REVIEW OF THE EFFECTIVENESS OF THE HIGH OCCUPANCY VEHICLE (HOV) LANES EXTENSION

Review of the Effectiveness of the Extended HOV Lanes

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October, 2005

ACKNOWLEDGMENTS

The authors thank the Utah Department of Transportation employees for the data they furnished and their assistance with this study. The authors also particularly thank the Technical Advisory Committee members for their invaluable input throughout the study. The valuable contribution of those who assisted in data collection is greatly appreciated.

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LIST OF ACRONYMS

AFV	Alternative Fuel Vehicle
AVO	Average Vehicle Occupancy
GP	General Purpose
GPS	Global Positioning System
GVWR	Gross Vehicle Weight Rating
HERO	Highway Emergency Response Operator
HOT	High Occupancy Toll
HOV	High Occupancy Vehicle
ILEV	Inherently Low Emission Vehicle
LOS	Level of Service
MOE	Measure of Effectiveness
MPH	Miles per Hour
MUTCD	Manual on Uniform Traffic Control Devices
MVMT	Million Vehicle Miles Traveled
NCHRP	National Cooperative Highway Research Program
ODOT	Oregon Department of Transportation
PPHPL	Persons per Hour per Lane
SOV	Single Occupant Vehicle
SR	State Route
UDOT	Utah Department of Transportation
UHP	Utah Highway Patrol
UTA	Utah Transit Authority
UTL	Utah Traffic Laboratory
VPHPL	Vehicles per Hour per Lane
WSDOT	Washington State Department of Transportation
WSP	Washington State Patrol

EXECUTIVE SUMMARY

High Occupancy Vehicle (HOV) lanes opened in the Salt Lake Valley May 14, 2001, on the reconstructed Interstate 15 (I-15). They were initially built on a 16-mile segment between 600 North and 10600 South. An 8.5-mile extension was opened between 10600 South and the Utah County line on Oct. 27, 2004. The Salt Lake Valley HOV lanes are single lanes and have a painted separation. They operate 24 hours a day, seven days a week. They operate in both the northbound and southbound directions. Two-or-more-person carpools, vanpools, buses, motorcycles, Alternative Fuel Vehicles (AFVs) and emergency vehicles are eligible to use the HOV lanes. There are inside ramps to the HOV lanes at 400 South, which is the central business district in Salt Lake City.

This study reports on the performance of the extended HOV lanes. Vehicle volume, average vehicle occupancy (AVO), modal split, person throughput, and violation rate were collected manually. Travel time and speed data were collected using the floating car method and global positioning system (GPS) software. The data collected was compared with the NCHRP standards and national averages.

The extended HOV lanes in the Salt Lake Valley are performing effectively in terms of several measures of effectiveness (MOEs) such as vehicle volume, person throughput, AVO and speed benefits. It was found that vehicle volume satisfies the **NCHRP's recommended minimum vehicle volume of 400 to 800 vehicles/peak hour for the HOV lane during both the AM and PM peak hours.** The NCHRP's recommended maximum operating threshold criterion of 1200 to 1500 vphpl was not exceeded during either the AM or PM peak hours.

HOV lane AVO was found to be much higher than the general purpose (GP) lane AVO during both the AM and PM peak hours. The overall AVO in the GP lane was 1.05, whereas the overall AVO in the HOV lane was 2.31. This is a strong indication of the HOV lane's effective performance. The overall peak hour AVO on I-15 was found to be 1.37 using the "average of averages method." Using the ratio of person throughput to vehicle volume, the overall peak hour AVO on I-15 was found to be 1.21.

In the GP lane, single occupant vehicles (SOVs) were the major mode, constituting 92.75 percent of all modes. In the HOV lane carpools were dominant, constituting 95.63 percent of all modes. The HOV lanes had a higher percentage of carpools, vanpools, motorcycles and buses than the GP lanes.

The NCHRP HOV Systems Manual's recommended minimum HOV lane person throughput threshold of 900 to 1,800 pphpl during the peak hours was met during both the AM and PM peak hours. HOV lane person throughput is higher during the PM peak hour than during the AM peak hour. It was found that compared to a GP lane, the HOV lane carried 18.21% fewer people with 61.97% fewer vehicles during the AM peak hour. Compared to a typical GP lane, the HOV lane carried 8.42% more people with 51.41% fewer vehicles during the PM peak hour. HOV lanes thus carry more people in fewer vehicles and are more effective during the more congested PM peak hour than during the AM peak hour when the congestion level is low.

Travel time in the HOV lane was found to be 19.75 minutes, whereas travel time in the GP lane was found to be 21.57 minutes. Travel-time savings was found to be 1.82 minutes or 8.44%. The decrease in travel-time benefits may be because of the lower levels of congestion in the GP lanes after the completion of the I-15 South project. As congestion gradually increases on I-15, the travel-time benefits of the HOV lanes are likely to increase.

The HOV lane speeds were higher than the GP lane speeds along the entire section of I-15 from 500 South to the Utah County line. Thereby the HOV lanes offer travel-time savings. Higher speeds in the HOV lanes as compared to the GP lanes indicate that the HOV lanes have less or no congestion. The HOV lane mean speeds are much higher than 45 mph which means that the HOV lane was not congested during the data collection period. Furthermore, the Salt Lake Valley HOV lane mean speed is higher than the national HOV lane mean speed of 54 mph during the peak periods.

The Salt Lake Valley HOV lane system experiences a low violation rate when compared to other cities nationally. The AM peak hour violation rate was found to be 2.59 percent. From the split of the violations it was seen that occupancy violations (SOV drivers using the HOV lanes) were the most common type of violation.

It was recommended that various managed-lane concepts need to be researched and adopted. This is most likely to optimize the performance of the Salt Lake Valley HOV lanes. There may be a need to better manage the HOV lanes through the use of other managed-lane techniques, such as pricing and reversible lanes. Improvements like direct on-ramps and off-ramps to the inside HOV lanes and prominent ILEV and carpool information signs are needed along the I-15 corridor. All these will enhance the popularity of the HOV lanes and lead to increased HOV lane use. HOV lane use in Salt Lake Valley is continuing to grow. As traffic volume in the Salt Lake Valley increases and congestion reaches higher levels, the benefits of the HOV lanes will likely increase. There is a need for continued monitoring to identify and keep track of these benefits and proactively manage the HOV lanes.

1. INTRODUCTION

High occupancy vehicle (HOV) lanes are freeway or roadway lanes restricted to vehicles carrying a minimum number of people (typically 2, 3 or 4). Buses, vanpools, and carpools are eligible to use them. On some facilities, motorcycles with a driver only, single occupant inherently low emission vehicles (ILEV) and toll paying single occupant vehicles (SOVs) are eligible to use the HOV lanes. HOV lanes are also known as carpool, vanpool or bus lanes (*1*). The main objective of HOV lanes is to increase the average number of persons per vehicle or the people-moving capacity of a roadway. Since an HOV lane carries more people in fewer vehicles, it reduces congestion, saves travel time and reduces emissions. These benefits in turn encourage people to carpool and use buses.

HOV lanes have many advantages. They move more people in fewer vehicles, thus reducing the demand for new highways. HOV lanes save time because of lower rates of congestion and incidents, making them high-speed; in other words, travel time becomes consistent and reliable. They provide cleaner, healthier air throughout the region due to reduced emissions (*1*). They also reduce the stress of driving for passengers because they are riding in cars, vans, and buses instead of maneuvering through traffic. The lanes lead to reduced use of personal cars, thereby reducing wear and tear and fuel consumption. They are flexible and their technique, design, and operation can be tailored to meet local needs and conditions. Finally, HOV lanes benefit SOV drivers by taking carpoolers out of the general purpose (GP) lanes (*1*).

A major disadvantage of HOV lanes is “empty lane syndrome,” or perceived underutilization of HOV lanes. Because HOV lanes carry more persons per vehicle, they are less congested and therefore seem to be underused. They primarily benefit the users of the lanes and do not necessarily manage overall traffic congestion. They need continuous enforcement and monitoring for maximum efficiency. Furthermore, the differentials in traffic speed, congestion at HOV entrance and exit points and the frequent moving in and out of vehicles from the HOV lanes create safety hazards.

1.1 Background

HOV lanes have been a part of the urban transportation scenario since the 1970s. There are presently about 100 HOV projects in North America. They represent nearly 1,000 route-miles of HOV lanes. Many new HOV facilities are in various stages of planning, design, and construction. With such a significant ongoing investment in carpool lane facilities, comprehensive monitoring and evaluation of the HOV lane systems’ performance is critical (*2, 3*).

Interstate 15 (I-15) is a major freeway oriented in the north-south direction in the Salt Lake Valley. HOV lanes opened in the Salt Lake Valley May 14, 2001, on the reconstructed I-15. They were initially built on a 16-mile segment between 600 North and 10600 South. An 8.5-mile extension was opened between 10600 South and the Utah County line on October 27, 2004. The HOV lanes operate in both the northbound and southbound directions. The Salt Lake Valley HOV lanes are single lanes and have a painted separation. They operate 24 hours a day, seven days a week. Two-or-more-person carpools, vanpools, buses, motorcycles, alternative fuel vehicles (AFVs) and emergency vehicles are eligible to use the HOV lanes. There are inside ramps to the HOV lanes at 400 South which provides access to the downtown area of Salt Lake City. Vehicles weighing more than 12,000 lbs and vehicles towing trailers are not allowed in the HOV lanes even if they satisfy the minimum occupancy requirement.

Before the completion of the I-15 South project in October 2004, there was a bottleneck at 10600 South. It was because of the reduction in capacity from four GP lanes and one HOV lane per direction to three GP lanes. This resulted in a level of service (LOS) 'E' around 10600 South (*5*). The Utah Department of Transportation (UDOT) expanded the I-15 lanes from 10600 South to the Utah County line from three GP lanes in both directions to three GP lanes and one HOV lane in the northbound direction and four GP lanes and one HOV lane in the southbound direction to alleviate this condition. Figure 1.1 shows the HOV lanes in the Salt Lake Valley. The thick red line shows the original HOV lanes and the thick green line shows the extended HOV lanes.

