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16. Abstract

This report documents the proceedings from the 11th International High-Occupancy Vehicle (HOV) Systems Conference held in Seattle, Washington on October 27-30, 2002. The Conference was sponsored by the Transportation Research Board (TRB) HOV Systems Committee. Sound Transit and the Washington State Department of Transportation (WSDOT) were conference hosts.

These proceedings summarize the presentations from the general sessions and the breakout sessions. The breakout sessions were organized around the three topic areas of HOV facilities, bus rapid transit (BRT), and managed lanes.

The theme of the conference was *HOV Facilities – Evolution or Revolution?* The sessions were developed to help participants share, compare, and contemplate the role and promise of what HOV, BRT, and managed lanes hold for current and future travelers. Speakers discussed recent experiences with a variety of projects, policy efforts in different areas, and potential future directions.

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11th International Conference on High-Occupancy Vehicle Systems

October 27-30, 2002
West Coast Grand Hotel
Seattle, Washington

Sponsored by

Transportation Research Board HOV Systems Committee
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Conference Proceedings

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11th International Conference on High-Occupancy Vehicle Systems

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Washington State Department of Transportation

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OPENING SESSION — WELCOME

Jerry Ayers, Washington State Department of Transportation, Moderator

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Welcome to Seattle
Greg Nickels
Mayor, City of Seattle

Good morning and welcome to Seattle. We are very pleased that you have chosen to hold the 11th International High-Occupancy Vehicle (HOV) conference here. I understand that the last HOV Conference in Seattle was in 1991.

We continue to work to address the transportation problems in the region. You are in a city that is working very hard with its regional partners – Sound Transit, the Washington State Department of Transportation (WSDOT), King County, and our neighboring cities – to address the transportation issues in the area. I think we are at the forefront of many exciting transportation activities.

We are moving forward with a light rail transit (LRT) system. A week from tomorrow voters will be considering a monorail measure, a transportation approach somewhat unique to Seattle. Also, a little over a year ago the Seattle area experienced an earthquake. It showed that the 1950s style double-deck freeway along the harbor front needs to be replaced. We have begun planning to remove the freeway and to eliminate it as a barrier between the downtown and the beautiful harbor front.

Those are just a few of the activities underway to create a transportation system to serve the area in the 21st Century. As all of you know, there is no magic answer to the transportation issues facing major metropolitan areas. We are proud to have King County Metro, which operates one of the finest bus systems in the country. We also have one of the largest vanpool programs in the nation. Of course, you are all familiar with our extensive HOV system.

Is it an exciting time in Seattle's history. I hope you will get a chance to experience the city while you are here. The National Association of Housing and Community Redevelopment Officials is meeting at the Convention Center this week. We know the importance of linking housing, transportation, and economic opportunities to increase livable communities.

We hope that while you are here that you have the opportunity to enjoy all the city has to offer. You are a few blocks from the famous Pike's Place Market and in one of the most vibrant downtown retail cores in the country.

Thank you for selecting Seattle for your conference. I hope you do not wait another 11 years to come back. I wish you a very productive conference.

Conference Welcome
Ron Sims
Executive King County

I would like to welcome all of you to Seattle. Mayor Nickels has done a great job establishing a vision for the city. Transportation, including the new LRT system, is a key part of that vision.

The theme of your conference focuses on HOV facilities as evolution or revolution. I would like to stress the need for revolutionary zeal in addressing the issues facing us today, including transportation. The Interstate system was built with a vision of linking the country. It is one of the finest systems in the world.

We know that the Interstate system is not enough, however. You cannot evolve additional capacity, you have to revolutionize behavior. You must bring revolutionary zeal to addressing transportation issues. We cannot build our way out of congestion. HOV lanes provide additional capacity for Metro transit to move some 100 million people per year in the region. HOV lanes allow Sound Transit and its Regional Express system to grow.

As you discuss the issues related to HOV facilities over the next few days, I hope you will focus on being revolutionary, on taking risks. You need to be on a mission to provide facilities for buses, vanpools, and carpools.

The issue is not on the differences between areas and between agencies, but on the ability to find commonality of views and purposes. Everyone is essential if we are going to build a transportation system of roads, HOV facilities, bus rapid transit, vanpools and carpools, LRT, commuter rail, and ferries. Everyone is important in making these opportunities happen. So be revolutionary in your zeal. Then we will touch the stars and see forever. Thank you.

PLENARY SESSION — THE FUTURE AIN'T WHAT IT USED TO BE

Mark Hallenbeck, Washington State Transportation Center, Moderator

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That Was Then/This Is Now

Katherine F. Turnbull
Texas Transportation Institute

Thank you Mark. It is a pleasure to have the opportunity to participate in the opening session of TRB's 11th International HOV Conference. I am also pleased to help fill in for Don Capelle, who was not able to attend the conference due to knee surgery.

My charge is to provide an overview of the changes that have occurred with HOV facilities on a national level since 1991 when the last HOV conference was held in Seattle. I thought it might be of help to set these changes in the context of other cultural changes that have occurred over the past 11 years.

For example, in 1991 George Bush was President of the United States. George W. Bush is currently President. You could mail a first class letter for 25 cents in 1991. Mailing that same letter today will cost you 37 cents. In 1991, most of us did not have any idea what the Internet was, while today some 581 million people worldwide use it daily.

On the sports scene, the Minnesota Twins won the 1991 World Series, while the Anaheim Angles just captured the Series title last night. The New York Giants won the Super Bowl in 1991. The New England Patriots are reigning champions. At the movies, Silence of the Lambs was the Best Picture of 1991, while a Beautiful Mind took the Oscar in 2002.

We have seen significant changes in the HOV scene over the previous 11 years. In 1991, there were 43 HOV projects on freeways and in separate rights-of-way in 21 metropolitan areas in North America. These facilities accounted for approximately 365 lane miles. Today we have 131 projects in 31 metropolitan areas, accounting for slightly over 1,400 lane miles. The newest HOV lane on Route 50 in Maryland just opened last week.

We have also seen a change in the types of HOV lanes in operation. In 1991, concurrent flow HOV lanes accounted for about 58 percent of the operating HOV facilities, with exclusive lanes accounting for 29 percent. Today, concurrent flow lanes represent 81 percent of the HOV projects and exclusive facilities comprise 10 percent. Busways and concurrent flow HOV lanes represented seven percent and six percent of the projects in 1991 and five percent and four percent today. The term managed lanes was not in our vocabulary in 1991, while today the concept is being implemented in some areas.

The theme of the 1991 conference was *HOV Facilities Coming of Age*. The conference theme this year is *HOV – Evolution or Revolution*. Travel Demand Management (TDM), Intelligent Vehicle Highway Systems (IVHS), enforcement, marketing, and design were some of the major topics discussed at the 1991 conference. Major topics at this conference include Bus Rapid Transit (BRT), managed lanes and value pricing, and performance monitoring. While planning, designing, marketing, and enforcing HOV facilities are still important topics, there appears to be less emphasis on these items at this conference.

Don Capelle was Chair of the TRB HOV Systems Committee in 1991 and Dave Schumacher is the current Chair. I had the pleasure to serve six years as Chair between these two distinguished

gentlemen. With the help of many of you in this room, the HOV Systems Committee has been one of the most active TRB committees over the years. Since 1991, the Committee has held six international HOV conferences. These conferences have been held in Ottawa, Los Angeles, Pittsburgh, Toronto, Dallas, and now Seattle. The Committee started an awards program at the Dallas Conference. This years awards will be presented at today's luncheon.

The Committee has sponsored numerous sessions at TRB annual meetings. The Committee regularly holds mid-year meetings. For many years the Committee published a newsletter. Thanks to the efforts of Danny Wu and others, the Committee Internet site was introduced this year. The Committee has developed numerous research problem statements, which have resulted in projects such as the National Cooperation Highway Research Program (NCHRP) HOV Systems Manual, the Federal Highway Administration (FHWA) HOV Marketing Manual, and the FHWA HOV Demand Estimation Procedures Manual.

