Katy (1998) and Northwest (1999) Freeways in Houston, Texas, I-394 (2005) and I-35W (2009), in Minneapolis, Minnesota, I-25 in Denver, Colorado (2006), I-15 in Salt Lake City, Utah (2006), and more recently, SR-167 in Seattle, Washington (2008), and I-95 in Miami, Florida (2008). As of September 2009 there were ten fully operational HOT lanes.

HOT lanes can provide benefits in reducing travel time, offering travelers viable options to congestion, improving freeway efficiency, and raising revenue to offset implementation and operating costs. However, the extent to which these benefits can be attained depends on the usage of those lanes.

With ten fully operational HOT lanes already in place, there is an opportunity to learn how different factors and policies impact the mode choice of travelers and ultimately the usage of HOT lanes. Additionally, the ways in which different HOT lane policies affect HOT lane operations also provides guidance for future HOT lane projects. This research examines six of
the ten HOT lanes. The most recent I-35W HOT lanes in Minneapolis were excluded due to lack of data. The two Houston HOT lanes and Utah’s HOT lane were excluded because of their significant differences from other lanes. For example, US290 in Houston does not allow SOVs and charges HOV2s a flat $2 fee during the morning peak period. These characteristics make it difficult to compare US290 to other HOT lanes.

The initial research effort focused on examining and comparing all six of these HOT lanes. However, it was clear that the differences between the lanes were just too great to draw many solid conclusions when comparing how different aspects of all the lanes impacted their performance. However, there are three pairs of similar HOT lanes and comparing these facilities in a pairwise fashion lead to interesting conclusions.

2.0 Comparison of I-95 and SR-91 Express Lanes

2.1 Description of the I-95 Express Lanes, Miami

The 95 Express Lanes are located on I-95 near Miami and extend from SR-112 to the Golden Glades Interchange (GGI) area just north of NW 151st Street. The implementation of these ELs included multiple design-and- policy changes, with one of the most significant being the change from a single HOV lane per direction to two express lanes per direction. The project created an additional express lane in each direction by narrowing the inside median width and reducing travel lanes from 12 feet to 11 feet. Additionally, the existing HOV lane buffer was reduced to one foot of separation between the general purpose lanes (GPLs) and the ELs and flexible delineators have been installed within the buffer area. The resulting cross section allows for two ELs, a one foot buffer (and no median shoulder), and four GPLs in both the northbound and southbound direction (FDOT, 2009). Note that this research only examined Northbound (Phase 1A) travel as the Southbound ELs opened only recently in January 2010. Compared to the
previous HOV lanes which could be accessed from anywhere, the ELs have no intermediate access points and can be accessed only at the two ends of the lanes (Florida DOT, 2009). The project also enhances and expands Bus Rapid Transit service. The EL operation also included increasing the carpool eligibility to HOV3+ from HOV2+ in the previous HOV lanes. Also, carpools and vanpools have to be registered to be able to use the HOT lanes for free. The eligibility criteria for a registered 3+ carpool includes: a) participants must live within a 3-mile radius of each other b) participants must work within a one mile radius of each other and c) participants must have a start/end work time within 30 minutes of each other (95 Express website).

2.2 Impact on Carpooling on I-95

In the year following the opening of the ELs there was a 4.6 percent increase in the person throughput on the whole corridor. This is similar to the growth in traffic from 2006 to 2008 (Cain, 2009). This likely indicates that the 256 percent increase in SOVs in the ELs was mostly due to the mode shift within the corridor and not due to an overall increase in travelers (see Table 1). The overall decrease in the number of HOV2s likely indicates that these carpools either shifted mode to SOV (an overall 33 percent increase in SOVs) or they shifted to higher occupancy modes (overall 9.6 percent increase in HOV3s). Overall, this resulted in a decrease in carpool/transit mode share from 50.8 percent to 48.6 percent of travelers.

To further investigate these mode shifts, data from a May 2009 survey was analyzed (see Table 2). Over 200,000 travelers in the Miami-Dade area were contacting regarding the survey and 9156 travelers participated in the survey. Table 2 contains only responses from those who indicated they used the ELs. For this analysis, the ‘usual mode’ of respondents was defined by
the survey question: “How do you usually get to and from work/school? Select the mode you use most often (3 or more days per week).”