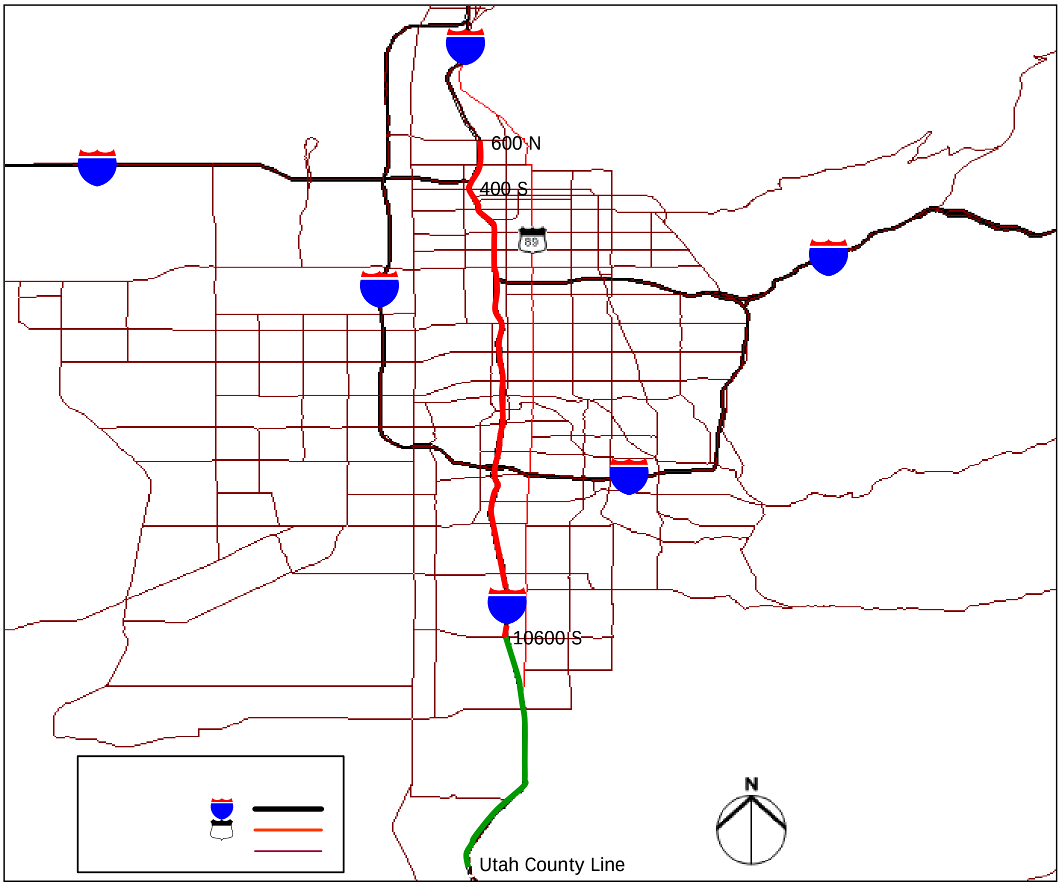

Figure 1.1: HOV Lanes in the Salt Lake Valley

The University of Utah Traffic Laboratory (UTL) did an evaluation project on HOV lanes from 2000 to 2001 for UDOT (*4*). The research objectives of the project were to evaluate the impact of the HOV lanes on I-15 and alternate routes and quantify the effectiveness by comparing before/after HOV lane statistics. Changes to existing HOV operation policies or procedures and educational programs for improving HOV lane acceptance and compliance were recommended. An analysis method was adopted. Measures of Effectiveness (MOEs) aid in identifying opportunities to increase the system-wide net benefits. Some of the typical HOV evaluation measures used were volume, speed, travel time, violation rate, and vehicle occupancy. Data collection included time periods before the HOV lanes opened, after they opened and recurring measures throughout the first year of operation.

Many benefits were recorded by the project. Travel time was found to be 13 percent lower in the AM peak period and 31 percent lower in the PM peak period. AVO increased from 1.12 to 1.32; that is, there was an 18 percent increase. Moreover it was found that during the PM peak period the average speed was 63.6 miles per hour (mph) in the HOV lane and 51.5 mph in the GP lanes. It was found that throughout the day the speeds in the HOV lanes were higher than the speeds in the GP lanes. Violation rates were 5-13 percent along the corridor and 20 percent at the ramp at 400 South, which is higher than the national average (*4*). The I-15 corridor with HOV lanes played an important role during the 2002 Salt Lake City Winter Games, providing the greatest amount of freeway capacity in the Salt Lake Valley. The study recommended the following:

1. Continued monitoring and evaluation to adjust policy as congestion demands,
2. Geometrical improvements (such as providing on/off-ramp for HOVs at the 10600 South exit or extension of HOV lanes after this point),
3. Frequent maintenance of traffic monitoring stations (TMS) for the continuous monitoring of HOV lanes,
4. Rigorous violation enforcement-implementing programs, and
5. Educational programs.

The second HOV lanes study (UTL-1003-70) evaluated the effectiveness of the HOV lanes in the Salt Lake Valley during their third year of operation, from 2003 to 2004 (*6*). It quantified and analyzed various MOEs including vehicle volume, AVO, modal split, person throughput, speed, travel time, crash rate, and violation rate. It also assessed the lanes' safety and determined public perception. The findings show that almost all of the National Cooperative Highway Research Program (NCHRP) HOV Systems Manual Report 414's standards were met with respect to vehicle volume, person throughput, and travel time. Meeting these standards justifies the retention of the HOV lanes in the Salt Lake Valley. The crash data analysis showed that the HOV lanes are not inherently unsafe. A public opinion survey indicated strong support for the HOV lanes from both users and non-users. The study concluded that the HOV lanes are performing better than they did during their first year of operation. The findings further indicated that as congestion in the Salt Lake Valley increases, the benefits of the HOV lanes will likely increase. The project recommended many improvements like better signage, more park & ride lots, discounted parking, rigorous enforcement (especially at the 400 South ramp), publicizing the travel time benefits of the HOV lanes, and continued monitoring and public surveys. Furthermore, the second study suggested the retention of the HOV lanes (*6*).

1.2 Problem Description

Congestion in Salt Lake City is showing an increasing trend and as congestion reaches higher levels, the benefits of the HOV lanes will likely increase. It needs to be determined whether the Salt Lake Valley HOV lanes and their extension are performing effectively in terms of travel time benefits, congestion mitigation at the 10600 South bottleneck, and the ability to carry more people in fewer vehicles. These factors should be thoroughly analyzed to track the increasing benefits, identify the problems that need to be addressed and determine the conditions that would encourage additional HOV users. In this way, policy-makers can be provided accurate information to enable them to make informed decisions about the future management and improvement of the HOV facilities in the Salt Lake Valley.

1.3 Research Goal and Objectives

The goal of the study "Review of the Effectiveness of the HOV Lane Extension" is to evaluate the effectiveness of the HOV lanes extension on I-15 in the Salt Lake Valley. The study's research objectives are:

1. Determine the efficiency of the extended HOV lanes, and
2. Recommend changes to the existing HOV operations.

Figure 1.2 shows a summary of the goal, objectives and MOEs for the research project.

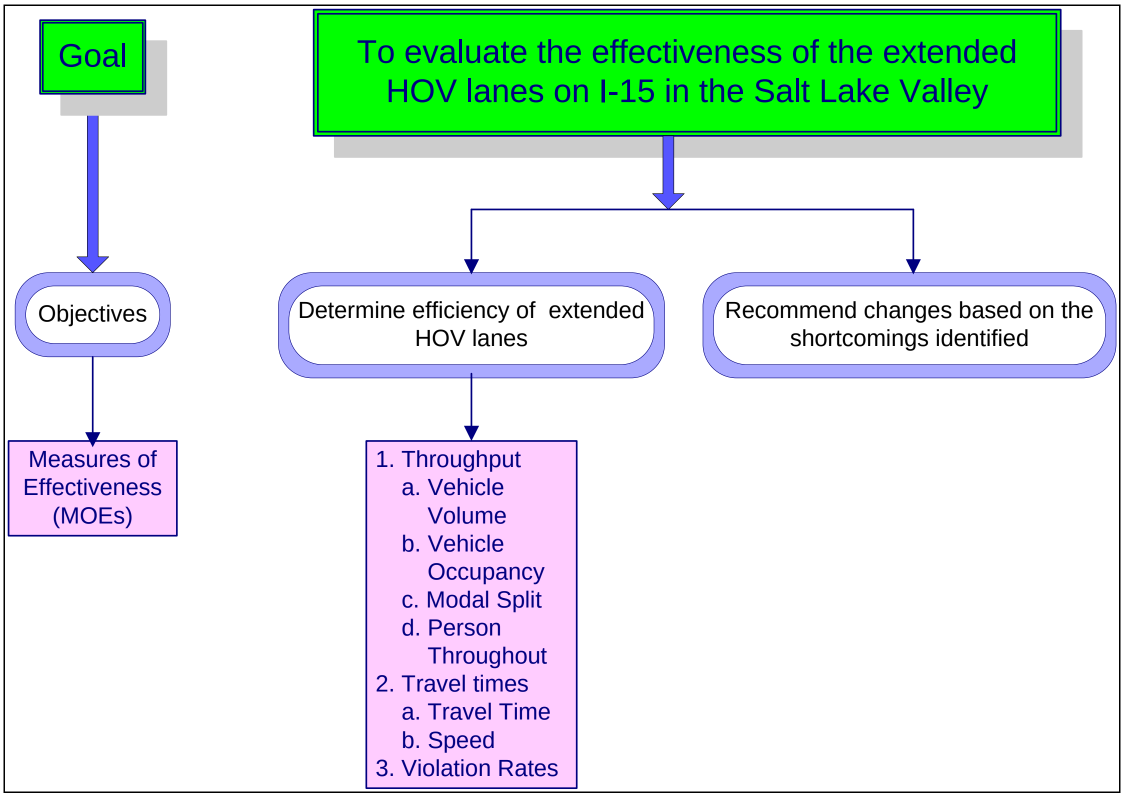

Figure 1.2: Goal, Objectives and Measures of Effectiveness

The project tasks and the actions are:

1. Review the success and failure of HOV lanes in metropolitan areas.
2. Collect vehicle volume data on both the extended HOV and GP lanes in the Salt Lake Valley.
3. Adopt the floating car method and use Global Positioning System (GPS) software to determine speed and travel time data. Analyze travel-time savings of the HOV lanes compared to the GP lanes.
4. Collect vehicle-occupancy data to obtain AVOs for both the GP lanes and the extended HOV lanes.
5. Apply AVO to vehicle volume and obtain person throughput.
6. Identify modal split of the GP lanes and extended HOV lanes.
7. Obtain violation rates at representative locations.

8. Compile the data collected from the HOV and GP lanes and compare them. Compute the changes, both numerically and as percentages for each MOE.
9. Discuss the effectiveness of the HOV lanes extension based on the evaluation of the data collected.
10. Recommend changes or improvements to the HOV lane system based on the analysis of the data collected.