What might we expect to see in another 11 years when Seattle again hosts the International HOV Conference in 2013? Given the past 11 years we might anticipated that George ? Bush will be President, the U.S. Postal Service will have become the U. S. Internet Service, and the Best Picture will be Silence of a Beautiful Mind. The Seattle Mariners would have won the World Series and the Seattle Seahawks will be the Super Bowl Champions, of course. The theme for the HOV Conference will be *HOVs – Coming of Age in the Evolving Revolution*.

We will hear more about the future of HOV facilities over the next three days. I think HOV facilities will continue to play important roles of providing mobility options and helping address congestion in metropolitan areas throughout North America. I hope you enjoy the conference. I encourage you to participate in the conference sessions and to talk to your peers from throughout North America. Thank you.

Greeting from the TRB HOV Systems Committee
Dave Schumacher
Metropolitan Transit Development Board

Good morning. I am pleased to provide a welcome from the TRB HOV Systems Committee. A great deal has changed since 1991 and it is appropriate that the conference is being held in Seattle again.

I think HOV facilities have evolved over the last 11 years. Managed lanes are an important component in many areas today. This approach allows local areas to tailor the lanes to specific needs. We know that one size does not fit all areas, and managed lanes, value pricing, and BRT are all important approaches today. Many transit agencies are becoming more interested in how HOV lanes and managed lanes can improve bus service in an area.

The HOV Committee needs to continue to work with a variety of TRB committees, professional organizations, and federal agencies involved with HOV facilities, managed lanes, value pricing, and BRT. The Committee has identified a number of research topics over the years. FHWA has recently developed a pooled fund study to help examine some of the current research issues. Jon Obenberger is heading this effort for FHWA. Some state departments of transportation and regional agencies will be pooling resources to help support this effort. Currently, five or six agencies are involved and approximately $400,000 has been allocated for research projects.

There are numerous examples of the Committee promoting successful information dissemination efforts. The Committee Internet site has been developed through the efforts of Danny Wu and Chuck Fuhs. You can find it at www.hovworld.org. We hope to make the Internet site the source for all

information about HOV facilities. Please take the time to log on and let us know your thoughts and ideas about the site.

I think HOV facilities and managed lanes have important roles to play in promoting regional mobility. I think we are just starting to see the benefits from these facilities. A recent study in Los Angeles shows there is widespread support for the HOV lanes in the county. HOV lanes provide priority treatments for buses, carpools, and vanpools. HOV and managed lanes are steps toward designing and operating facilities to promote ridesharing and bus use, not just providing space for single-occupant vehicles. We are starting to see the positive changes from these approaches.

Finally, we need to communicate our successes. HOV facilities have enhanced regional mobility over the past 10 years. HOV and managed lanes should continue to provide numerous benefits in major urban areas in the future.

HOV Facilities in the Puget Sound Region

Aubrey Davis
Washington State Transportation Commission

It is a pleasure to discuss the changes that have occurred since 1991 with HOV facilities in the Puget Sound region. It is clear to me that the HOV concept in the Seattle area was revolutionary in the 1970s. Since that time, HOV facilities have been more evolutionary.

My comments will focus on a review of the HOV program in the Puget Sound region, HOV policy development, state and local policies supporting HOVs, and possible future directions. The objectives of the HOV system are to increase mobility by increasing the people moving efficiency and capacity of freeways, to provide reliable travel time savings to HOVs, and to improve the efficiency and safety of both the transit and the highway systems. Examples of the measures of success for the HOV system in the region include moving more people than the general-purpose lanes, maintaining travel speed and trip time reliability, bypassing congestion, and maintaining public support.

There are state and local policies that support HOV facilities. The Washington Growth Management Act and the Commute Trip Reduction law, which were adopted in the early 1990s, support the HOV concept. The Washington State Transportation Plan and the Regional Metropolitan Transportation Plan include HOV projects. The Sound Transit Express Regional Bus system includes a commitment to use HOV facilities and to develop bus direct access ramps.

The policy history in the region includes a regulatory directive to reserve portions of state highways for HOV lanes for the exclusive use of public transit vehicles and private vehicles with multiple occupants. The Blue Streak Express Bus project was initiated in the 1970s. This project was followed by a Memorandum of Understanding between WSDOT and Metro to develop and operate a series of park-and-ride lots and flyer stops. The HERO program was also initiated for reporting violators of the HOV lane-occupancy requirements. There was also a pro-HOV group called SHOV that promoted the development of HOV lanes on I-5 South, which WSDOT did by modifying the shoulder.

In 1991, after a long review, WSDOT adopted an HOV System Policy. The policy defines the core HOV system in the Puget Sound region. In 1996, WSDOT re-examined many policy issues and established a local process for advising the Department on the use of HOV lanes. A process was established through the MPOs that could result in different approaches in different parts of the state. Committees established through the MPOs included representatives from the local transit agencies, the State Patrol, local communities, and other groups. The committees meet annually and provide advice to WSDOT on operation of the HOV facilities.

The HOV policy has been amended several times. In 1992, a speed and reliability standard was adopted. According to this standard, HOV lanes should operate at 45 mph measured over a six-month period 90 percent of the time. A 3+ occupancy requirement was initially used with the HOV lanes in the area, which was in keeping with the FHWA policy at the time. In 1998, FHWA policy became more flexible. The 3+ requirement remained in use in the Puget Sound region until the early 1990s. Legislation requiring a 2+ occupancy level was vetoed by the governor on the understanding that WSDOT would conduct a demonstration on the I-5 North HOV lanes. The 2+ vehicle occupancy requirement was ultimately adopted as the WSDOT standard.

The Department also examined a policy for converting general-purpose lanes to HOV lanes. Although there was a successful lane conversion on I-90, the general policy is not to convert general-purpose lanes. Conversion will be considered before adding general-purpose lanes, however. In 1992 and 1993, a policy was adopted establishing HOV operations on a 24 hours a day, seven days a week (24/7) basis. The potential of tolling HOV lanes was examined and there was general agreement that HOVs should be given favorable consideration. The tolling issue was tabled, however, as there were no toll facilities in the region. There are still none today, although one is being developed. This issue may be coming back up for further consideration.

Currently, allowable user groups on the HOV lanes in the area are 2+ carpools, buses, vanpools, motorcycles, fuel efficient vehicles, and emergency vehicles. The State Patrol provides good levels of enforcement for the HOV lanes. The HERO program has also been effective at deterring violators from using the lanes.

In 1991 there were approximately 60 lane miles of HOV facilities in the region. In 2002 there are 205 lane miles of HOV facilities. There are an additional 91 lane miles to be constructed in the core HOV system. This growth accounts for an approximate 300 percent increase in HOV lane miles.

There has been a constant growth in the use of the HOV system. On I-5 North, there has been a 50 percent increase in HOV use compared to a 12 percent growth in volumes in the general-purpose lanes. The HOV lanes on I-5 South have experienced an 85 percent growth, on I-405 growth has been in the 52 percent range. The HOV lanes represent the only real capacity, with the exception of I-90, that has been added in the region.

HOV Facilities and WSDOT
Doug MacDonald
Washington State Secretary of Transportation

Thank you, Mark. It is a pleasure to welcome you to Seattle and to the HOV Conference. By way of introduction, I have been the Secretary of Transportation for one and one-half years. I have found HOV facilities to be one of the most interesting topics facing WSDOT today.

Like other state agencies, WSDOT focuses on accountability to the public and utilizing resources efficiently. We live in a world of constrained resources, so maximizing the efficiency of the existing transportation system is critical.

I hear a good deal about HOV facilities from the public at different types of meetings, on talk radio, and from the legislature. It did not take me long to start asking the staff questions about the HOV lanes in the area. The answers to these questions are that the HOV lanes carry more people than the general-purpose lanes and provide travel time savings and trip time reliability to users.

While you might think this statement closes debate on the issue, it does not. The statement that the HOV lanes carry more people than the general-purpose lanes is true in some places, some of the time. HOV lane utilization rates are complex and even the data about utilization is confusing and not altogether available. It is very clear that in some places at some times and in some places all the time, the HOV lanes are not carrying more people than the general-purpose lanes. These situations are a problem because they go to the core of the fundamental efficiency question.