### Table 1: Person Throughput by Vehicle Type in I-95 Express Lanes (Northbound; PM Peak Period- 4 to 6 PM)

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Express Lanes</th>
<th>Total Facility (GPLs + ELs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Person Volume per Peak Period</td>
<td>Total Person Volume per Peak Period</td>
</tr>
<tr>
<td></td>
<td>2008</td>
<td>2009</td>
</tr>
<tr>
<td>SOV</td>
<td>1061</td>
<td>3778</td>
</tr>
<tr>
<td>HOV2</td>
<td>3040</td>
<td>1899</td>
</tr>
<tr>
<td>HOV3</td>
<td>477</td>
<td>171</td>
</tr>
<tr>
<td>Transit</td>
<td>810</td>
<td>821</td>
</tr>
<tr>
<td>Total</td>
<td>5387</td>
<td>6669</td>
</tr>
</tbody>
</table>

Source: Cain, 2009. Note: All transit buses use the ELs.

### Table 2: Mode Shifts on I-95 by EL Users

<table>
<thead>
<tr>
<th>Current Mode used to Access Express Lanes</th>
<th>Usual Mode of Travel (Number of respondents)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SOV (n=2558)</td>
</tr>
<tr>
<td>Toll Paying (SOV/HOV2/Unregistered HOV3+)</td>
<td>94%</td>
</tr>
<tr>
<td>Registered HOV3+</td>
<td>0%</td>
</tr>
<tr>
<td>Hybrid</td>
<td>5%</td>
</tr>
<tr>
<td>Vanpool</td>
<td>0%</td>
</tr>
<tr>
<td>Prior Mode on I-95</td>
<td>Carpool in HOV</td>
</tr>
<tr>
<td></td>
<td>Hybrid in HOV</td>
</tr>
<tr>
<td></td>
<td>Not Carpool lanes</td>
</tr>
</tbody>
</table>

Note: The percentages for current mode do not total 100 percent since the respondents could select more than one mode if they frequently used different modes to access the ELs.

Prior to implementation of the ELs, HOV2s had unrestricted, toll-free access to the HOV lane and nearly a quarter of them still did not use the lanes (see Table 2). This may have been due to the relatively congested conditions on the lane at that time. With the ELs, HOVs now have to pay a toll and can only enter the lanes at their beginning – but congestion was greatly reduced.
Since almost all HOV2s (92 percent) now use the Express Lanes as paying users it is a clear indication of the attractiveness of the improved travel conditions on the Express Lanes.

For those who mentioned HOV3+ as their current usual mode, 81 percent of them previously used the HOV lanes as carpools. However, with the ELs, only 33 percent are registered HOV3+ users while 61 percent are toll paying SOV/HOV2/unregistered HOV3+. These data, combined with the substantial decrease in HOV3+s in the ELs during the peak period (Table 1), indicates a substantial amount of those travelers have shifted to either SOV or HOV2. This shift of the HOV3+ to toll paying vehicles can likely be attributed to the strict registration requirement for the carpool registration.
<table>
<thead>
<tr>
<th>HOT Lane</th>
<th>Number of Lanes</th>
<th>Separation</th>
<th>Intermediate Access points</th>
<th>Free Travel Eligibility</th>
<th>Impacts</th>
</tr>
</thead>
</table>
| SR 91X, Los Angeles              | 2 HOT lanes and 4 GPLs per direction | Painter buffer and pylons | None                      | HOV3+                  | - HOV2+ traffic volumes in the corridor remained relatively stable  
- HOV3+ traffic volumes increased by 40 percent in PM peak after the Express Lanes started (but this is starting from a small baseline).  
- 40 percent of the survey respondents mentioned driving comfort and safety in the Express Lanes as the reasons to use the Express lanes other than travel time savings.                                                                 |
| I-95, Miami                      | 2 HOT lanes and 4 GPLs per direction | Double White Stripes with breakable poles | None                      | HOV3+ registered carpools | - For those who mentioned HOV3+ as their usual mode, 81 percent of them previously used the HOV lanes as carpools. However, with the opening of the Express Lanes, only 33 percent are registered HOV3+ users while 61 percent are toll paying LOVs (SOV/HOV2).  
- Daily transit ridership increased 30% due to travel time improvement on the Express Lanes. This was despite a bus fare increase, a decrease in gas prices, reduced service and an economic recession.                                                                 |
| I-15, San Diego (until May 2008) | 2 Reversible HOT Lanes and 4 GPLs per direction | Concrete Barrier | None                      | HOV2+                  | - Total weekday usage of Express Lanes increased from 7685 (pre-Express Lanes) to 15,000 in three years after the Express lanes started  
— Congestion on the GPLs was alleviated by directing the increasing traffic on corridor to HOT lanes.                                                                                                                                                                           |
| I-25, Denver                     | 2 Reversible HOT Lanes and 4 GPLs per direction | Concrete Barrier | None                      | HOV2+                  | - Express lane users indicated more use of transit due to the Express Lanes.  
- Little change in carpooling after the lanes opened  
- Large increase in transit ridership seen with an increase in gas price (2008) and vice versa (2009).                                                                                          |
<table>
<thead>
<tr>
<th>Highway</th>
<th>Description</th>
<th>Lane &amp; Stripes</th>
<th>HOV2+</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-394, Minneapolis (Diamond Section)</td>
<td>1 HOT Lane and 2 GPLs (most of the time) per direction</td>
<td>Double White Stripes</td>
<td>6 in each direction</td>
<td>HOV2+</td>
</tr>
<tr>
<td>SR 167, Seattle</td>
<td>1 HOT Lane and 2 GPLs per direction</td>
<td>Double White Stripes</td>
<td>6 Northbound and 4 Southbound</td>
<td>HOV2+</td>
</tr>
</tbody>
</table>
2.3 Reasons for Using the I-95 Express Lanes