2. LITERATURE REVIEW

HOV lane operations and evaluations have been going on in many North American states. An overview of some of the HOV lane programs is given in this chapter.

2.1 California Success

Caltrans operates 1,061 miles of HOV lanes and is constructing an additional 162 miles. California's HOV lanes carry an average of 2,518 persons per hour during peak hours, which is much higher than that carried by a congested GP lane (*7)*. It is approximately equal to the number of people carried by a typical GP lane operating at maximum capacity. California's HOV lanes are, however, operating at only two-thirds of their capacity in terms of vehicles carried. There are some groups who say that allowing AFVs to use the HOV lanes increases alternative vehicle attractiveness. Some of California's HOV facilities allow 2+ occupancy during off-peak periods and 3+ during peak-periods. Some bridges in the San Francisco Bay region eliminate tolls for HOVs during peak periods. In March 2000, a study was commissioned to evaluate Los Angeles County's extensive HOV lanes. Its objectives were to enhance existing HOV data collection; analyze the travel impacts and user benefits of the HOV system; provide policy-makers with information to enable them to make decisions about the future of HOV facilities; sustain, market, and promote user and non-user acceptance of the HOV system; and develop policy recommendations to help guide future HOV investments. Market research was done as a part of the evaluation process. The general public telephone survey focused on a group of core questions to measure the public's perceptions and attitudes towards HOV facilities. It was found that more than half of the HOV users use carpool lanes more than five days per week. This in turn reveals that the availability of HOV lanes plays a major role in users' decisions to access HOV lanes (*1)*.

2.2 Vancouver Evaluation

The Vancouver HOV Pilot Project Evaluation Report # 4 is the most recent evaluation report monitoring the effectiveness of the Southbound Interstate 5 (I-5) HOV Lane Pilot Project in Vancouver. The Vancouver HOV lanes opened to traffic on October 29, 2001 (*8)*. The three main goals of the Vancouver HOV Lane Pilot Project were to 1) move more people per lane in the Vancouver HOV lane during the 2-hour AM period (6:00 a.m. to 8:00 a.m.) than in either of the adjacent GP lanes 2) reduce peak period travel time for HOV lane users and 3) minimize impacts to other traffic in the corridor and on parallel facilities. During September 2002, a public opinion survey was conducted as a part of the evaluation. About 39 percent of the respondents felt the Vancouver HOV lane is an excellent or good idea. This value has decreased as compared to 58 percent of respondents in September 2001 and 47 percent in March 2002 (*8)*. Before and after traffic count data was collected from the Washington State Department of Transportation (WSDOT), City of Vancouver, Regional Transportation Council (RTC), and Clark County. A WSDOT incident response vehicle patrolled the I-5 corridor during the AM peak period. The vehicle collected corridor travel time data daily. Vehicle occupancy counts consisted of counting every vehicle in a single lane for 15-minute intervals and noting the number of occupants in each vehicle. The occupancy counts rotated across all lanes. Bus ridership was determined using C-TRAN counts provided for those routes using the I-5 corridor on the same dates that vehicle occupancy counts were taken. Percentages of vehicles and persons for each travel mode were then applied to traffic counts taken for each lane by WSDOT's automated traffic recorders (*8)*.

2.3 Seattle System

In Seattle, HOV lanes exist in the major corridors around the Puget Sound area. Corridor-wide and location specific HOV performance results were evaluated for the I-5, I-405, I-90, State Route 520 (SR 520), and SR 167 corridors. The primary measures used were vehicle volume, person throughput, AVO, speed, travel reliability, and travel time. Secondary performance measures included enforcement and violation rates along the HOV lane systems (*9)*. Person and vehicle volumes were analyzed at certain locations along the major HOV corridors. The results obtained were compared with those of GP lanes for morning and afternoon periods (6:00 a.m. to 9:00 a.m. and 3:00 p.m. to 7:00 p.m.) in the direction of the heaviest traffic flow. It was found that it takes longer to travel in the GP lane (around 13 minutes) than in the HOV lane (around 10 minutes) during the afternoon peak period. The operation of the HOV lanes at specific locations was also examined to obtain more details about HOV traffic performance. The principal measures used to evaluate HOV performance at a particular site included average vehicle volume, average speed at the location, and the percentage of days during which the average speed was less than 45 mph at that location. Violation rates were calculated using vehicle occupancy data collected by traffic observers at a limited number of locations throughout the region. During the year 2000, Washington State Patrol (WSP) reported 12,591 contacts with HOV violators and issued 9,045 tickets. There were 44% more tickets issued in 2000 than in 1998 (*9)*. Another source that provided some insight into HOV violation rates was the HERO program. It encourages motorists to report HOV violators by telephoning or by sending in reports of violations electronically. The HERO program does not issue tickets because the WSP must actually observe the violation to enforce the infraction. A public opinion survey was also conducted. A major finding was that 83% of the respondents supported the HOV lanes (*9)*.

2.4 Houston System

In Houston, Texas, the HOV lane system consists of six corridors, namely Katy Freeway (IH 10W), North Freeway (IH 45N), Gulf Freeway (IH 45S), Northwest Freeway (US 290), Southwest Freeway (US 59S) and Eastex Freeway (US 59N). In June 2003, the total system utilization was measured at 37,173 daily vehicle trips and 121,079 daily passenger trips. Support facility utilization was measured at 16,751 daily parked vehicles. Because of construction in the vicinity of the US 59/I-10 interchange, there was a continued reduction in bus utilization of the US-59 Eastex HOV lane during the morning period. Buses are expected to return to the HOV lane once construction is complete. The overall AVO was 3.46 during the peak period and 2.00 during the off-peak period along the Katy Freeway (IH 10W). The accident rates (number of accidents per 100,000 vehicle trips) on the Katy, North, Gulf, Northwest, Southwest and Eastex corridors were found to be 2.54, 2.56, 0.00, 0.21, 1.51 and 0.00 respectively (*10)*.

2.5 Dallas Evaluation

The HOV lanes studied in Dallas operate on I-30, I-35E, and I-635. The MOEs include vehicle volume and occupancy data, speeds and travel times, transit operation, cost-effectiveness, enforcement and violations, air quality impacts and public acceptance. The average automobile occupancy of freeways with an HOV lane increased by 8 percent to 12 percent, while the corresponding average of freeways without HOV lanes decreased by 2 percent (*11)*. An increase in occupancy implies that motorists are forming carpools to take advantage of the benefits offered by HOV lanes. Since the opening of the HOV lanes, there has been a significant increase in carpooling in each of the lanes ranging from a 79 percent increase to a 296 percent increase. On incident-free days the HOV lanes typically save motorists at least five minutes. Bus operating speeds have more than doubled since the HOV lanes opened. A survey of

HOV lane users on I-30 indicated that carpoolers and bus riders use the HOV lane to save time and money (*11*).

2.6 Oregon System

The Oregon Department of Transportation (ODOT) conducted an evaluation of the I-5 before and after the introduction of the HOV lanes. Four follow-up evaluations have since been conducted. Performance measures such as total person throughput, travel time, safety, enforcement, and modal impacts, which included HOV lane utilization, transit ridership, number of persons per vehicle, park-and-ride use, vanpools, and employer programs, were evaluated. Enforcement of HOV lane violators was measured in two ways: the number of observed violators based on occupancy counts (which are used to calculate compliance rates) and the number of citations written (warnings plus tickets). A public opinion survey was also conducted. ODOT surveyed 220 households with a margin of error of +/- 6.25% (*12)*. The major findings of the public survey were:

1. 74.1% of the respondents favor the permanent adoption of the HOV lane, and
2. The most attractive carpool/bus rider incentives offered were more convenient park-and-ride locations and discounted downtown parking.

The summarized results from the latest evaluation are (*12*):

1. HOV lane drivers who drive the entire length of the corridor save an average of eight to ten minutes.
2. Overall vehicle occupancy has increased to 1.39 from the Baseline Report value of 1.37 (April 1999 information was used in the Baseline Report).
3. Occupancy compliance rates have increased to 92 percent.
4. The accident rate (number of accidents per million vehicle miles traveled or MVMT) has decreased slightly for the entire HOV lane period compared to “No-HOV Lane” conditions.

2.7 Florida Evaluation

The I-95 HOV facility extends from SR 112 in Miami-Dade County to just south of Linton Boulevard in Palm Beach County, a distance of approximately 46 miles (*13)*. The objective of the monitoring effort was to collect traffic data such as volume, speed, travel time and delay, vehicle occupancy, and violation enforcement. The data was summarized, evaluated, and compared to previous reports to document the level of success of the HOV facility and to determine whether operational changes should be implemented. For Miami-Dade County, vehicle counts were collected using video. This method was used because there are no imbedded loops for traffic data collection on I-95 in Miami-Dade County, and it was considered the safest technique. The videos were then analyzed to produce 15-minute interval counts and summed to hourly counts at all locations. To evaluate typical weekday conditions, 72-hour traffic volume counts were conducted between Tuesday and Thursday at various locations along the I-95 corridor. For all the data collection points along the corridor, the vehicles per hour per lane (vphpl) met the recommended criterion (400 to 800 vphpl) and in most cases the threshold was well exceeded. An LOS analysis was performed using the latest version of Florida Department of Transportation LOS software. Speed data was collected via travel time and delay runs. Travel time runs were performed for the entire length of the HOV lanes using the floating car method. The overall travel time savings for the entire corridor in the northbound direction during the PM peak is approximately 9.5 minutes. On all segments except for one, the speeds in the HOV lanes were significantly higher than the GP lanes. Vehicle occupancy was reported as a percentage of SOVs, two-person vehicles, and vehicles containing three or more persons within the traffic stream. AVO and traffic volume data were then used to calculate the person throughput of the HOV lane at selected locations. In all cases, the person throughput threshold of 900 to 1,800 persons per hour per lane (pphpl) was well exceeded except for one location at Glades Road southbound in the AM period. The vehicle occupancy surveys recorded the number of SOVs observed in the HOV lane during the enforcement periods (*13)*.

2.8 New Jersey Failure

In New Jersey, the HOV lanes on I-80 were opened with a peak-period two-person vehicle (2+) HOV designation in March 1994. The HOV lanes on I-287 were opened in January 1998, with the same 2+ and peak period operating requirements. The HOV lanes on both I-80 and I-287, however, were repealed and re-opened to all vehicles on Nov. 30, 1998. The diverse origins and destination of trips on I-287, low-density suburban developments in both corridors and the absence of a major employment center or any trip-generating center made ridesharing or taking the bus more difficult. The HOV lane on I-287 was used very little with under 400 vphpl and did not do much to solve the severe congestion problem on this corridor. In contrast, the I-80 HOV lane was well-used with more than 1,000 vphpl. Strong political opposition, however, encouraged the closure of I-80's HOV lane as well. Both the HOV facilities did not carry much transit service and the public was not prepared when it opened initially. The direct HOV connection between I-80 eastbound and I-287 southbound, which would have provided HOVs with significant travel time savings, was not implemented. Therefore, lack of transit service, support facilities (like park-and-ride lots), services (like rideshare programs) and policies and poor marketing were the major reasons for the failure and subsequent closure of the HOV lanes in New Jersey (*3, 14*).