A second problem is that public support for HOV lanes is a very complicated and ambiguous question. There are many different ways to measure support for the HOV system. By some measures it is clear that public support for the HOV system is strong. The public generally supports the HOV system in the region. People who drive in the HOV lanes or take the bus strongly support the facilities. People in the adjoining general-purpose lanes are not so sure, especially if they are traveling in congested general-purpose lanes next to lightly-used HOV lanes. Public opinion on HOV hours of operation appears to be very mixed, especially related to maintaining the 24/7 operating policy. It appears that the support for 24/7 operation may be less strong today than in the past.

This change in public perception is important. Public support is critical for HOV lanes. Public support is even more critical for investments in a balanced transportation system, of which HOV expansion is one element. Referendum 51, which will be voted on next week, includes funding for a wide range of transportation investments, including the expansion of the HOV system. It also includes significant state operating support for transit. If Referendum 51 is not passed, it will be difficult to address many of the mobility needs in the region.

I do not think we will see any kind of revolution related to HOV facilities in the region. HOV facilities are an important part of the transportation system in the region. HOV facilities contribute a number of positive benefits. According to the latest census figures, Seattle ranks seventh in the nation in the number of work trips made by transit, above many areas with heavy and light rail systems. Without the HOV lanes, we would not have this high a ranking.

Currently, approximately 6.7 percent of the work trips in the region are made on transit. This figure represents an increase from 1990. All but one city above Seattle in the ranking has lost transit market share. San Francisco is the only city, like Seattle, to have seen an increase in transit journey-to-work trips. The growth in San Francisco is lower than that in Seattle. Thus, it is clear that the HOV facilities in the region play a critical part in increasing mobility. The HOV lanes have contributed to the growth in transit ridership and to encouraging vanpooling and carpooling.

There is also a commitment to completing the HOV lane system in the region. The SR 525 project includes expansion of HOV components on the eastside. The new Vancouver Narrow Bridge project includes provisions for HOVs. The completion of HOV lanes to the south in Pierce County is also an important project included in Referendum 51.

WSDOT is currently conducting an evaluation of HOV operations in the Puget Sound region. Charlie Howard will be speaking on the evaluation at other sessions. I will focus my comments on the pressures that HOV facilities may face in the future.

First, it is critically important for transit and vanpooling that the travel time savings provided by HOV lanes be protected. This guarantee is a very expensive lock on highway capacity, however, if it extends to portions of the system that are not being used by either transit or vanpools. This situation is what causes concern among drivers in the adjacent general-purpose lanes. The unused capacity of HOV facilities is valuable. The issue is what is the best and highest use of public sector investments in freeways.

This issue becomes even more difficult to address as the cost of providing needed additional general-purpose lane capacity becomes prohibitively expensive. The value of unused capacity continues to increase. There are a number of factors influencing the increased value of the unused capacity. First, adding capacity is expense. Second, some groups question adding general-purpose lanes for environmental reasons. If we can not add capacity in the general-purpose lanes, the value of the unused capacity in the HOV lane increases.

There are a variety of other ways that the unused capacity in the HOV lanes could be allocated. From an economical standpoint, HOV lanes are a rather crude method of allocating capacity. Managed lanes, HOT lanes, and other capacity allocation techniques present more economically rational allocation methods. HOV lanes do work. If the rest of the system does not work, however, pressure will continue to be applied to try other allocation techniques, especially pricing. There is a need to address both personal mobility and freight mobility in the region. The movement of goods is critical to the economic development in the region. Moving produce to ports, moving goods to stores in the region, and moving freight through the region are all important.

All of these are complex issues that do not have easy answers. WSDOT will continue to examine different ways to maximize the use of the HOV system, as well as alternative strategies to meet the two goals of pursuing and enforcing the benefits of the HOV system and achieving an optimization of public investment in the highway system. Thank you.

Transit and HOV Facilities
Jim Jacobson
King County Metro/Sound Transit

I have been asked to speak about the HOV issues in the Puget Sound region from the perspective of the local transit operator. The decade of the 1990s was a great time for HOV facilities in the Seattle area. In the early 1990s there were several segments of HOV lanes in place and additional projects were being planned and constructed. While there were gaps in the system, transit was beginning to realize the benefits of faster travel times and more reliable trip time.

A statute was passed in the early 1990s requiring large employers to develop programs to proactively reduce the number of employees driving alone to work. The law also provided funding to help make the program work. This statute encouraged commuters to use transit.

A number of HOV-related policies were being discussed in the 1990s. The use of the inside or the outside lane for the HOV lane was one of the policy questions. This issue effects transit operations. From a transit perspective, inside lanes favor long distance commute trips, while outside lanes provide better access to freeway flyer bus stops and park-and-ride lots. Inside HOV lanes became the recommended approach in the area. A second issue being discussed in the early 1990s was the use of a 2+ or a 3+ vehicle-occupancy requirement. The 2+ requirement became the standard in the region.

There are three key realities associated with the HOV system from the perspective of a transit operator. First, we no longer have just HOV segments. There is an HOV system of over 200 miles in the region. Second, traffic congestion has increased significantly throughout the region. Third, the increase in population and growth, while occurring throughout the region, has accelerated in suburban areas. As a result, there is more reverse-commuting and two-way congestion on many freeways.

Bus schedule reliability and travel speeds have improved in corridors with HOV lanes. Predictability is critical to transit and to attracting and maintaining riders. The ability to operate services

reliable at all times has allowed us to redesign our system to better serve development patterns in the region. Transit ridership has increased by almost 25 percent over the past 10 years. There are more than five times as many vanpools today as 10 years ago. According to the census, the Puget Sound region is one of the few metropolitan areas where transit market share increased. As a bonus, evening and weekend transit services have been extended to serve major traffic generators, like the baseball and football facilities. Therese services have enabled thousands of people to get to and from sporting events quickly and easily.

We are still struggling as a region to reach a consensus on some fundamental HOV concepts. One question is how to manage the system to provide incentives for that next person to decide to take the bus, ride in a vanpool, or form a carpool. Another is how to structure a management system that will have the strength to increase restrictions in use as traffic conditions in the HOV lanes deteriorate. A major question is how do you define what full means? A full lane of traffic moving at 65 mph visually looks very different than a full lane of stop-and-go traffic. Those are very difficult educational traffic engineering concepts to explain to the general public.

Because we lack unity on many of these issues we continue to revisit issues related to the relaxation of HOV restrictions. We also have some transit operational issues due to the missing links in the system. For example, there are reversible HOV lanes rather than two-way lanes in the I-90 corridor. This situation causes problems during periods of strong demand for travel in both directions.

Expanding the HOV system onto the arterial streets is also critical from a transit perspective. Most of the transit service and transit ridership is on the arterial street system. Addressing signal priority for buses, removing parking for some locations, and providing passenger facilities would all benefit buses.

We have come a long way in the past 10 years. We have seen an emerging HOV system develop into a mature system. The HOV network is an integral part of the transit system in the region. I do not know how the transit system would function without the HOV system. Thank you.

Setting the Context – What is Different Today Compared to 1991
Agnes Govern
King County Metro/Sound Transit

It is a pleasure to have the opportunity to participate in this Opening Session. Katie and Dave have provided a national overview and Aubrey and Doug have given a state perspective. Jim has discussed transit service in the region. My focus is on the partnerships and challenges related to the HOV facilities in the area, especially as we look to the future.

The Central Puget Sound area is the economic engine of Washington State. Over half of the state's population, some 2½ million people in the three-county area, are squeezed between waterways and mountains. Given geographic constraints, bus-based transit is an essential component of fully utilizing limited freeway capacity to move people. Improving regional mobility is dependent on transit and dependent on the extensive HOV lanes built by WSDOT.

Regional coordination and cooperation is critical to making the transportation system work. Transit is a key element of the Puget Sound regional mobility strategy. Dependable and reliable service is essential for attracting and maintaining transit ridership. About 10 years ago a regional transit plan was being developed. The planning process involved transit agencies, the Puget Sound Regional Council (PSRC), WSDOT, and local jurisdictions. The plan, approved by the voters in 1996, called for implementation of light rail transit (LRT), commuter rail, and express bus network.