Respondents who have used the ELs were asked their reasons for using the lanes. The respondents were grouped by the modes they used to access ELs: carpool, toll paying users (SOVs/HOV2/unregistered HOV3+) and Hybrids. More than three-quarters of the respondents in each group indicated the time-savings/free-flowing traffic on the ELs as the reasons for using them. For example, prior to the ELs the 7.5 mile trip from downtown Miami to the Golden Glades Interchange took 25 minutes on the HOV lane during the peak period. Now, on the ELs, this trip only takes 8 minutes. Apart from these reasons, the absence of trucks and a perception of safety in the lanes were also noted as important reasons for using the ELs.

2.4 Travelers not Using the I-95 Express Lanes

Among the respondents who mentioned they used the HOV lanes previously but no longer use the ELs, almost three-quarters of them carpooled (occupancy not known) on the HOV lanes (while the rest of them used hybrid vehicles or motorcycles). When carpoolers were asked their reasons for not using the ELs, almost 10 percent mentioned not qualifying as a 3+ carpool, more than 50 percent mentioned not willing to pay a toll (which would also indicate not qualifying as a 3+ carpool), while more than one-third mentioned no access to get in to or out of the ELs. Therefore, among the changes made in the design and operations of the ELs, access and toll were the two major reasons for carpoolers to not use the ELs.

2.5 Similarities between SR 91 Express Lanes and I-95 Express Lanes

There are many similarities between the SR 91 Express Lanes (December 1995 through January 1998, the period when HOV3+ could access the ELs for free) and I-95 Express Lanes. Similarities were found in both operations as well as design:
- two ELs and four GPLs in each direction,
- HOV3+ requirement for free carpool access to the ELs,
- no intermediate access to the ELs, and
- flexible pylons separating the GPLs and the ELs with no median shoulder (see Table 3).

Both corridors had high congestion levels before the ELs. Around the time of Express lane implementation, average daily traffic (ADT) on the two corridors was 200,000 vehicles per day (vpd) on SR 91 and 290,000 vpd on I-95. Major differences were that there was no HOV lane on the SR 91 corridor and the SR 91 express bus route 149 did not use the ELs. Despite these two differences, the many similarities between the two ELs provide an opportunity to compare the different impacts that EL implementation had in the respective corridors. As the SR 91 Express Lanes were built by a private company one of their key objectives was profit. Thus HOV2s had to pay a toll. On the I-95 Express Lanes the objective was to encourage ridesharing (but excluding fampools) and transit. This resulted in the requirement that HOV2s pay and HOV 3+ had to register. The objectives were different but the resulting policies were similar.

### 2.6 Impact on HOV3+ Travelers

After one year of operation of the SR 91 Express Lanes, there was a 40 percent increase in HOV3+ vehicles in the 2-hour peak period (496 to 725) on the SR 91 corridor (Sullivan, 1998) while there was a 10 percent increase (778 to 852) of HOV3+ vehicles on the I-95 corridor (Cain, 2009). However, the large difference in the percentage increase may be largely due to the low number of baseline HOV3+ vehicles on the SR 91 corridor since, on SR 91, there were previously no HOV lanes and less incentive for carpooling (Sullivan, 1998). Also, the increase in HOV3+ on SR 91 can be attributed primarily to the implementation of ELs providing much needed additional capacity. In case of I-95 there was a 64 percent reduction in HOV3+ vehicles in the ELs and an increase in HOV3+ vehicles in the GPLs.
Next, the usage of the ELs by the toll exempt vehicles in the two corridors after one year of operation (December 1996 for SR 91 and December 2009 for I-95) were compared. One way, weekday volume of HOV3+ on SR 91 Express Lanes (2500 vehicles) was approximately equal the total toll exempt trips (including Hybrids, Buses, motorcycles) in one week (approximately 2000 trips) on the I-95 Express Lanes.