2.9 System Overview

There are more than 30 metropolitan areas with HOV lanes nationwide. Approximately 52 percent of them are enforced 24 hours a day, seven days a week. Approximately 86 percent of the HOV lanes operate as 2+ facilities with the remainder operating as 3+. The purpose of HOV lanes is to increase vehicle occupancy and reduce travel time for both private vehicles and transit services. The average peak period speed for HOV lanes as determined from the HOV lane studies across the country is 54 mph which is much higher than the average peak period speed of 28 mph for the GP lanes. The nationwide average violation rate is 9.5 percent on barrier-separated HOV lanes and 13 percent on concurrent facilities (*3, 15, 16*).

2.10 Overall Performance Summary

HOV lanes are performing effectively in many cities and are either meeting or exceeding the minimum effectiveness thresholds. They need continued assessment to check whether they are meeting their goals and objectives. There are many MOEs that are used in such assessments and evaluations. MOEs generally include volume, vehicle occupancy, modal split, speeds, travel times, and violation rates. Public surveys are also an integral part of the evaluation process. Information obtained from various evaluations and public surveys have indicated that support for HOV lanes has been steadily increasing. Continued evaluations and public surveys are key to the nationwide success of the HOV lanes. Moreover, various managed-lane concepts need to be adopted to optimize underutilized and overutilized HOV lanes.

3. METHODOLOGY

MOEs provide an effective way to select between alternative solutions and to know the success of a system. MOEs should be equal to or exceed the effectiveness thresholds. Any single MOE does not solely determine the achievement of the objectives. Therefore, the satisfaction of the majority of the MOEs by the HOV lanes has been considered. Data have been collected, analyzed and compared to previous data to measure the performance of the HOV lanes. Data have been compiled to develop the following MOEs:

1. Vehicle volume
2. AVO
3. Modal split
4. Person throughput
5. Travel time
6. Speed
7. Violation rate

The MOEs have been chosen to enable the fulfillment of the project's objectives. The primary objective of the project is to determine the efficiency of the HOV lanes extension. Vehicle volume has been selected as a MOE because volumes higher than the minimum threshold indicate that the HOV lanes are well used. Vehicle volume will thus help meet the objective of determining the efficiency of the HOV lanes. Additionally, HOV lanes aim at carrying more people per vehicle. Vehicle occupancy as a MOE will provide quantitative data to evaluate occupancy and ascertain whether HOV lanes are enhancing the person-carrying capacity of the system. Moreover, modal split obtained from the AVO data will give the percentages of the various vehicle types and classify them as SOVs, carpools, vanpools, buses, motorcycles, and trucks/trailers. HOV lanes are intended to increase the person carrying capacity of a freeway by encouraging carpooling, vanpooling and bus ridership. Person throughput as a MOE will provide this data. Travel time as a MOE will measure and compare travel time. Travel time data measures the effectiveness of HOV lanes in reducing commute time. With speed as a MOE it can be checked if there are any congested segments, because speeds below 45 mph are considered congested on I-15 (*4)*. The methodologies to be adopted for the various MOEs are described in this chapter.

3.1 Vehicle Volume

It was checked whether the vehicle volume meets the National Cooperative Highway Research Program (NCHRP) HOV Systems Manual Report 414's standards. The NCHRP recommends a minimum operating threshold criterion of 400 to 800 vehicles per hour per lane (vphpl) during the peak hour for concurrent flow freeway HOV lanes (*17)*. When this condition was met at a location, it was concluded that the HOV lane is well-used at that location. The NCHRP's recommended maximum operating threshold criteria of 1200 to 1500 vphpl was checked.

3.2 Average Vehicle Occupancy

A major objective of the HOV facility is to increase its person-moving capacity and not necessarily its vehicle-moving capacity. The HOV lane should carry more people in fewer vehicles than the adjacent GP lanes to meet this objective. AVO is the average number of persons in a vehicle. Occupancy data from the different modes (SOVs, carpools, vanpools, buses, trailers and trucks) were collected separately during both the AM and PM peak periods. This person ridership distribution was then put into a spreadsheet to calculate the AVO of the HOV and GP lanes**.**

The following breakdown of person ridership was assumed for the different modes:

1. Carpools
   2 persons
   3 persons
   4 persons
   5+ persons

2. Vanpools
   1-5 - 3 persons
   5-10 - 7 persons
   10+ - 11 persons

3. Buses
   Empty - 1 person
   ½ Full - 20 persons
   Full - 40 persons

3.3 Modal Split

Modal shifts occur when individuals switch from driving alone to carpooling, vanpooling, or riding the bus. Such modal changes indicate the popularity of the HOV lanes. To obtain modal split, the percentages of vehicles for each travel mode were calculated from the vehicle occupancy data. The effectiveness threshold for modal split is that the HOV lanes should have a higher percentage of carpools, vanpools and buses than the GP lanes. If more HOVs use the GP lanes than the HOV lanes, this may imply that HOV lanes are inconvenient to use and that on-ramps and off-ramps are needed for the HOV lanes.

3.4 Person Throughput

One of the major objectives of the HOV lanes is to increase person throughput, or person-carrying capacity. AVO and traffic volume data will be used to calculate the person throughput of the HOV lanes at the selected locations. The following formula will be used to obtain person throughput:

Person throughput = AVO * (Traffic Volume)

The NCHRP HOV Systems Manual's recommended person throughput threshold of 900 to 1,800 pphpl during the peak hours (*17)* was checked. Wherever it was satisfied, it was concluded that the HOV lanes are well-utilized and are meeting the goal of carrying more persons than the national average.

3.5 Travel Time

The focus of considering travel time as a MOE is to determine peak period travel time savings for vehicles in the HOV lanes as compared to those in the GP lanes. According to the NCHRP HOV Systems Manual Report 414, HOV facilities should provide an overall travel time savings of at least 5 minutes during the peak hour (*17)*. An overall travel time saving of 7 minutes is desirable. It was checked whether travel times for the HOV lanes were lower than for the GP lanes. Speed data was also collected along with travel time data using the GPS software. Travel speed profiles were developed using this data. Higher speeds in the HOV lanes, as compared to the GP lanes, indicate that the HOV lanes have lower congestion levels.

3.6 Speed

Speed as a MOE helps in determining congested segments. Speeds less than 45 mph are considered congested on I-15 (*4*). It was checked if the HOV lane speeds were less than 45 mph. It was also checked whether the HOV lane speeds were higher than 54 mph which is the average peak period speed for HOV lanes as determined from other studies across the country (*14)*. The speed limit in the Salt Lake Valley HOV and GP lanes on I-15 is 65 mph. If the speeds collected from the HOV lanes were found to be much higher than 65 mph, it was concluded that HOV lanes encourage illegal speeds.

3.7 Violation Rate

Violation is defined as the percentage of the total HOV lane volume that is comprised of SOVs and prohibited vehicles, such as those weighing more than 12,000 lbs and those towing trailers. Lower violation rates indicate public awareness and acceptance of the HOV lanes. Since the nationwide average violation rate is 13 percent on concurrent HOV lanes (*14)*, it was determined whether the violation rate in the Salt Lake Valley is higher than 13 percent. The effectiveness threshold is that the violation rate should be lower (that is, less than 10 percent) and should decline over time. If this threshold is not met, appropriate enforcement steps like stronger patrolling are recommended.

4. DATA COLLECTION

Data was collected only on Tuesdays, Wednesdays and Thursdays to evaluate typical weekday conditions. The AM peak period was considered to be from 6:30 AM to 8:30 AM and the AM peak hour from 7:30 AM to 8:30 AM. The AM peak direction was taken as southbound between 600 North and 400 South and northbound between 400 South and the Utah County line. The PM peak period was considered to be from 4:00 PM to 6:00 PM and the PM peak hour from 4:30 PM to 5:30 PM. The PM peak direction was taken as northbound between 600 North and 400 South and southbound between 400 South and the Utah County line. The directional split was determined by taking into consideration the northern dense employment district (400 South being a major trip generating center) as compared to the southern residential areas. The assumptions in this study were kept constant with those of the previous HOV lane studies conducted by UTL. Manual data collection was done during the peak hours only (and not during the entire peak periods) because AVO data collection becomes inaccurate in the dark.

4.1 Vehicle Volume

AM and PM peak hour vehicle volume data were collected along the peak directions. The initial plan was to use video detection and UDOT's camera feeds to obtain volume and speed data. However, the cameras near 10600 South and the Utah County line could not be zoomed and focused suitably to use them for video detection. Additionally, the cameras at the I-15 Point of the Mountain (Salt Lake County and Utah County) were in auto-focus and the camera views were not distinct. Hence, they could not be used for video detection. For these reasons, vehicle volume data was collected manually by standing on the overpass at 10600 South.

4.2 Average Vehicle Occupancy

Vehicle occupancy data was collected manually in 15-minute intervals in the peak periods and peak directions. The counts consisted of noting the number of occupants in each vehicle in a particular lane for 15-minute intervals in datasheets. Only peak periods and peak directions were considered. Data was collected manually by standing on the overpass at 10600 South**.**

4.3 Modal Split

The AVO datasheet was prepared so that modal split, vehicle volume and person throughput could be obtained in addition to AVO.

4.4 Person Throughput

Person throughput was calculated using AVO and vehicle volume data. The formula used to obtain the person throughput was:
Person throughput = AVO * (Vehicle Volume)

4.5 Travel Time

Travel time is the time it takes a vehicle to traverse a given section of a road. Travel time and speed data were collected using the floating car method and GPS software. Laptops loaded with the GPS software were carried in each test vehicle. The test vehicles ran at the mean speed of traffic. Two test vehicles were used to collect data – one ran in the HOV lane and the other ran in the GP lane. While traversing the test segment from 500 South on I-15 to the Utah County line, the "node" on the laptop was changed at every test point. The test points (or "nodes") for this study were:

1. I-15 500 South
2. I-15 2100 South
3. I-15 3300 South
4. I-15 4500 South
5. I-15 5300 South
6. I-15 7200 South
7. I-15 9000 South
8. I-15 10600 South
9. I-15 14600 South
10. I-15 Utah County Line

Data from the GPS units were extracted using PC-Travel software after the travel time runs were done. They provided both travel time and speed data.