My comments today focus on the express bus component of the plan. The bus component of the plan included a $1.4 billion investment over 10 years. Of this, $550 million was for service and $850 million was for capital facilities, including, $500 million in HOV direct access ramps, in-line stations, and arterial street HOV projects. The HOV projects came directly from the predesign report completed by WSDOT and the Sound Transit express bus network relied on existing and planned HOV lanes built by WSDOT. The Sound Transit goal is to create transportation choices that give people viable alternatives to driving alone. Increasing ridership depends on speed and reliability. The HOV facilities are critical to achieving the regional bus network.

The partnerships have not come easily. Partnerships require ongoing work. Building and maintaining effective relationships is critical to successful projects, however. There are numerous examples of the partnership between WSDOT and Sound Transit. Sound Transit is contracting with WSDOT to design and build the direct access projects, as well as other HOV projects that will become part of the state system upon completion. This approach leverages the expertise available at both agencies to ensure projects are delivered on time and within budget.

Transit agencies all share a common interest in well-functioning HOV systems. Local jurisdictions are also interested in HOV projects, especially access to local streets. Elected officials, staff of key stakeholders, environmental groups, and good government and citizen advocacy groups also pay important roles.

There are many challenges ahead for the HOV partnership in the Puget Sound region. Maintaining the performance of the existing HOV system is critical. The current performance standard related to occupancy levels is maintaining operating speeds of 45 mph for 90 percent of the peak hours. We can build a constituency for raising occupancy requirements where needed to keep the system working effectively, for raising fines to help enforcement and keep violation rates low, and for making sure operational decisions work for transit.

We are continuing to build partnerships. Planning studies are underway on Translake and I-405 with WSDOT and Sound Transit as co-leaders on setting priorities with limited resources and moving into final design and construction. Partnerships also help address competing constituencies, such as transit vs. roads, when we both are needed.

Other forces are also at play in the region. Initiatives and state legislation affect various agencies differently. We need to continue to keep the partnership strong rather than going our separate ways. We can work regionally, reaching beyond our specific agency mandate to meet regional objectives.

Related to the theme of the conference – evolution or revolution – we may only know in the long term if steps taken now advance the overall goal of HOV facilities. Evolution reflects adapting that can lead to either survival or extinction. Since the winners write the history books, it may be a long time after the specific revolution is over that we know the outcome.

I look forward to learning from all of you over the next few days. Thank you.

PLENARY SESSION — TOO MANY, TOO FEW, JUST RIGHT: CHALLENGES TO THE HOV CONCEPT

Jon Obenberger, Federal Highway Administration, Moderator

HOV Facilities: Challenges and Opportunities

Katherine F. Turnbull
Texas Transportation Institute

Thank you, Jon. It is a pleasure to discuss some of the challenges and the opportunities facing HOV facilities from a national perspective. My comments will focus on four general topics. First will be a summary of current HOV projects in North America. Second will be an overview of the public and political perspectives relating to HOV facilities. Third will be a highlight of opportunities with HOV projects. My closing comments will address the ongoing challenges facing HOV facilities.

With the opening of the HOV lanes on US 50 in Maryland last week, there are 131 HOV lanes operating in separate rights-of-way or on freeways in 31 metropolitan areas in North America. These projects account for some 1,400 miles. There has been a steady growth since the 1970s in the number of HOV lanes in operation and the route miles. In 1970 there were 11 route miles in operation. By 1980, there were 120 route miles and by 1990 there were 400 route miles. Currently there are a little over 1,400 route miles in operation.

Concurrent flow HOV projects are the most common type of HOV facilities comprising 81 percent of the current projects. Exclusive freeway HOV facilities represent 10 percent of the total projects, followed by busways at five percent and contraflow lanes at four percent.

A total of 52 percent of current projects maintain the HOV requirement 24 hours a day, seven day a week (24/7). Some 43 percent operated as HOV lanes only during the morning and afternoon peak-periods. About 5 percent have extended HOV operating hours beyond the peak-periods, but not full time.

The most common vehicle occupancy requirement is two or more (2+) persons per vehicle. Currently, 84 percent of HOV facilities in North America use a 2+ requirement. Some 8 percent of the projects are reserved for buses only. A three or more (3+) persons per vehicle occupancy requirement is used on 5 percent of the facilities. There are 3 projects, the Katy (I-10 West) and Northwest (US 290) HOV lanes in Houston and the El Monte Busway in Los Angeles that use a variable occupancy requirement (3+/2+).

As noted by the title for this session, maintaining appropriate vehicle volumes is an issue with some HOV facilities around the country. Too few vehicles using a lane raises concerns over the empty lane syndrome. Too many vehicles using a lane results in congestion levels that degrades the travel time savings and trip time reliability that makes HOV lanes an attractive alternative to driving alone. So, like the three bears, how do we get the porridge, or the vehicle volumes in this case, just right.

Looking at utilization levels on HOV projects around the country, most fall into the about right to slightly over utilized categories. One of the breakout sessions will focus on how to address over utilization concerns. There are a few projects that appear to be underutilized or that have not yet attained the forecasted volumes.

I was asked to talk briefly about the dedesignation of two HOV lanes in New Jersey in the late 1990s and the recent legislatively-directed demonstration lowering the vehicle occupancy requirements

on the El Monte Busway from 3+ to 2+. These case studies provide insight into public and policymaker's perceptions of HOV utilization.

FHWA sponsored a study in 1999 examining the dedesignation of the HOV lanes on I-80 and I-287 in New Jersey. Planning studies on both projects occurred during the early 1980s. The HOV lanes on I-80 opened in March 1994 and the HOV lanes on I-287 opened in January 1998. The HOV designation was removed on the facilities in November 1998.

The policy and regulatory environment in the early 1990s, when the planning process was underway, was much different than that in the late 1990s when the dedesignation occurred. The 1990 Clean Air Act Amendments contained a strong mandate, including the employer trip reduction (ETR) requirement for addressing transportation-generated air pollution. The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 implemented many of the transportation-related measures for the Clean Air Act Amendments. The New Jersey Traffic and Air Pollution Act of 1993 contained similar provisions at the state level. The New Jersey Executive Council also took a strong role in promoting travel demand management strategies and other related measures. Many of these provisions had been modified or weakened by the time the HOV lanes were opened.

I-80, an east-west radial travel corridor, serves trips into and out of the Newark/New York City area. Planning for adding a fourth lane was underway in the early 1980s. The results of the planning study recommended that the additional lane be reserved for HOVs during the peak hours. Funding for construction of the lane came from the state's allocation of the Federal-Aid Program.

The I-80 HOV lanes opened in March 1994. A 2+ vehicle occupancy requirement was used. Marketing efforts introduced the HOV lane to the public and promoted its use. Extra enforcement was provided during the opening and the early phases of operation, as well as periodically throughout the life of the project. The corridor was served by transit, with buses operating in the HOV lanes. New and existing park-and-ride lots served buses and carpoolers in the corridor.

The I-80 HOV lanes were well utilized. About 900 vehicles used the HOV lane during the morning peak hour during the first few weeks of operation. Morning peak hour use levels increased to about 1,200 vehicles during the life of the project. Vehicle volumes in the afternoon peak hour started at 1,000 vehicles, increasing to 1,400 over time. The violation rates ranged from four percent to 21 percent, depending on the level of enforcement.

I-287 serves a suburb-to-suburb travel market, with diverse origin and destinations. The facility experienced congestion during the peak-periods and planning was initiated to examine possible options. Funding for the HOV lane was specifically earmarked in a federal appropriations bill. Construction of the HOV lane occurred over a six-year period. Segments of the HOV lane were initially opened during the construction period, but were changed to allow general-purpose use due to concerns over congestion.

The full 28 miles of the I-287 HOV lanes were opened in January 1998. The HOV lanes operated during the morning and the afternoon peak periods with a 2+ vehicle-occupancy requirement. A marketing program was conducted to promote opening the lanes. Extra enforcement was also provided. There was no bus service in the corridor. There were no park-and-ride lots in the corridor and little supporting services or programs were provided.

Utilization levels on the I-287 HOV lanes were relatively low during the first months of operation. Volumes in the morning peak hour averaged 330 vehicles. Volumes in the afternoon peak hour averaged 650 vehicles. Violation rates ranged from five percent to 75 percent depending on the level of enforcement.