There are different factors which could be responsible for the different HOV3+ usage trends on the two corridors:

- **Induced traffic:** Over the first year of EL operations on SR 91, there was an increase of 14 percent (28000 vehicles) in the ADT of the corridor. Sixty percent of that increase was new traffic (traffic above the long term growth trend and not from parallel streets). According to one estimate (Sullivan, 1998), during the PM peak period, this induced traffic contributed to a 39 percent increase in the pre-Express level of HOV3+.

Conversely, over the first six months of EL operations on I-95, northbound traffic on I-95 (ELs and GPLs) decreased by almost 3 percent.

- **New incentives for carpooling:** Unlike on the I-95 corridor, there were no HOV lanes on the SR 91 corridor. With ELs, SR 91 travelers had an additional incentive for forming a 3+ person carpool. This may explain the high percentage increase in HOV3+ volume on the SR 91 corridor.

- **Registration Requirement:** On the SR 91 Express Lanes, registration is required by all users (toll and non-toll) with no extra eligibility requirements for carpool members other than the number of people in the vehicle. However, on the I-95 Express Lanes, there are strict requirements that must be met to register as a carpool. The effect of strict guidelines on carpooling can be seen in the results from the I-95 survey. Sixty-six
percent of those whose typical mode is HOV3+ mentioned using the ELs as toll users while before the ELs more than 80 percent of them used the HOV lanes as carpools.

- **EL availability:** SR 91 Express Lanes started operating in both directions from opening day. The I-95 Express Lanes began only in one direction (northbound, going away from downtown Miami). In the southbound direction, the HOV lanes were still congested during peak periods. Therefore, for the two-way commuters, that might not have been enough incentive to register as a carpool and use the lanes or switch to transit.

- **Access Convenience:** SR 91 survey responses included almost no complaints about a lack of intermediate access points. This was not surprising given the commuter patterns of many people using the facility. However, in a fall 1996 telephone survey of SR 91 commuters it was found that 76 percent of the HOV3+ travelers used the ELs for their trip while 24 percent used the GPLs. Mastako et al. (1998) surmised the access inconvenience was the reason for not all the HOV3+ using the ELs (even though they could use the lanes for free). In the I-95 survey, almost one-third of the respondents who previously carpooled in the HOV lanes but do not use the new ELs mentioned access inconvenience as one of the reasons. This difference in the perception of access inconvenience between the two ELs may be because I-95 carpoolers were already used to unrestricted access to the HOV lanes while SR 91 travelers had no HOV lanes and hence, the SR 91 Express Lanes was a fresh start for them. It is also possibly because of the difference in the O-D patterns of commuters on the two corridors.

### 2.7 Impact on HOV2 Travel

Since both SR 91 and I-95 ELs treat HOV2s as toll paying vehicles similar to SOVs, their impact on HOV2s can be examined and compared. After the SR 91 Express Lanes opened, there was a significant increase in HOV3+ vehicles as well as SOVs in the corridor. However, only a small
increase in the number of HOV2s was observed. Only 30 percent of HOV2s used the SR 91 Express Lanes as compared to 60 percent in conventional HOV lanes in study areas during the peak 2 hours (Sullivan, 1998). Therefore, “opening of the SR 91 Express Lanes did relatively little to encourage or discourage HOV-2 ridesharing” (Sullivan, 1998).

Only 23 percent of all HOV2s in the corridor use the I-95 Express Lanes during the 2 hour afternoon peak period. Therefore, the percentage of HOV2s using the ELs on both corridors is clearly less than those in conventional HOV lanes (approximately 60 percent). This may be because the only incentive left for HOV2 as compared to SOV mode on ELs is that they could split the toll. The low percentage of HOV2s using the HOT lanes may also be due to the lack of intermediate access points.

2.8 Impact on Transit

In late 1996, bus riders on the SR 91 corridor were asked if the toll lanes had changed their travel in any way. Only 14 percent answered positively and 60 percent said no. Conversely, in a May 2009 survey, bus riders along I-95 mentioned service reliability (55 percent) and travel time (75 percent) were better with the new ELs. This is because the express bus on the SR 91 corridor does not use the ELs while the express bus on I-95 does. With the implementation of the I-95 Express Lanes (going from one HOV lane to two ELs) the travel time of buses from downtown Miami to the Golden Glades Interchange during the afternoon peak period was reduced from 25 minutes to 8 minutes. However, there was no evidence of SR 91 Express Lanes changing bus operations in any way. After the ELs opened there was no change in ridership for the express bus on SR 91 but there was a 30 percent increase in average daily ridership for the express bus on I-95 comparing January through March in 2008 versus 2009 (Cain, 2009). It is interesting to note that the bus ridership of the 95 Express Lanes increased in
spite of the reduced fiscal advantage of using transit (increase in bus fare and decrease in the
price of gas) as well as reduced service and economic recession.