4.6 Speed

Speeds in the HOV and GP lanes were collected using the floating car method and GPS software. Data was collected only along the peak directions during the peak periods.

4.7 Violation Rate

Violations were monitored by standing on overpasses. SOVs using the HOV lane (other than AFVs that have license plates with the letter C painted in black on a blue background) are generally the main HOV lane violators. The Gross Vehicle Weight Rating (GVWR) displayed on the Vehicle Identification Number (VIN) plate or on the side of the vehicle was noted to detect vehicles weighing more than 12,000 pounds. Trucks larger than a pickup generally have a GVWR more than 12,000 pounds.

5. DATA ANALYSIS AND RESULTS

Regular data analysis, system monitoring and adjustment in the operation of the HOV lanes are required because, even after HOV lanes are opened or extended, changes occur in land use, levels of traffic congestion, and commuting patterns. Therefore, travel impacts and user benefits of the HOV system need to be analyzed periodically. This chapter presents the results and determines whether the MOEs have met and/or crossed the effectiveness thresholds. The deficiencies identified from these assessments have been taken as direct input into developing the recommendations for improving the efficiency of the HOV lanes.

5.1 Vehicle Volume

Figure 5.1 shows the AM peak hour traffic volume at 10600 South. GP 1 refers to the GP lane next to the HOV lane. The NCHRP's recommended minimum vehicle volume of 400 to 800 vehicles/peak hour for the HOV lane was satisfied and exceeded at 10600 South during the AM peak hour.

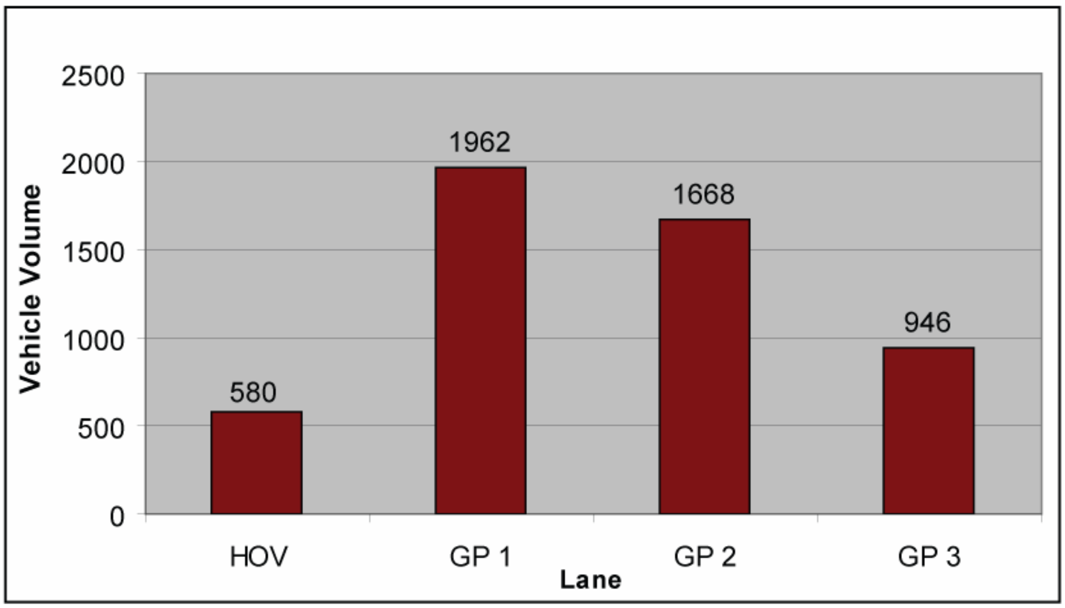

Figure 5.1: AM Peak Hour Vehicle Volume at 10600 South

Figure 5.2 presents the PM peak hour traffic volume at 10600 South. The NCHRP's recommended minimum vehicle volume for an HOV lane (400 to 800 vehicles/peak hour) is satisfied at 10600 South during the PM peak hour. This implies that the HOV lanes are well used. Also, PM peak hour volume is higher than the AM peak hour volume in the HOV lane. The NCHRP's recommended maximum operating threshold criterion of 1200 to 1500 vphpl was not exceeded during either the AM or PM peak hours.

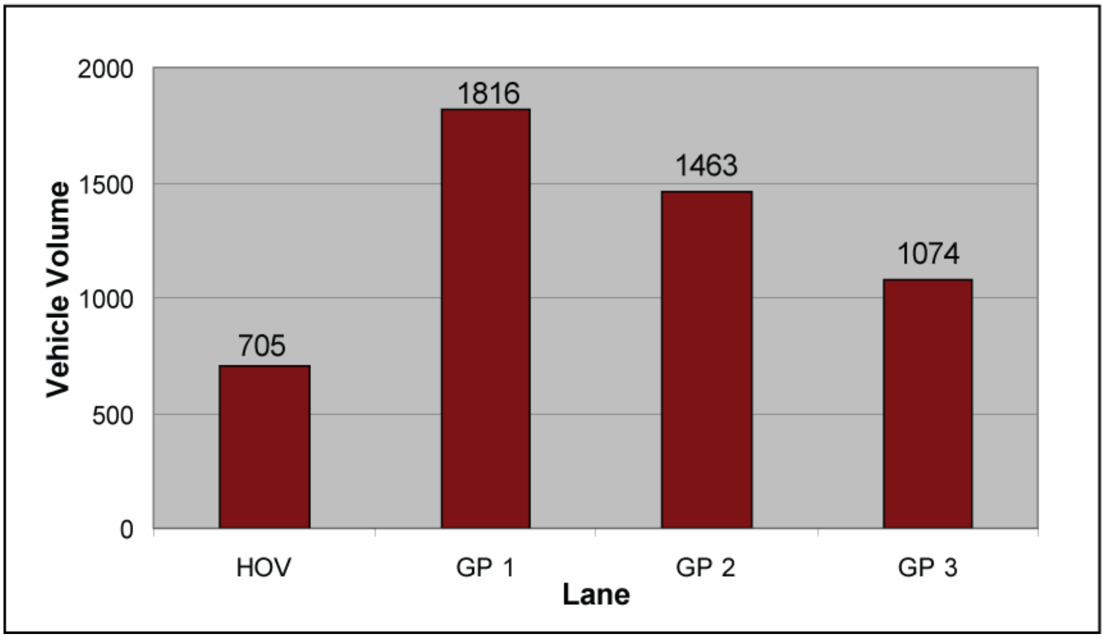

Figure 5.2: PM Peak Hour Vehicle Volume at 10600 South

5.2 Average Vehicle Occupancy

Figures 5.3 and 5.4 show that AVO in the HOV lane is much higher than AVO in the GP lanes during both the AM and PM peak hours.

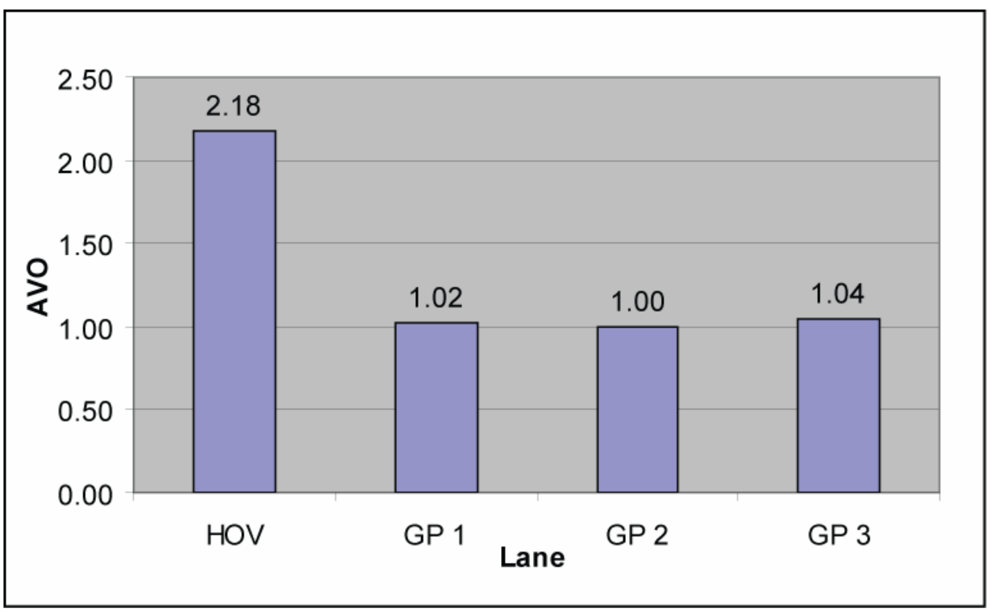

Figure 5.3: AM Peak Hour AVO at 10600 South

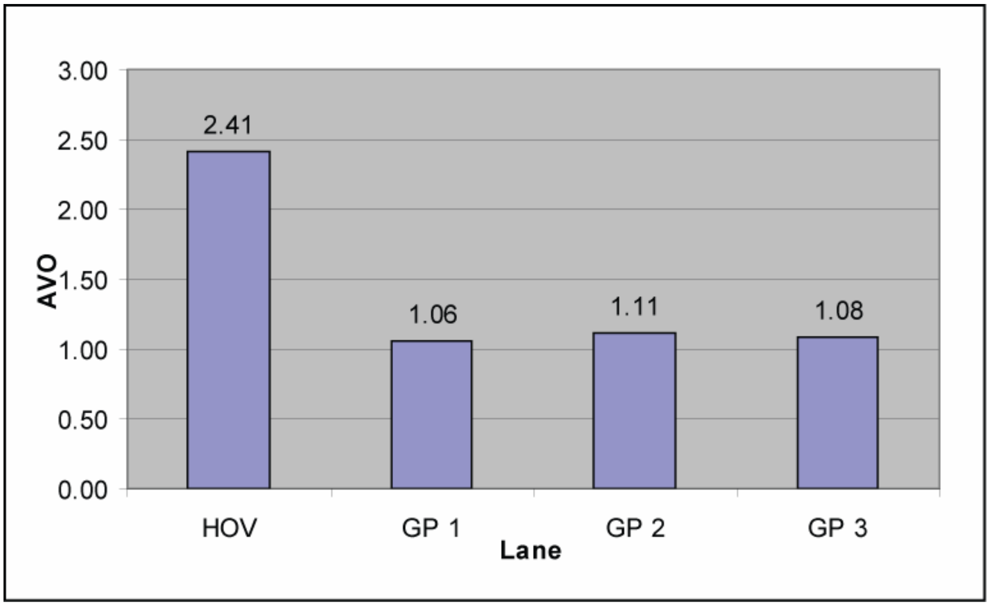

Figure 5.4: PM Peak Hour AVO at 10600 South

The AVO in the HOV lanes increased from 2.18 in the AM peak hour to 2.41 in the PM peak hour. Similarly, the AVO in the GP lanes increased from 1.02 in the AM peak hour to 1.08 in the PM peak hour. The overall AVO in the GP lane was 1.05, whereas the overall AVO in the HOV lane was 2.31. This is a strong indication of the HOV lane's effective performance.