The media coverage on the I-80 HOV lanes was generally favorable, both immediately after the opening of the lanes and on an ongoing basis. The nature and the tone of the media coverage changed significantly with the opening of the I-287 HOV lanes. Articles and columns in local papers took a negative perspective toward the lanes. Examples of headlines included, *HOV Lanes: Paved with Good Intentions but Impractical*, *Honk If you Hate HOVs*, and *HOV to LOV*. A *Lanes of Pain* column was a regular feature in one newspaper. Commuters also formed a *sHOVe it* Group and organized a, Internet site and other efforts to promote changing the HOV lanes to general-purpose lanes.

The New Jersey Department of Transportation (NJDOT) initiated a review of the HOV lanes in response to the public concern. The state congressional delegation held a fact finding forum. Waiving repayment of the federal funds used for the I-287 HOV lanes was included in the appropriations bill. The governor of New Jersey informed the U.S. Secretary of Transportation that the HOV requirement would be rescinded on both I-80 and I-287. The lanes were officially dedesignated in November 1998.

A number of key elements appear to have influenced the dedesignation process. First, the policy and regulatory environment was much different in the early 1990s when the planning process was underway compared to the late 1990s when I-287 was opened. Second, the characteristics of the I-287 corridor were not generally conducive to HOV operations. The diverse origins and destinations and the dispersed travel patterns in the corridor are difficult to serve with transit and by carpooling and vanpooling. Third, there was a lack of supporting components in the I-287 corridor. Finally, the negative press was very difficult to overcome. While most transportation professionals would argue that the I-80 lanes were operating well, they were not able to survive the problems encountered with the I-287 lanes.

The El Monte Busway demonstration provides a different example of legislative involvement with the operation of an HOV project. The El Monte Busway on the San Bernardino Freeway in Los Angeles represents one of the longest operating HOV project in the country. Opened in 1973 as a bus only facility, 3+ carpools were allowed to use the lanes on a full-time basis in 1975. The facility operated with the 3+ designation until Senate Bill 63 was passed by the California Legislature in 1999. Senate Bill 63 directed the California Department of Transportation (Caltrans) to lower the vehicle-occupancy requirement on the Busway from 3+ to 2+, and to study the effects of this change. Based on the results of the monitoring program, legislation was passed increasing the vehicle-occupancy requirement back to 3+ during the morning and the afternoon peak-periods effective July 2000.

FHWA also sponsored a study to assess the influence of the 2+ demonstration based on data available from Caltrans and other local agencies. The change to the 2+ requirement had a negative effect on the operation of the Busway. The increase in 2+ carpools caused congestion in the lanes, resulting in a decline in operating speeds and travel times. Trip time reliability declined. Bus operations were negatively effected. Bus schedule adherence and on-time performance declined significantly and passengers reported delays. At the same time, significant improvements were not realized in the general-purpose freeway lanes.

Morning peak-hour travel speeds on the Busway declined from 65 mph to 20 mph with the change to the 2+ vehicle occupancy requirement. Morning peak-hour Busway vehicle volumes increased from 1,100 to 1,600 with the 2+ designation, but the number of persons carried declined from 5,900 to 5,200. The freeway lane vehicle volumes and passengers per lane per hour remained relatively similar. Bus operating speeds and on-time performance declined during the 2+ operation, and extra buses had to be added to maintain schedules. Bus riders were very vocal in their opposition to the 2+ demonstration.

Value pricing, managed lanes, and BRT represent opportunities to potentially enhance HOV facilities. Buses have been a key part of HOV facilities since the first projects on the Shirley Highway in the Washington, D.C. area and the El Monte Busway in Los Angeles. Buses play a significant role in increasing the people moving capacity of many HOV lanes today. The BRT concept builds on and expands on this success. BRT encompasses additional elements, including unique vehicles, convenient fare payment methods, revised routes and schedules, and priority measures on arterial streets.

Value pricing and managed lanes provide additional methods for allocating use of a facility. Freeway lanes could be managed by occupancy levels, vehicle types, time-of-day, pricing, access controls, and even a driver's hair color.

Transportation professionals will continue to face challenges in planning, designing, and operating HOV facilities. Institutional arrangements will continue to be a challenge since HOV facilities require the coordination and cooperation of state departments of transportation, transit agencies, state police, and other groups. This multi-agency coordination and cooperation becomes even more complex with value pricing and managed lanes, as toll road authorities and other diverse groups may be involved. Project champions will continue to be important in advancing and maintaining HOV facilities.

Performance monitoring programs will also continue to be critical to ensure that data is available on projects. Communicating this information to policy makers and the public on an ongoing basis is also critical. Finally, funding for construction and operation will always be a challenge.

Legislating HOV Rules: Two Stories from California

Antonette Clark
California Department of Transportation

Good morning. It is a pleasure to participate in this conference and to represent the California Department of Transportation (Caltrans). I have been asked to share our experiences with legislative challenges. My presentation this morning will cover two major topic areas. First, I will provide a brief overview of California's HOV lane program, the key reasons behind the HOV strategy, the types of HOV facilities in operation, and the growth in HOV facilities in the state. Second, I will discuss recent political activities and criticisms, including proposed and enacted legislation, and the importance of ongoing monitoring and evaluating of HOV facilities.

HOV facilities have been built and operated in metropolitan areas across the country for a number of reasons. These facilities provide priority treatment to carpools, vanpools, and buses, generally vehicles carrying at least two or more persons. The idea behind HOV facilities is to increase the person-movement capacity of roadways rather than the vehicle capacity.

HOV projects have been implemented across the country as a means to address declining mobility and worsening air quality. In some cases, federal and state legislation, such as the 1990 Clean Air Act Amendments, have supported or directed the application of HOV facilities. Our challenge at Caltrans is to serve commuters in six major metropolitan areas. These metropolitan regions are Sacramento and San Francisco in the north-central part of the state and Los Angeles, Orange County, San Bernardino and San Diego in the southern part of the state. Although California currently operates over 40 percent of the nation's HOV lanes, we still consider our system to be only half-complete.

The HOV system in the state has grown since the opening of the El Monte Busway in 1973. The system grew gradually in the 1980s during a time of experimentation. More aggressive growth occurred in the 1990s, with HOV facilities as a traffic management strategy.

Currently there are some 1,061 lane miles of HOV facilities in the state. Approximately 162 lane miles are under construction. Proposed HOV projects through the year 2030 account for some 1,114 lane miles, a doubling of the current system.

With such a large HOV program, the HOV Coordinators in the six major metropolitan Caltrans district offices play a key role in the day-to-day operations and maintenance. They are also responsible for coordination with local planning agencies and the California Highway Patrol (CHP).

The coordination with Metropolitan Planning Organizations (MPO's), the Regional Transportation Planning Associations (RTPA's), Air Districts, FHWA, and CHP has been critical to the success the of HOV system in California. Caltrans is working to formalize its role at the regional level.

A number of factors have influenced recent legislative interest in HOV facilities. Media attention has tended to focus on the perception that lanes are underutilized. In addition, the media highlighted the New Jersey decisions to convert two of their HOV facilities back to regular lanes. These changes are often used as proof that HOV lanes are being decommissioned across the country.

The public often views Caltrans as being inflexible, unresponsive, and biased in our analysis. A recent independent study by the State Legislative Analyst's Office concluded that the impact of HOV lanes on carpool formation is unclear and that Caltrans lacks comprehensive performance criteria for HOV facilities.

There have been numerous legislative challenges to HOV operations in the state. For these reasons, there has been statewide criticism of HOV facilities in the media, and bills have been introduced to either eliminate HOV facilities altogether, to limit their operations, or to mandate performance studies. Examples of recent legislation include allowing paratransit vehicles to "deadhead" in HOV lanes, and a dual (2+/3+) occupancy requirement demonstration on I-10 El Monte Busway.

Caltrans and other agencies have taken proactive approaches to address these criticisms. Two HOV Summits were held in southern California to help focus discussion on HOV facilities. The first HOV Summit was for technical staff, while the second focused on policy makers and public officials. There have also been studies to encourage transit utilization, as well as park-and-ride facilities. Finally, public information campaigns have been undertaken.