3.0 Comparison of I-15 and I-25/US 36 Express Lanes

3.1 Description of I-25/US 36 Express Lanes, Denver

The I-25/US 36 (hereafter referred to as I-25 for simplicity) Express Lanes began operations in
June, 2006 and extend between downtown Denver and US 36. The ELs are 7 miles long with
two reversible lanes separated from the GPLs by a barrier. SOVs are allowed to use the ELs for
a fee while HOV2+ and motorcycles can use the lanes for free. In May 2008, 2000 permits were
issued to Hybrids for free access to the lanes (Colorado DOT website 2011). The SOV fee
varies by the time of day in an attempt to control the demand for the facility. The goals of the
lane were to optimize HOV lane use, provide a new transportation option, and for toll revenues
to cover expenses.

3.2 Impact on Transit along I-25

There are two primary transit routes, Route B and Route 120X, and approximately 10 secondary
transit routes that use the I-25 Express Lanes. The implementation of the ELs had no impact on
travel time as the travel time of transit buses was generally maintained at the pre-ELs level
(Colorado DOT, 2007).

The total ridership of the 12 primary and secondary routes from 2005 (pre-ELs) through 2009 for
the months September and October along with the average price of gas (EIA website) over the
same two months was examined (see Table 3). Comparing the transit ridership soon after the
implementation of the lanes (September – October 2006) to the ridership levels the year before,
there was a very small change (0.4 percent increase). Transit ridership in subsequent years
changed much more dramatically. However, this was likely due to the fluctuations in the price of gas rather than the new express lanes (APTA, 2011).

However, according to survey results it appears that the ELs did have some impact on transit use. In August and September of 2008, a survey was conducted in which respondents included those who recently used the ELs. There were indications from the survey that EL implementation encouraged some additional use of transit. Approximately 12 percent of the EL users also agreed to the statement “Because of the Express Lanes I use public transit more often than I otherwise would.” This additional use of transit due to the ELs may help explain the one anomaly in Table 4. For most results in Table 4, a decrease in the price of gas corresponds to a decrease in transit use (and vice-versa). However, just after the ELs opened (September and October of 2006) the price of gas was almost 10 percent lower than the previous year, yet transit ridership on the EL was almost unchanged. It is possible the new transit ridership due to the ELs could have offset the expected decrease in use of transit due to the drop in the price of gas. However, this is only a possibility – it could have been that transit ridership did not change for a number of other reasons.

### Table 4: Average Weekday Ridership for Selected Denver Transit Routes
(Regional Transportation District, unpublished data, Routes using I-25)

<table>
<thead>
<tr>
<th>Year</th>
<th>Gas Prices (cents per gallon)</th>
<th>Change</th>
<th>Transit Ridership</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>September-October 2005</td>
<td>283.0</td>
<td></td>
<td>13982</td>
<td></td>
</tr>
<tr>
<td>September-October 2006</td>
<td>256.2</td>
<td>-9.5%</td>
<td>14034</td>
<td>0.4%</td>
</tr>
<tr>
<td>September-October 2007</td>
<td>273.1</td>
<td>6.6%</td>
<td>15148</td>
<td>7.9%</td>
</tr>
<tr>
<td>September-October 2008</td>
<td>374.2</td>
<td>37.0%</td>
<td>16926</td>
<td>11.7%</td>
</tr>
<tr>
<td>September-October 2009</td>
<td>235.0</td>
<td>-37.2%</td>
<td>14633</td>
<td>-13.5%</td>
</tr>
</tbody>
</table>

Source: Jeff Dunning, Regional Transport District
3.3 Impact on Carpooling

In the August 2008 survey it was found that 54 percent of the respondents, whose only mode of access to ELs was drive alone, mentioned they drive alone (irrespective of lane) for 4 days or more in a week. Almost all of them (98.3 percent) mentioned they did not carpool at all in the last 7 days. Therefore, this group of travelers consistently travels as an SOV.

Also, 17 percent of the carpoolers in the ELs mentioned that they carpool in order to use the ELs. This indicates that ELs have been able to encourage carpooling among some travelers.

A graph of the average weekday usage of ELs by toll users, HOV users and total users was compiled from monthly EL performance reports (see Figure 1). Along with the usage data, the average gas price is also plotted for each month for the Denver area. This data was obtained from Energy Information Administration (EIA) website.