The overall AVO before May 2001 (before the HOV lanes were opened on the reconstructed I-15) was 1.12 and the AVO within one year of their opening increased to 1.32 (*4*). Hence there was an 18% increase in the AVO on I-15 after the HOV lanes opened. Furthermore, as found in the second HOV lane evaluation study, the overall AVO on I-15 was 1.40 in March 2004 (*6*). Thus, as a result of the HOV system there was a 6% increase in AVO from its first year of operation to its third year of operation.

There are two ways to calculate the overall AVO of a freeway with HOV lanes. The first method, adopted in the previous two HOV lane studies conducted by UTL, considered the average of the AVOs of the HOV and GP lanes. This "average of averages" method may lead to certain inaccuracies. The other method considers the overall AVO as the ratio of person throughput and vehicle volume. Overall AVOs on the I-15 HOV lanes, calculated using the first method, are 1.31 and 1.42 respectively during the AM and PM peak hours. The overall peak hour AVO is 1.37. The AVO in the extended portion of the HOV lanes is 2% less than the overall I-15 AVO as found during the third year of operation of the HOV lanes. Considering the second method, the overall AVOs on I-15 with the HOV lanes are 1.15 and 1.27 respectively during the AM and PM peak hours. Thus, the overall peak hour AVO is 1.21.

5.3 Modal Split

Figures 5.5, 5.6, 5.7 and 5.8 present the peak hour vehicle classification percentages of the HOV lane and a GP lane at 10600 South on I-15. In the GP lane SOVs were the major mode, constituting 92.75% of all modes. In the HOV lane, carpools were dominant, constituting 95.63% of all modes. In fact, the HOV lanes had a higher percentage of carpools, vanpools, motorcycles and buses than the GP lanes. The express buses operated by the Utah Transit Authority (UTA) and Greyhound buses were observed using the HOV lanes during the peak hours. Vanpools and other buses, however, constituted only a small portion of the total vehicles (1.47% and 0.76% respectively) in the HOV lane and therefore need to be encouraged to further increase the person-carrying capacity of the HOV lanes.

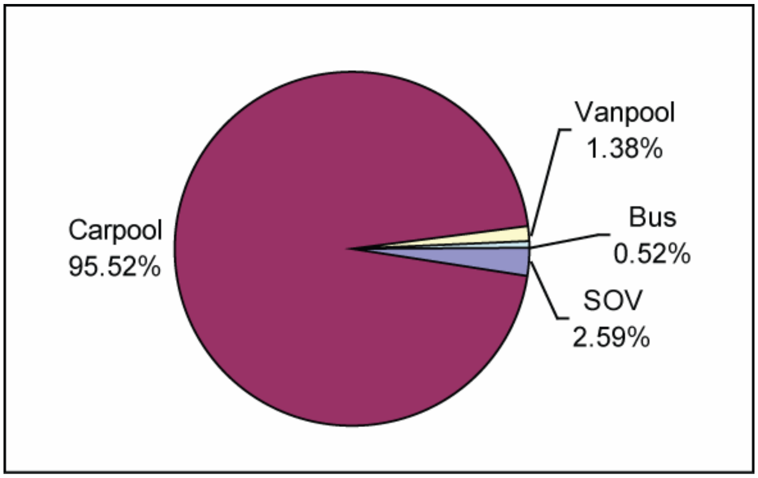

Figure 5.5: AM Peak Hour Modal Split at 10600 South HOV Lane

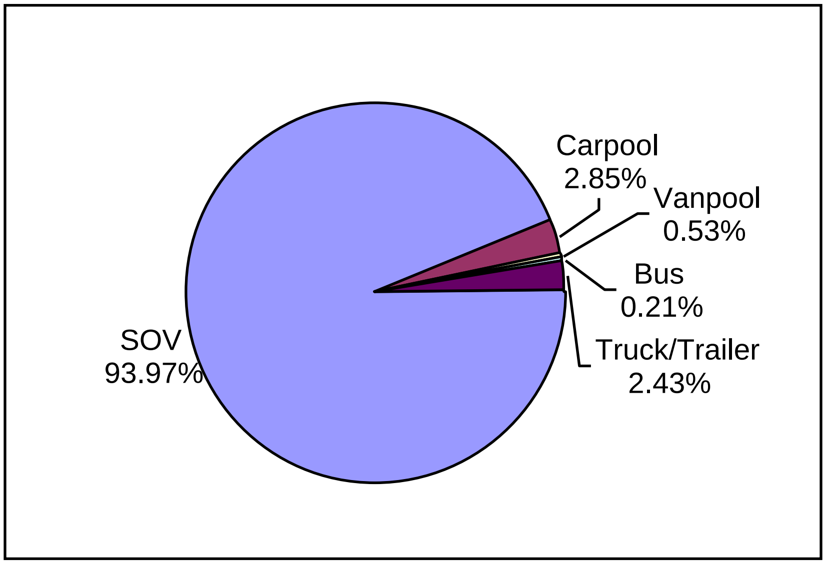

Figure 5.6: AM Peak Hour Modal Split at 10600 South GP 3 Lane

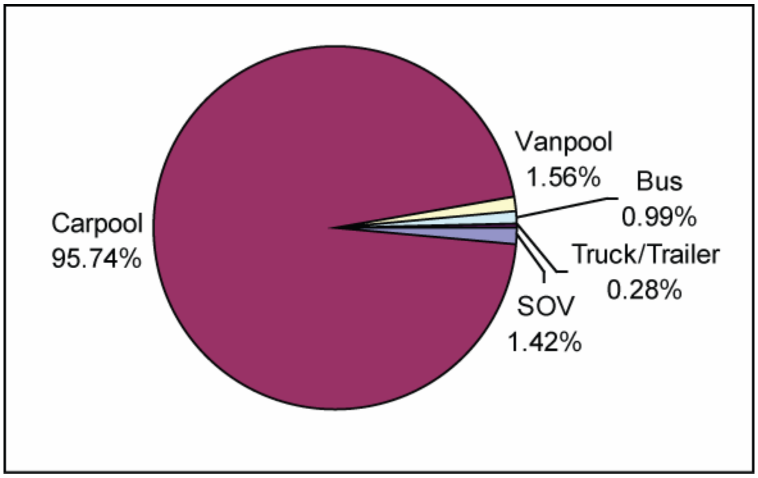

Figure 5.7: PM Peak Hour Modal Split at 10600 South HOV Lane

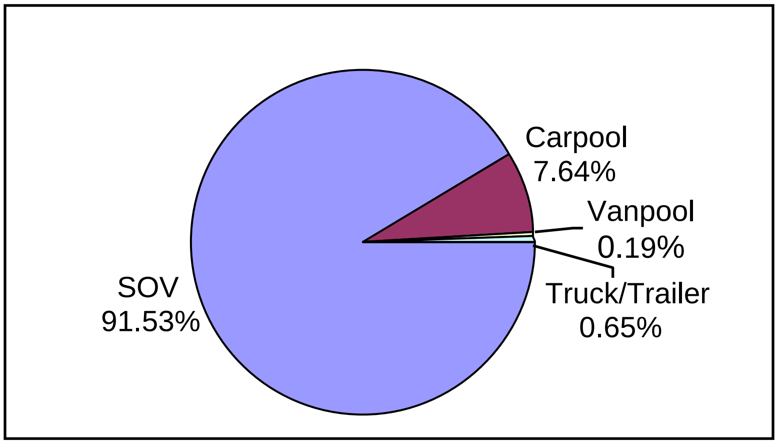

Figure 5.8: PM Peak Hour Modal Split at 10600 South GP 3 Lane

5.4 Person Throughput

Person throughput helps determine how well-utilized the HOV lanes are. Person throughput at a particular location was obtained by multiplying AVO by the traffic volume at the corresponding location. The NCHRP HOV Systems Manual recommends a minimum HOV lane person throughput threshold of 900 to 1,800 pphpl during the peak hours (*17*). This standard was met during both the AM and PM peak hours.

Figures 5.9 and 5.10 show the AM and PM peak hour person throughputs at 10600 South. HOV lane person throughput is higher during the PM peak hour than during the AM peak hour.