Caltrans and other agencies have also realized the importance of ongoing monitoring and evaluation programs. These efforts are important to meet federal and state requirements, to identify project benefits and causal factors, and to determine if project goals and objectives are being met. By establishing uniform methods for data collection, analysis and reporting, monitoring programs provide the basics for marketing and education purposes. The information provides input for operational adjustments and diagnosing problem areas. Lastly, the program provides information for future planning activities and for model calibration.

Caltrans will continue to work with its partner agencies to ensure ongoing monitoring and evaluation efforts. The information obtained through these studies provides the basis for ongoing communication with the legislature, other stakeholders, and the public.

Are HOV Lanes the Best Solution for the Money

Jim MacIssac
Transportation Consultant

It is a pleasure to participate in this conference. I may be the mystery speaker at this session, as I am not well known outside the Seattle area. My comments focus on the challenges and the opportunities facing HOV facilities in the Puget Sound region. I will highlight the Seattle region HOV lane program and home-to-work travel mode statistics. I will also discuss if HOV lanes have helped create new vanpoolers, carpoolers, and bus riders. I will close with a few comments on specific projects.

During the 1990s and early 2000s, the Puget Sound region had one of the more aggressive HOV development programs in the country. There were few HOV facilities in the area in the 1980s. In 1990 there were approximately 60 HOV lane miles in King County. By 2000, this figure had increased to 182 HOV lane miles in King and Snohomish counties. By 2010, 330 HOV lane miles are projected to be in operation in King, Snohomish, and Pierce counties. By 2030, 504 HOV lane miles are forecast to be in operation in the four-county region.

Even with this growth in HOV miles, census journey-to-work person trips by mode figures indicate that transit and carpooling declined between 1980 and 1990, and then increased between 1990 and 2000. The 2000 percentages for HOV modes are still below the 1980 levels, however. The 2000 figures are also lower than the Puget Sound Regional Commission's estimates for 1998, which raises questions about the even higher 2010 forecasts. Journey-to-work vehicle trips by mode reflect similar trends.

A number of issues may need to be addressed with the HOV lanes in the area. Increasing 2+ carpools may overload some HOV lanes. Forecasts indicated that if the vehicle-occupancy requirement is raised to 3+, however, up to 80 percent of the HOVs go to the general-purpose lanes and less than five percent of vehicles qualify as HOVs. Other issues relate to hours of operation and coordination with LRT and BRT.

The two project examples are SR-520/Trans-Lake Corridor and I-405 Corridor/Central Bellevue. A number of alternatives were examined in the SR-520 corridor. One option was to maintain the existing two lanes in each direction on the floating bridge to serve the estimated 173,200 daily person trips in 2020. A second option was to widen the bridge to add a pedestrian/bicycle lane and wider shoulders at a cost of $1.9 billion. The preferred alternative was to expand option two and include an HOV lane in each direction for a total of three lanes. The cost for this option is approximately $3.5 billion. A fourth alternative would add both the HOV lane and another general-purpose lane in each direction at a cost of $4.8 billion. A managed six-lane alternative has also been suggested at a cost of $0.7 billion. The I-405/ SR-520 Interchange includes freeway-to-freeway HOV connection in three quadrants. The cost of the HOV connection is very expensive, raising a question if they are really needed.

In closing, I would like to suggest a few questions for further discussion. First, we need to ask if transit and HOV priority is a viable future course. Second, we need to consider if our plans stimulate popular choice. Third, is encouraging carpooling, vanpooling, and riding the bus working? Finally, what do we need to do to make our alternatives a choice of the people?

The Need for Performance Monitoring

Darren Henderson
Parsons Brinckerhoff

Thank you Jon. I am pleased to participate in this session on HOV challenges and opportunities. My comments focus on the four challenges of the empty lane syndrome, establishing realistic rather than great expectations for HOV facilities, elsewhere envy or comparing facilities on a national level, and legislative initiatives. All of these challenges relate to the need for ongoing performance monitoring programs.

The perceived under-utilization of HOV lanes, termed the empty lane syndrome, seems to be the easiest target when criticizing HOV lanes. HOV lanes are often expected to solve more problems than is reasonably possible. These great expectations place unrealistic goals on HOV facilities.

HOV needs vary greatly in different areas. Comparing HOV lanes in different metropolitan areas often leads to consideration of changing operating policies, hours of operation, minimum occupancy requirements, and value pricing. Too often it appears that operational changes are implemented by legislative initiatives without appropriate evaluation.

The biggest challenge in many areas may simply be answering questions about how the HOV lanes are performing. All transportation planning professionals involved in HOV system planning will be asked to answer the question of HOV lane performance. Answering these questions is not always possible for a number of reasons.

First, HOV goals and objectives are often unrealistic, poorly defined or non-existent. Second, although HOV performance monitoring is common, data availability, evaluation measures, and analysis methodologies vary widely. Third, there is often a disconnect between HOV goals and objectives and performance monitoring. The recent experience in Southern California is consistent with these observations, despite defined goals and objectives at state and regional levels, and Caltrans monitoring efforts.

There are ways to address these issues. First, locate the target by defining appropriate HOV goals and objectives that can be used as a basis for assessing performance. Second, identify appropriate measures of effectiveness that ensure consistency with goals and objectives and the availability of data. Finally, identify only realistically attainable and useful data sources and determine regularity of collection and analysis within resource constraints.

Unfortunately HOV performance monitoring is often an afterthought for many agencies. There is a need to explore creative and innovative ways to conduct data collection, including utilizing existing data collected for other purposes, sampling, and using technology to automate the process. It is also important to keep the data collection process and the analysis procedures simple. Be careful not to unnecessarily overcomplicate performance monitoring, as the most fundamental information can be very telling.

A number of interesting themes emerged from the recent evaluation of HOV facilities in Los Angeles County. First, people like the HOV lanes. Survey results indicate that 88 percent of Los Angeles County residents support having HOV lanes. Second, HOV lanes save time. All Southern California lanes save time and provide trip time reliability, which may be as important as time savings. Third, HOV lanes encourage carpooling. Over half of all Southern California HOV lane users previously drove alone. Fourth, over-utilization of Southern California HOV lanes is a bigger challenge than under-utilization. Fifth, both public and private transit providers indicate the HOV lanes are

important in the provision of services. Finally, one size does not fit all. There are compelling reasons to deal with HOV lanes differently in different areas.

There is a full session on Tuesday morning devoted to HOV performance and policy in Southern California. More detailed information on the various aspects of the recent study and other activities will be presented at this session. Thank you.

KEYNOTE LUNCHEON SPEECH – HOV FACILITIES IN THE SEATTLE REGION

Grace Crunican
Seattle Transportation Director
City of Seattle

Thank you all for coming to this conference and to Seattle. I am relative newcomer here myself, but, after nine months of living here, I can truly say that this is a fine place.

It is no wonder that Seattle continues to rank as one of the top five places to live in the nation. Of course, along with this elite status, we have the dubious distinction of being on the "top five" list for traffic congestion. Despite our highly debatable congestion ranking, I can safely report to you that matters would be far worse, were it not for our world-class HOV system.

I have been asked to describe Seattle's HOV system. I want to be clear that while I am an admirer of the system, I take no credit for the past. My tenure began this year and I am working to support the system, but I deserve none of the credit for the terrific and flexible mode currently in use today.

After investing nearly $1 billion into HOV facilities, I am proud to report that we have one of the most successful HOV programs around. There are approximately 31 metropolitan areas in the United States with HOV lanes totaling approximately 2,200 HOV lane miles. About 10 percent of that total is located here in Seattle. We are planning to increase our 200-centerline miles by at least 100 more centerline miles.

Every central Puget Sound freeway has HOV facilities. We are beginning to create more and more lanes on arterials and bridges to address the overflow traffic from our major freeways.

Our users generally understand that the HOV lanes are a critical element of transit, carpooling and vanpooling programs. These lanes form a critical "third mode," the complexities of which are generally understood.