As shown in Figure 1, HOV usage tends to increase when the price of gas increases, and vice-versa. This makes sense as travelers attempt to share travel costs (such as gas) as those prices rise. The total number of HOV users has been fluctuating between 6000 and 8000 vehicles per day. Toll usage shows an increasing trend from the opening of the lanes until early 2008 when it starts decreasing.
The unemployment rate for the Denver area may partially explain the decreasing number of toll users. The unemployment rate was fairly stable from 2005 until early 2008, after which there was a steady increase in unemployment. Interestingly, the decreasing number of toll paying users starts around the same time. This is not to say each lost toll paying customer lost their job- but the worsening economic problems likely pushed some travelers off the tolled lanes.

3.4 Similarities between I-15, San Diego Express Lanes and I-25 Express Lanes

Until May 2008, the I-15 Express Lanes in San Diego extended 8 miles in the median of I-15, from SR 163 to SR 56/Ted Williams Parkway. It was a two-lane, reversible facility with access available only at its two ends. SOVs paid a fee to use the lanes. HOVs of two or more
occupants (carpools, vanpools, and buses), motorcycles, designated hybrid vehicles and two-
axle trucks were permitted to use the I-15 Express Lanes for free. There are many similarities
between the I-15 Express Lanes in San Diego (from March 1998 through May 2008) and the I-
25 Express Lanes near Denver. Both have two reversible lanes with concrete barrier separation
from the GPLs, no intermediate access points and both the ELs allow HOV2+ carpools to travel
for free. Both were converted to ELs with no design changes from the previous HOV lanes. The
lengths are also comparable (8 miles and 7 miles respectively) and both the corridors have 4
GPLs in each direction. Therefore, the following section explores these two lanes, their
similarities and what can be learned from their differences.

3.5 Usage of the I-15 and I-25 Express Lanes

During the year 1999, when the I-25 Express Lanes were planned, the ADT of I-25 was
approximately 200,000 vpd. On I-15, the ADT exceeded 250,000 vpd in 1996 when the Express
Lanes started. Therefore, congestion along I-15 was considerably worse. One objective of the
lanes was to relieve GPL congestion (along with increase in HOV lane use and to help fund
transit) (Supernak et al. 2002).

The I-25 and the I-15 Express Lanes started with a similar number of carpools; 7,680 carpools
and 8,050 carpools per weekday, respectively. Over a period of three years the carpool usage
on I-15 Express Lanes increased to 11,400 per weekday (December 1996 through November
1999) (San Diego Association of Governments, 1999) while it changed very little on I-25 (June
2006 through July 2009).

During the same period, daily toll users in both ELs reached almost the same number; 3500 vpd
on I-15 and 3400 vpd on I-25. Therefore, the ELs differ in terms of encouraging their carpool
usage, but not tolled SOV travel.
One key difference between the two ELs was in their objectives. I-15 includes the objective of optimizing the use of HOV lanes as well as to reduce congestion on I-15 by providing a toll option to SOVs while I-25 has just the objective of optimizing the use of HOV lanes. Also, I-15 has dynamic pricing while I-25 has fixed variable pricing with a minimum peak hour toll decided by the bus fare ($3.25). Thus, on I-25, the decreasing trend of toll users might be partially due to the high fixed toll value during the peak period which might have discouraged some travelers from continuing the use of the ELs.

In terms of supporting services, both ELs have park-and-ride lots. The difference in the available capacities of the park-and-ride lots might influence the difference in the increase in carpooling in the two ELs. However, there are three park and ride lots in the vicinity of the I-25 HOT lane with over 2400 spaces operating at less than two-thirds full. Therefore, two factors have likely played a role in the much larger use of carpooling on I-15: gas prices and congestion. However, no conclusions can be made because of lack of information in this aspect.

4.0 Comparison of I-394 and SR 167 HOT Lanes

4.1 Description of the I-394 HOT lanes, Minneapolis

The I-394 Express Lanes run 11 miles between downtown Minneapolis and the western suburbs. The project allows solo drivers to pay to use the ELs while carpoolers, buses, and motorcyclists may use the lanes free of charge. Tolls are set by dynamic pricing ensuring continued free flow in the lanes at about 50 to 55 mph. Along with maintaining free flow on the lanes, objectives of the lanes included maximizing HOV lane usage and funding highway and transit improvements. The ELs consist of two sections. The per-trip fee depends on where users enter and exit the MnPASS ELs. The variable, per-trip fee is always charged for SOV use in the eastern 3 miles, from Trunk Highway (TH) 100 to I-94. This section consists of 2 reversible
lanes, barrier separated from the GPLs. The western 8 mile of the ELs are separated by paint
stripes. This section west of TH 100 is called the diamond lane section and fees are only
charged in the peak direction during rush hours (6 AM to 10 AM eastbound and 2 PM to 7 PM
westbound).