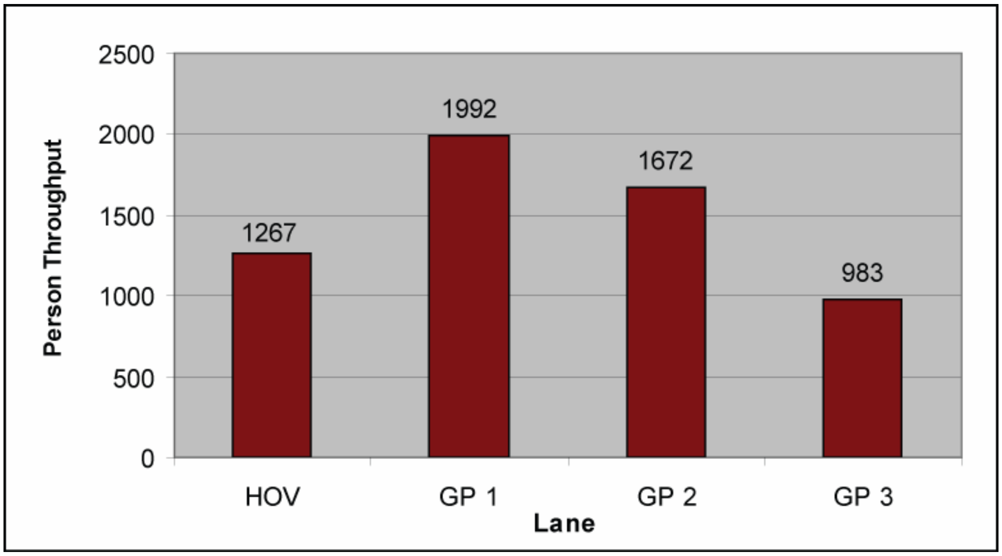

Figure 5.9: AM Peak Hour Person Throughput at 10600 South

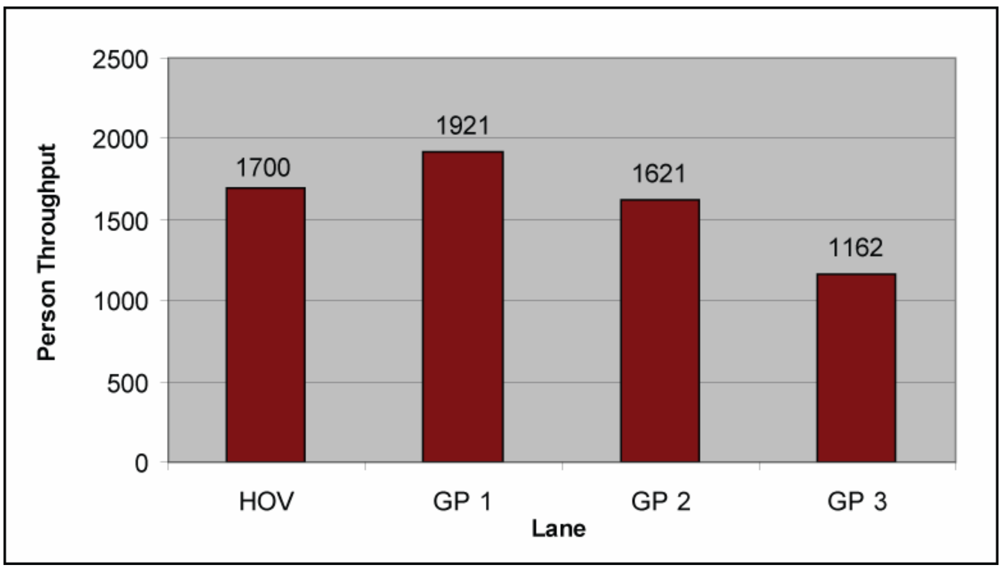

Figure 5.10: PM Peak Hour Person Throughput at 10600 South

Figure 5.11 shows that the person throughput per lane per vehicle of the HOV lane is much higher than that of a GP lane. Overall AM peak hour vehicle volume and person throughput of a typical GP lane and the HOV lane were compared. It was found that, compared to a GP lane, the HOV lane carried 18.21% fewer people with 61.97% fewer vehicles during the AM peak hour.

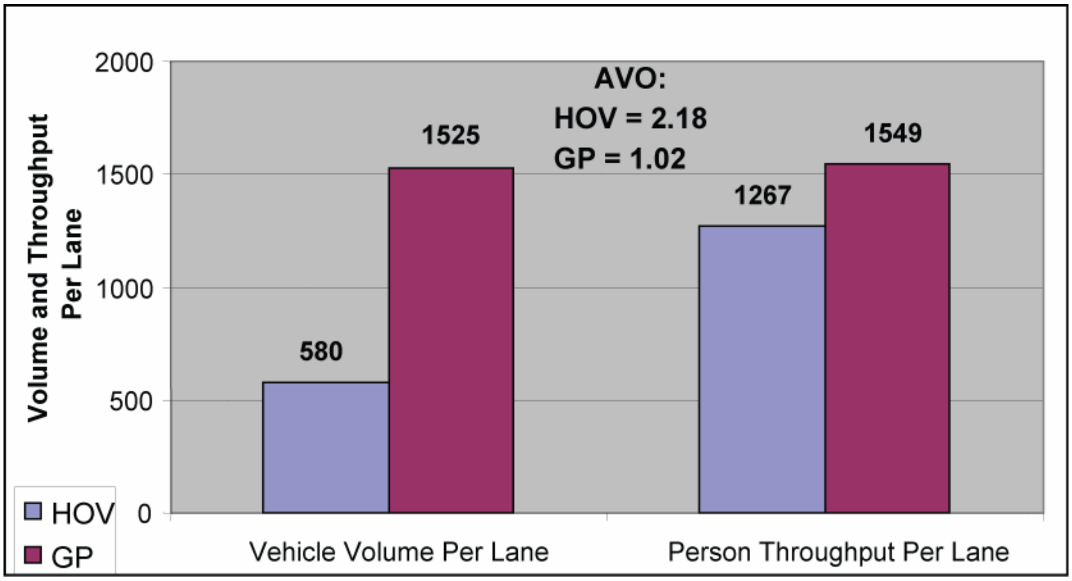

Figure 5.11: AM Peak Hour Volume & Person Throughput at 10600 South

Figure 5.12 presents the overall PM peak hour vehicle volume and person throughput of a typical GP lane and the HOV lane. Compared to a typical GP lane, the HOV lane carried 8.42% more people with 51.41% fewer vehicles during the PM peak hour. HOV lanes thus carry more people in fewer vehicles and are more effective during the more congested PM peak hour than during the AM peak hour when the congestion level is low.

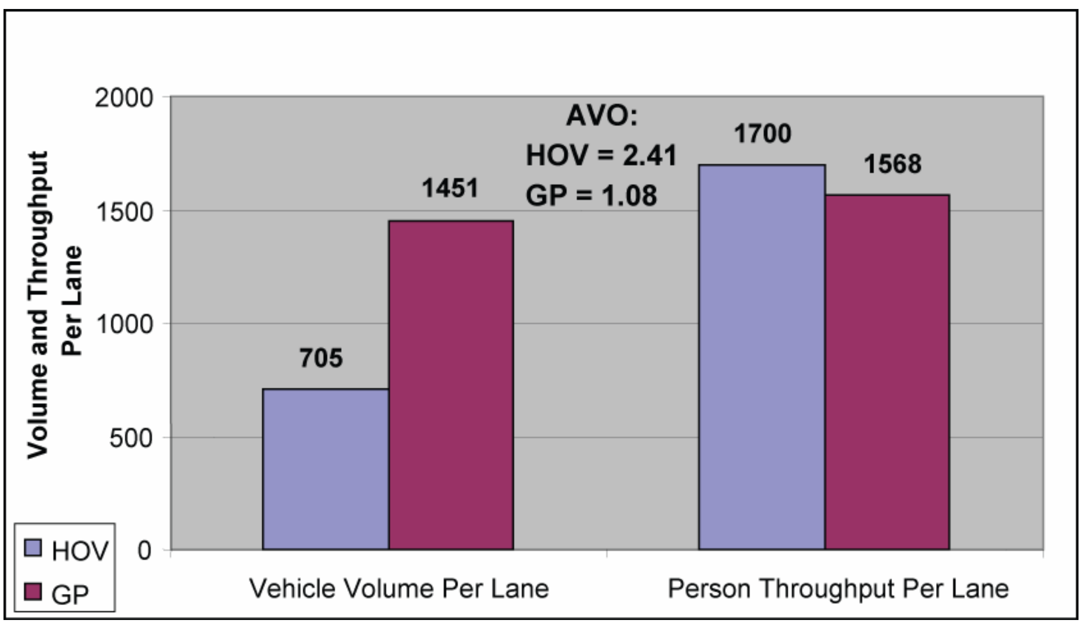

Figure 5.12: PM Peak Hour Volume & Person Throughput at 10600 South

5.5 Travel Time

Travel-time runs were conducted between 500 South and the Utah County line on I-15. Travel time in the HOV lane was found to be 19.75 minutes whereas travel time in the GP lane was found to be 21.57 minutes. Travel-time savings was, thus, 1.82 minutes or 8.44%. The NCHRP's recommended overall peak hour travel-time savings of at least 5 minutes and the desirable overall travel time savings of 7 minutes (*17)* were not met during the PM peak period when the travel-time savings was 1.82 minutes. The first HOV study recorded travel time benefits of 13.4% during the AM peak period, 30.7% during the PM peak period and 4.7% during the off-peak period (*4*). The second study recorded an increase in the travel-time savings from 30.7% in 2001-2002 to 46.3% in 2004 during the PM peak period. Travel-time savings during the AM peak period and off-peak period remained nearly the same at about 13% and 5% respectively (*6*).

The decrease in travel-time benefits may be because of the lower levels of congestion in the GP lanes after the completion of the I-15 South project. As congestion gradually increases, the travel-time benefits of the HOV lanes are likely to increase.

5.6 Speed

Figure 5.13 shows that the HOV lane speeds were higher than the GP lane speeds along the entire section of I-15 from 500 South to the Utah County line. Therefore, the HOV lanes offered travel time savings. Higher speeds in the HOV lanes as compared to the GP lanes indicate that the HOV lanes have less or no congestion. The HOV lane mean speeds are much higher than 45 mph which means that the HOV lane was not congested during the data collection period. Furthermore, the Salt Lake Valley HOV lane mean speed is higher than the national HOV lane mean speed of 54 mph during the peak periods. The mean peak period speeds for the HOV and GP lanes were 68.18 mph and 58.60 mph respectively in 2001-02 (*4*). They were 65.47 mph and 58.50 mph respectively during the year 2004 (*6*) and 63.26 mph and 51.17 mph respectively during the year 2005, as recorded in this study. The decrease in HOV lane speed since the first year of its operation is probably due to the increased use of the HOV lanes.

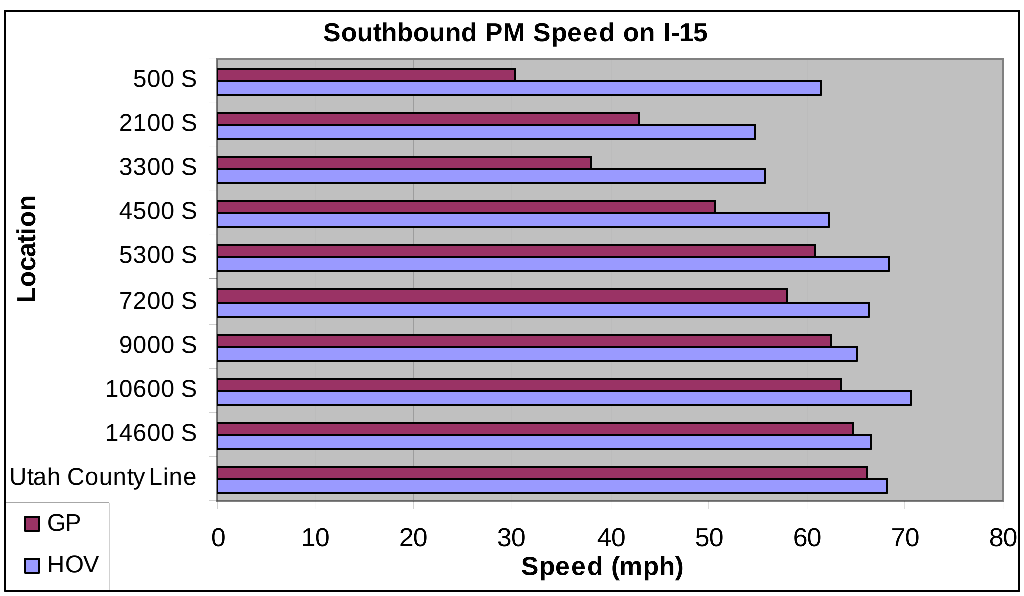

Figure 5.13: Speed Variation in the HOV and GP lanes

5.7 Violation Rate

The AM peak hour violation rate was found to be 2.59%. Only SOV violations and no trailer violations were observed during the AM peak hour. The PM peak hour violation rate was found to be 1.70%. SOV violation rate was found to be 1.42% and trailer violation was found to be 0.28%. The overall peak hour violation rate was found to be 2.15%.