We need to begin to talk about and plan for these facilities as though they are a unique third mode. The HOV lanes themselves are part of the basic infrastructure to host this third mode. But, this mode has many other complex components.

These other components are the transit plans and operations, which utilize the express nature of the lanes. They are the policies, programs, and partnerships that support vanpooling, carpooling, better land use, and commute trip reduction implementation.

To leverage existing HOV lanes, we are building more connections – a web of HOV service to increase the efficiencies of the system. Already, during peak periods, buses, which only make up 2 percent of the highway vehicles, carry 40 percent of the people into downtown Seattle. Additionally, on I-5 in the peak, one HOV lane carries the same number of people as three lanes of general-purpose traffic.

The 2000 census data reports that approximately 12 percent of the King county population carpools or vanpools to work. Those that carpool and vanpool get the typical economic benefits of pooling that anyone who shares travel costs nationwide would get. But, here in the Puget Sound region,

they get the added benefits of predictability, reliability, and timesaving from their trip.

It is not as simple as "build it and they will come." But, here in the Puget Sound region, it was built and they did come. Many other metropolitan areas have not experienced the same success. Other areas have had to re-designate HOV lanes back to general-purpose lanes due to public pressure.

That scares me, because while they may have experienced the short-term apparent gain of adding one more general-purpose lane at the expense of HOV, they have lost options for their future. Remember that 3-to-1 ratio on I-5 that was achieved during peak periods? Think of it as paying for the construction of four lanes and getting the capacity of six.

Before getting into some of the threats and opportunities the HOV system is currently facing, I thought it would be best to first discuss how we got to where we are today. In 1970, WSDOT, the City of Seattle, and King County developed the first transit only-lane to serve Blue Streak, the region's first express bus system. Augmenting that initiative, the City of Seattle, the Downtown Seattle Association, and the Building and Office Managers' Association, joined together to start a carpool program in 1973, in response to Federal Clean Air requirements. These players knew that if they did not begin reducing emissions, they would face federal sanctions.

Just a year later, in 1974, the transit only lane on I-5 was converted to an HOV lane. As part of the designation, WSDOT, the City of Seattle, and King County signed a Memorandum of Understanding (MOU) calling for the construction of 24 park and ride lots and 35 bus stops. This reinforced the purpose of HOV lanes and guaranteed their use.

Can you imagine the great leap of faith that was called for to make this move? It took visionaries to understand the future demand for such facilities. I am not sure that we would be able to implement that program today – even knowing how successful it has become in other cities.

But, Seattle's lead on the HOV curve did not end there. Having made the investment in the infrastructure, they went further and designed programs to feed and feed off of the investment. They nurtured the program concept and physical infrastructure with human initiative.

Early enforcement let people know that the program would be taken seriously. Washington started its HERO program in 1984 to deter single-occupancy vehicles from violating the 2+ person requirement on HOV lanes. Since then, hundreds of thousands of reports have been called in and tens of thousands of tickets have been issued. As a result, violation rates range from one to seven percent here, compared to the 10 to 15 percent national average. It is considered good citizenship to protect the lanes for intended use.

Another step occurred in 1990. That year, Seattle was one of the first cities to incorporate trip reduction requirements into its land use codes through the Major Institutions Ordinances. These ordinances required hospitals and universities to develop plans to reduce their drive-alone trips by 50 percent.

This ordinance made employers with more than 100 employees a major part of the equation in promoting transit use, carpooling, and vanpooling and ultimately in HOV lane use. The city and state reinforced that program by developing reduced-rate parking for carpools and vanpools at convenient downtown locations. Effectively, commuter pools paid very little to participate in a program from which they could reap large rewards. Today, King County's Commuter Pool Program is still nationally known. Per capita, King County has the largest vanpool fleet in the country.

When the state and the locals first decided to build HOV facilities, much of the funding came from federal sources. As part of the Interstate withdrawal and substitution program in the 1970s, Seattle chose to use highway funds for HOV lanes instead of building more highways. Now, the HOV system represents a partnership between the state, the city, Sound Transit, and King County. The state provides the construction and the design of the lanes. The state and Sound Transit provide funding. King County Transit coordinates the program.

The city guides land use and commuter trip reduction policies. These commitments and combined investments continue to pay off. The central Puget Sound region is one of only two metropolitan areas to increase its HOV participation over the past 10 years, according to the U.S. Census. The other area is Washington, D.C.

This fact shows that you cannot assume that HOV use will increase over time. You cannot assume that if you build it, they will come. In the Seattle area, they have not assumed anything. Instead, they are always reviewing their policies to make sure that they are keeping up with the times and that the incentives offered by HOV facilities continues to entice users. They treat HOVs as a separate and very real mode that continuously needs attention.

As most of you know, HOV policies and practices do not happen overnight. Before getting aboard the HOV bandwagon, a community needs to make a commitment to all or some of the following steps:

- giving priority to transit through land use and building codes;
- providing travel time savings through speed and reliability;
- providing incentives to use alternatives to driving alone;
- connecting neighborhoods – developing a web of HOV services – not just one facility;
- investing in additional infrastructure to support the HOV lanes, such as on and off ramps from park-and-ride lots; and
- enforcing the program so there are disincentives to violating HOV guidelines.

With the breadth of issues involved, you can see why I consider HOV lanes to be the third mode. It takes a complex equation to establish a successful HOV system. It takes all public agencies, business associations, and citizens to make it work.

For users, the benefits of HOV are clear:

- predictability of time travel;
- reliability of the mode;
- personal travel time saving – and except for the drivers, personal time put back in your day;
- environmental friendly with fewer cars creating less congestion and lower emissions.
- savings to businesses – employees spend less time in traffic, and employer-provided parking compensation is less of a consideration; and
- parking space demand and use is greatly reduced leaving the space for building owners and operators to put to more productive use.

Unfortunately, many HOV operators and participants take these benefits for granted. We do not take the time to explain to people all of these opportunities because we assume they know.

We assume as single-occupant vehicles are stuck in traffic, drivers see these HOV cars go flying past and think, “Boy I should start a neighborhood vanpool program.” We’ll we’re wrong.

A lot of the single-occupant vehicle drivers are sitting there wondering, “how can I get around the system, how can I be a part of that free-flowing traffic?” They are not considering behavior modification; rather they are figuring out how to manipulate the system.

Recently, in Seattle, a woman with a mannequin strapped in her passenger seat caused a six-car pile up trying to get into an HOV lane. How sad it is that someone so desperate to skirt the HOV regulations could end up causing delays for thousands of HOV users.

We cannot assume that everyone gets it. And in that regard, we have to play with an offense. We need to be touting our successes at every given opportunity. I am sure that everyone at this conference understands the benefits of the HOV system. And to us, this seems intuitively obvious. But, it is not to everyone.

Portland launched an HOV lane in the 1970s, but backed away. The state of New Jersey re-designated two HOV systems on two major highways after determining that the facility did not encourage carpooling. These are major setbacks because if and when they ever consider another HOV system, everyone will remember the first experience as a waste of time and resources.

Minnesota considered converting HOV lanes to general-purpose lanes, but eventually rejected the initiative. It will take more efforts to overcome future initiatives. In a fairly remarkable situation, Massachusetts overcame two failed HOV attempts in the 1970s to re-launch HOV service in the 1990s. Transportation officials were savvy enough to know that they could not just put it out there and hope for the best. They invested a substantial budget into marketing the new facility and the results were great.

How many of us consider marketing as part of the equation? It is far too easy to be myopic and look so closely at the system that we miss everything else that is going on around the system. But, there are those that keep their eye on the prize. According to WSDOT, it will take an additional $1.8 billion to complete the Central Puget Sound HOV system. That figure, as intimidating as it is, has not deterred us.

Now the news is not all rosy here. I need to say something about the threats that we currently are facing. The theme of this year’s conference is “Evolution or Revolution.” It poses an interesting question. My response is that we cannot afford to let HOV programs evolve or else we will be facing extinction.

A local anti-tax advocate has filed an initiative with the Legislature that would open the HOV lanes to general traffic except from 6 to 9 a.m. and 3 to 6 p.m. WSDOT conducted a study to identify the impacts of such a change. To date, they have focused primarily on the impacts of transit. They found there were no real benefits to opening HOV lanes to single occupant vehicles during weekends and evenings. Furthermore, they discovered there were some very real costs to such a $6 million initiative.