4.2 Impact on I-394 Transit Ridership

Between July and September 2005, shortly after the MnPASS lanes opened, transit ridership
along I-394 increased by more than 13 percent over the ridership from the same period in 2004,
before MnPASS was available. In comparison, transit ridership in the I-35W corridor increased
only 1.4 percent. Chum and Burris (2008) indicated some possibility of bus ridership being
positively affected by the adaptation of HOV to HOT lanes. However, there was no specific
study to determine the effect that having a new SOV toll option had on existing transit users and
it was unknown how many former transit users switched to the SOV toll mode.

Both Turnbull (2008) and Johns et al. (2006) observed that the transit usage remained relatively
constant during the later years after the MnPASS implementation, due in part, to the park and
ride lots generally operating at or near capacity.

4.3 Description of the SR 167 HOT Lanes, Seattle

The SR 167 HOT lanes began operation in May of 2008. They consist of a single HOT lane
running in each direction of SR 167 for approximately nine miles between Renton and Auburn.
SOVs are allowed to use the lanes for a toll, while two-person carpools, vanpools, transit and
motorcycles can use the lanes for free.

Previously, carpoolers could enter and leave the lane anywhere along its entire length and the
lane was separated by a single white line from the GPLs. As a HOT lane, motorists can enter
and exit the HOT lanes only at designated access points providing more predictable entry and
exit maneuvers. The access point design is based on I-394 diamond lane section of the HOT
lane project in operation in Minnesota (http://www.wsdot.wa.gov/projects/sr167/hotlanes/). Other
than at entry/exit points, a two-foot buffer with two solid white stripes separate the HOT
lanes from the GPLs. A 10 foot inside shoulder is also available. The objectives of the lane were
to test the HOT lane concept and the publics’ reaction along with collecting data on its use.

4.4 Impact on SR 167 Transit Ridership

There were seven buses using the HOV lane during the peak period in the peak direction. With
HOT lanes the only service change in bus operations was the slight modification of two of those
routes (routes 564 and 565). Transit officials fine-tuned the route alignments, directing buses to
enter SR 167 at SR 516 instead of 84th Avenue. The adjustment allowed the buses to better
use the HOT lanes’ access zones (Washington State DOT, 2009).

Bus ridership increased by 17 percent in the corridor and by 23 percent in the region from 2007
to 2008 likely due to increased gas prices (Puget Sound Trends, 2009). Ridership then
decreased in 2009. The decrease in 2009 was attributed to a reduction in gas prices, economic
recession and regional job loss. Conversely, comparing the months May through November for
2008 and 2009, the average daily tolled trips on the HOT lanes increased by 46 percent.

Therefore, the relationship between the HOT lane usage (toll as well as carpool) and gas prices
was examined further. Tuesday through Thursday HOT lane usage from May 2008 through April
2009 (compiled from the performance reports sent by Kevin C. Beireis, WSDOT - Toll Division)
and monthly average gas prices in Seattle (EIA website) are compared in Figure 2. Carpool
usage on the HOT lanes and gas prices followed remarkably similar trends. On the other hand,
tolled vehicles generally increased in number as the price of gas declined.
This strongly implies that the reduction in the price of gas resulted in carpools breaking up and transit riders leaving the bus (as noted above). While the carpools can shift to SOVs on HOT lanes and/or GPLs, bus riders can shift to these two modes as well as carpool on the HOT lanes. Other shifts, such as from a carpool to transit, are unlikely to occur due to a decrease in the price of gas.

Figure 2: Usage of HOT lanes by HOV Vehicles and Tolled Vehicles and Gas Prices for May 2008 Through April 2009

The above findings provide some insight into the impact of the price of gas on the mode choice of travelers. An increase in the price of gas makes carpooling more attractive by travelers splitting the cost of auto expenses and possibly saving the toll if the traveler was previously an SOV on the HOT lanes. Therefore, the usage of HOT lanes, to some extent, is dependent on exogenous factors like the price of gas which are generally not included as one of the elements in the planning of HOT lanes. It also implies that the performance of HOT lanes should be
judged in light of the gas prices in the respective locations and it becomes even more crucial when the two HOT lanes are compared based on their usage.