The violation rates, however, are much lower than the national average of 13% for concurrent HOV lane facilities (*16*). From the split of the violations it was seen that occupancy violations (SOV drivers using the HOV lanes) were the most common type of violation. Trailer violation is quite low when compared to occupancy violation. The other type of prohibited vehicle, trucks weighing over 12,000 lbs., were not seen in the HOV lanes during the data collection period. HOV lane violation rates along the I-15 corridor and at the 400 South ramps decreased from 9% and 17% respectively in 2002 (*4*) to 2% and 10% respectively in 2004 (*6*). The corridor violations have remained stable at 2% in 2005. This decrease and the subsequent stability in violation rates is probably because of increased awareness about the HOV lanes, strong and frequent patrolling and heavy fines ($70 minimum and up to $1,800 depending on the type of violation) imposed on HOV lane violators. The low violation rates reflect high compliance with HOV lane requirements and ensure that the maximum possible HOV lane capacity is available for those eligible to use it.

6. CONCLUSIONS

The I-15 South project added an HOV lane in each direction and a GP lane in the southbound direction from 10600 South to the Salt Lake/Utah County line (*18*). This study reports the performance of the HOV lanes extension. The data collected was compared with the NCHRP standards and national averages.

The extended HOV lanes in the Salt Lake Valley are performing effectively in terms of several MOEs such as vehicle volume, person throughput, AVO and speed benefits. It was found that vehicle volume satisfies the NCHRP's recommended minimum vehicle volume of 400 to 800 vehicles/peak hour for the HOV lane during both the AM and PM peak hours. The NCHRP's recommended maximum operating threshold criterion of 1200 to 1500 vphpl was not exceeded during either the AM or PM peak hours.

HOV lane AVO was found to be much higher than the GP lane AVO during both the AM and PM peak hours. The overall AVO in the GP lane was 1.05, whereas the overall AVO in the HOV lane was 2.31. This is a strong indication of the HOV lane's effective performance. The overall peak hour AVO on I-15 was found to be 1.37 using the "average of averages method." Using the ratio of person throughput to vehicle volume, the overall peak hour AVO on I-15 was found to be 1.21.

SOVs were the major mode in the GP lane, constituting 92.75% of all modes. Carpools were dominant in the HOV lane, constituting 95.63% of all modes. The HOV lanes had a higher percentage of carpools, vanpools, motorcycles and buses than the GP lanes. Vanpools and buses, however, constituted only a small portion of the total vehicles (1.47% and 0.76% respectively) in the HOV lane and therefore need to be encouraged to further increase the person-carrying capacity of the HOV lanes.

The NCHRP HOV Systems Manual recommended a minimum HOV lane person throughput threshold of 900 to 1,800 pphpl during the peak hours. This was met during both the AM and PM peak hours. HOV lane person throughput is higher during the PM peak hour than during the AM peak hour. It was found that, compared to a GP lane, the HOV lane carried 18.21% fewer people with 61.97% fewer vehicles during the AM peak hour. Compared to a typical GP lane, the HOV lane carried 8.42% more people with 51.41% fewer vehicles during the PM peak hour. HOV lanes thus carry more people in fewer vehicles and are more effective during the more congested PM peak hour than during the AM peak hour when the congestion level is low.

Travel time in the HOV lane was found to be 19.75 minutes, whereas travel time in the GP lane was found to be 21.57 minutes. Travel-time savings was found to be 1.82 minutes or 8.44%. The decrease in travel-time benefits may be because of the lower levels of congestion in the GP lanes after the completion of the I-15 South project. As congestion gradually increases on I-15, the travel time benefits of the HOV lanes are likely to increase.

The HOV lane speeds were higher than the GP lane speeds along the entire section of I-15 from 500 South to the Utah County line. Therefore, the HOV lanes offer travel-time savings. Higher speeds in the HOV lanes as compared to the GP lanes indicate that the HOV lanes have less or no congestion. The HOV lane mean speeds are much higher than 45 mph which means that the HOV lane was not congested during the data collection period. Furthermore, the Salt Lake Valley HOV lane mean speed is higher than the national HOV lane mean speed of 54 mph during the peak periods.

The Salt Lake Valley HOV lane system experiences a low violation rate when compared to other cities nationally. The AM peak hour violation rate was found to be 2.59%. Only SOV violations and no trailer violations were observed during the AM peak hour. The PM peak hour violation rate was found to be 1.70%. SOV violation rate was found to be 1.42% and trailer violation was found to be 0.28%. The overall peak hour violation rate was found to be 2.15%.

Improvements like direct on-ramps and off-ramps to the inside HOV lanes and prominent ILEV and carpool information signs are needed along the I-15 corridor. All these will enhance the popularity of the HOV lanes and lead to increased HOV lane use. HOV lane use in Salt Lake Valley is continuing to grow. As traffic volume in the Salt Lake Valley increases and congestion reaches higher levels, the benefits of the HOV lanes will likely increase.

7. RECOMMENDATIONS

Salt Lake Valley HOV lane performance continues to meet or exceed nationwide HOV lane performance. Thereby, the HOV lanes should not be closed, but should continue to offer benefits to users. Although this study found that HOV lanes are becoming increasingly effective, a few shortcomings were noted and were used to develop recommendations for improvements.

Various managed lane concepts need to be experimented and adopted to optimize the performance of the Salt Lake Valley HOV lanes. There may be a need to better manage the HOV lanes through the use of other managed lane techniques. Pricing may be introduced to utilize the unused capacity. Reversible lanes may also be introduced on I-15 in the Salt Lake Valley because the flow is primarily directional, with the peak direction being northbound during the AM peak period and southbound during the PM peak period.

Signage along the I-15 corridor also needs to be improved. Proper signs need to be posted informing drivers that AFVs are allowed in the HOV lanes. Along the I-15 HOV lanes, some signs include the letter C painted in black on a blue background. Many people, however, are not aware of what that symbol stands for. The Manual on Uniform Traffic Control Devices (MUTCD) recommends the use of the Inherently Low Emission Vehicle (ILEV) sign (MUTCD Code R3-10b) when it is permissible for a labeled and certified ILEV to use an HOV lane even if it is a SOV (*19*). There needs to be carpool and rideshare information signs along the I-15 corridor so that people become aware of UTA's carpool programs. The signs may display UTA's rideshare phone number 533-RIDE. Vanpooling also needs to be encouraged by popularizing UTA's Interest Free Van Purchasing and Van Leasing Programs. Vanpooling especially needs to be emphasized to encourage increased vehicle occupancy in the HOV lanes. Figure 7.1 displays the ILEV and carpool information signs recommended by MUTCD (*19, 20*).

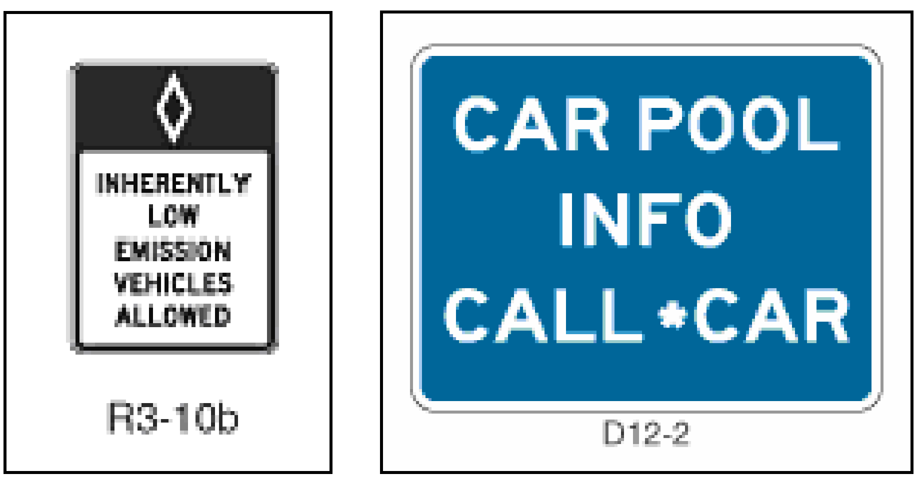

Figure 7.1: MUTCD's ILEV and Carpool Information signs

The travel time messages on the Variable Message Signs may include HOV lane travel-time savings (based on either real-time or historical data). This will popularize the travel-time benefits of the HOV lanes.

Direct entrance and exit ramps to the inside HOV lanes are needed to make entering and exiting the HOV lanes more convenient. Direct ramps would provide travel-time savings for the HOV users and enhance the safe operation of both the HOV and GP lanes. Many potential HOV lane users do not use the HOV lanes for short freeway trips because they have to cross four GP lanes to exit the freeway. This could have been overcome had there been inside ramps to the HOV lanes. Additionally, there is a need for more park & ride lots and discounted parking charges for HOV users.

People need to be educated via the media about HOV lane restrictions and benefits, particularly the potential travel-time savings. Hence, there is a need for the implementation of public outreach programs to promote HOV facilities. It needs to be emphasized that HOV lanes do not have to look full to be effective and backed up traffic on GP lanes does not mean that HOV lanes are ineffective. The concept that a single-occupant AFV is allowed in the HOV lanes needs to be popularized. Furthermore, public opinion surveys should be made an integral part of the ongoing project operations. Public feedback can then be used as a direct input to the facilities management so that the HOV lanes operate more efficiently and hence become more popular.

As congestion in the Salt Lake Valley increases, the benefits of the HOV lanes are also expected to increase. A continuous system of HOV lanes is likely to result in higher use and benefits. There is a need for continued monitoring to identify and keep track of these benefits and proactively manage the HOV lanes. The periodic monitoring programs may be conducted every two or three years. They may be performed on a small-scale and include MOEs like vehicle volume, person throughput, travel time, and violation rate.

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