4.5 SR 167 HOT Lanes and I-394 Diamond Section

There are many similarities between the SR 167 HOT lanes and the diamond lane section of the I-394 Express Lanes. Both are concurrent, one lane each direction alongside 2 GPLs in each direction (as an exception, I-394 has one auxiliary lane in westbound direction in addition to the 2 GPLs). The HOT lanes are separated from the GPLs using double white lines. Also, both HOT lanes have dynamic pricing with designated intermediate access points. One difference was congestion levels on the two corridors at the time of HOT lane implementation. The ADT was 120,000 vpd on SR 167 in 2008 and 148,200 vpd on I-394 in 2005. Before the SR 167 HOT lanes, the speed in the GPLs commonly dropped to 35 mph during the peak period. However, before the I-394 Express Lanes, travel speeds in the GPLs were generally above 50 mph.

The many similarities between the two HOT lanes help to avoid many exogenous factors and provide an opportunity to compare different impacts of the two HOT lanes.

4.6 Usage of the HOT lanes

When the SR 167 HOT lanes started operation in May 2008, the price of gas reached its peak ($4). When I-394 HOT lanes started operation in May 2005, price of gas was $1.95 a gallon and reached over $3.00 a gallon by July 2006 (Cambridge Systematics, 2006). Therefore, the price of gas could have had a significant impact on usage of the HOT lanes and comparisons between the lanes need to be cognizant of this.
I-394 usage data from January through April of 2007 (Minnesota DOT, 2008) was compared to
SR 167 usage data from January to April 2009 (carpool data from WSDOT) (see Table 5). The
price of gas in the two cities was similar at these times and both lanes had been open for at
least 6 months. This may help to minimize the impact of the price of gas.

Table 5: SR 167 and I-394 Traffic Volume Data

<table>
<thead>
<tr>
<th>Road</th>
<th>Time of Day</th>
<th>HOV Lane</th>
<th>GPLs</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Toll (SOV)</td>
<td>No Toll (carpools, HOV, transit)</td>
<td></td>
</tr>
<tr>
<td>SR 167</td>
<td>AM Peak (7 to 8 AM)</td>
<td>250 (6%)</td>
<td>690 (18%)</td>
<td>3200 (76%)</td>
</tr>
<tr>
<td></td>
<td>PM Peak (5 to 6 PM)</td>
<td>155 (4%)</td>
<td>760 (21%)</td>
<td>3000 (75%)</td>
</tr>
<tr>
<td>I-394</td>
<td>AM Peak (7 to 8 AM)</td>
<td>360a (7%)</td>
<td>744 (13%)</td>
<td>3921 (80%)</td>
</tr>
<tr>
<td></td>
<td>PM Peak (5 to 6 PM)</td>
<td>310b (5%)</td>
<td>474 (6%)</td>
<td>5572c (89%)</td>
</tr>
</tbody>
</table>

a = counted at the Louisiana section of the diamond lanes.
b = counted at the Winnetak Avenue section of the diamond lanes
c = one additional auxiliary lane

The one large difference was that HOVs comprise a larger percentage of travelers on SR 167.
Since the GPLs on SR 167 were more congested than on I-394, carpoolers may have more
incentives to carpool on SR 167 than I-394.

5.0 Conclusions

This research examined:

- the different factors which led to the development of six HOT lanes
- the changes made in the corridor due to HOT lane implementation
- the different impacts of the HOT lanes on travel and mode choice in the corridor
These issues were examined by comparing three pairs of HOT lanes with similar design and operational characteristics. By comparing the impacts of the HOT lanes on two similar corridors the impact of many of the exogenous factors are minimized.

With the strict registration requirement for HOV3+ to travel for free on the I-95 ELs, there were indications of some carpools breaking up. Tolled access for HOV2s on the I-95 ELs as well as the SR 91 ELs resulted in lower usage of both of these ELs by HOV2s (fewer than 30 percent of the total corridor HOV2s use the ELs) as compared to a conventional HOV lane (60 percent) where HOV2 access is free. As for transit, the Express bus does not use the SR 91 ELs and, not surprisingly, there was almost no change in its ridership after the SR 91 ELs were implemented. Conversely, on I-95, the Express bus uses the ELs and travel time of buses decreased by 17 minutes due to ELs implementation. Additionally, the daily ridership on the I-95 express bus increased by 30 percent.

On the SR167 and I-25 ELs, exogenous factors such as the price of gas and the economic recession seemed to influence the usage of the ELs. On both the ELs, carpool usage increased along with the price of gas. On I-25, the increasing unemployment rate coincided with a decreasing number of toll paying travelers. On SR 167 there were also indications of mode shifts among the transit, carpool and toll paying SOVs due to fluctuating gas prices. With declining gas prices, the transit and carpool usage decreased while the number of toll paying users increased.

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