Unfortunately, some have interpreted the “no real benefit,” to also mean, “no real harm.” So, as you may have heard, WSDOT is still considering opening HOV lanes during off peak hours. WSDOT officials have told me that they support the HOV system. This move is being pursued as a means of “saving” HOV from the initiative process. Reasonable people can disagree. As our mayor has stated previously, we believe this move threatens our ability to move forward on critical major projects.

There are two major projects under study across Lake Washington. The political agreements WSDOT is advocating have the assumption of trust included in them. They have HOV commitments, which we are supposed to assume, will be followed through on in years to come. It is difficult to trust with these other HOV proposals on the table. Reinforcing that belief, studies show that non-work and

weekend trips now account for 75 percent traffic in Washington State. And, peak hours continue to grow. In the central Puget Sound region, carpool lanes are used most heavily on the weekends, in many areas. In 1996, voters in Washington State approved $850 million in HOV connections that provide a 5-to-10 minute reduction in travel time. Now that commitment is at risk.

So, nothing is perfect here either. Now that we have begun to see real success with HOV as a third mode, we cannot back down. We must continue with an offense. Our strategy should keep the benefits of the third mode – HOV – top in the minds of users and non-users alike. Part of this strategy involves pointing out what is at risk when HOV lanes are converted. We cannot let a minority of those who question the value of the system during evening and weekends fundamentally change the way it works. We need to become a part of the HOV Revolution. We need to be thinking about change even when we are experiencing success.

There are four key conclusions I hope you take away from our lunch together today. First, HOV is a unique and third mode which requires its own transportation focus. TRB is one organization that has recognized this fact. Second, we cannot just build HOV facilities and expect that the users will come. We have to support it with programs, policies, and partnerships. Third, we have to better understand and explain the third mode – even to transportation professionals. We have to tell people how the HOV system works and how it helps them in their daily life. We have to guide the design of the infrastructure. We have to guide the policies which govern the use and political construction of the facilities. We have to guide the programs which integrate our users with our policies. We have to reinforce the partnerships which fund, design, and integrate the many components of this third mode.

Finally, we have to market, market, market the program. We have to show people how it benefits their pocketbook, their lungs and the community's economy. We have to market the convenience of vanpooling. We have to market the independence of carpooling. We have to market the time back in your life from transit. We have to market the shorter trip for all HOV users. We have to market the taxpayer savings from not having to build added lanes to move people, one person at a time, one car at a time. We have to market the cleaner streams from reduced highway runoff. We have to market the economics of land use and the productive use of space for things other than parking.

We can take nothing for granted. And for that, I thank you for putting your energy and brainpower to work at this conference and beyond. It is up to all of us to make sure the HOV systems are never referred to as a thing of the past. Thank you!

PLENARY SESSION — MEETING THE CHALLENGE: SOLUTIONS & STRATEGIES

Rob Fellows, Parsons Brinckerhoff, Moderator

Responding to Issues: Experiences from Washington State

Charlie Howard
Washington State Department of Transportation

Thank you. It is a pleasure to participate in this session. My role this morning is to advocate for monitoring and evaluating HOV facilities on an ongoing basis. Maintaining an ongoing monitoring program has been important for the HOV facilities in the Puget Sound region. Performance monitoring programs provide critical information for operating agencies, policy makers, and the public.

The HOV facilities in the area are intended to serve multiple objectives. It is important to realize that these objectives may change over time, which may result in changes to the monitoring program. Obviously, a monitoring and evaluation program has to be tied to the goals and objectives of the HOV facilities in the area.

A monitoring program should provide information that can be used by the operating agencies, which typically include the state department of transportation, the transit agency, and the state patrol. Performance data is critical to managing the system. Management uses the information from the monitoring program to make needed adjustments in the system.

The information from monitoring programs should also be used to communicate with state and local policy makers. Too often we take for granted that these individuals understand the benefits of HOV facilities. Ongoing outreach efforts are needed, especially given the turnover in elected officials. The same information can be used to communicate with neighborhood organizations, special interest groups, and the public.

The HOV lanes are just one part of the transportation system. While they are an important component, the monitoring program must also cover the general-purpose lanes, public transit, incident management, and other elements. All of these components must be working together to maximize the efficiency of the total system.

There are limits to data collection and monitoring systems. There is never enough funding to measure all of the elements you would like to measure. Trade-offs often typically have to be made. It is critical to focus on the main measures of effectiveness linked to the objectives of the HOV lanes.

A number of issues continue to be examined in the Puget Sound region. The information from the ongoing monitoring program is critical to help explore these issues. While there will always be differences of opinion, having sound information to base discussion and decisions on is critical.

Promotion and Education: Painting the Picture of Success

Heidi Stamm
HS Public Affairs

Good morning. I would like to provide you with some ideas on how to paint a picture of success for HOV facilities in your area. A successful HOV facility has high use and the adjunct general-purpose lanes are full. A number of speakers over the past two days have stressed the importance of public education and marketing with HOV lanes. My presentation focuses on the education aspect of building

consistencies for HOV facilities. I will talk about the specific education actions you may want to consider in your region. These actions will help ensure that your audience understands and embraces HOV facilities. It is one thing to like HOV facilities, but it is another thing to have a call to action. My comments will focus on how you can develop a call to action in your area. A good education program is just as important today as it has been in the past.

This is not a presentation about how to convince people to use HOV lanes. I am assuming that your HOV facilities are operating fairly well. I will talk about how to define HOV success, who should embrace HOV success, and ways to talk about HOV success.

What is the evidence of HOV success and how do we talk about HOV success? The measures of success vary by metropolitan area, and sometimes even by facilities within the same area. Success can be defined in a number of different ways.

System success is often defined by differences in the performance measures used with HOV projects throughout the country. We also see that performance measures may change over time. In California, 800 vehicles and 1,800 persons an hour was used as one measure of success in the early years of the development of the HOV system. In Washington, Texas, and Massachusetts, recommended use levels are more dependent on the individual facility. With mature HOV lanes, one common measure is that the HOV lane should carry more people than the adjacent general-purpose lane.

In terms of travel speeds and travel time savings, an early measure used was that an HOV lane should provided at least one minute per mile in travel time savings over the general-purpose lanes. In Washington, there is a policy that HOV lanes should operate at 45 mph or better 95 percent of the time over a six-month period. HOV system success may also be defined by low violation rates. A violation rate of 10 percent or lower is used in many areas. In many cases, violation rates are more a measure of enforcement levels and public perceptions than of demand for a facility.

Another measure of success may relate to an area's commitment to an HOV system vision. California and Washington both have written policies relating to HOV facilities. Other states may have written policies or guidelines. The link to land use may also be included in measuring the success of HOV facilities. These measures may be defined in regional transportation plans and carried out through specific projects.

The success of HOV facilities may also be measured from the user's perspective. Two measures that appear important to HOV lane users are travel time savings and trip time reliability. Surveys in many areas indicate that trip time reliability is becoming the most important measure for users.

It is also important to examine HOV success from the perspective of taxpayers. Public acceptance of HOV lanes provides one possible measure of taxpayer's support for HOV lanes. A recent survey in Los Angeles County showed that 88 percent of residents thought HOV facilities were good. A recent survey in the Puget Sound region showed 72 percent of single-occupancy vehicle drivers and 95 percent of HOV lane users support HOV facilities.

All of these measures may be used as indicators of success. One question to ask is who do you want to embrace this evidence? You will want to package the information on measures of success differently for different audiences. Typical groups you may want to communicate with include elected officials, policy makers, community groups, special interest groups, print and broadcast media, and law enforcement and judicial representatives.

Elected officials typically are one of the most important groups to educate about HOV facilities.

Policy makers are also every influential in making day-to-day operating decisions. Community groups may represent commuters in a certain area. Special interest groups may include environmental organizations, business interests, or mobility groups. The media really helps shape public opinion and should be treated as a separate market. Finally, law enforcement agencies and the judicial system should not be overlooked, as these groups are key to effective enforcement.

There are many techniques that can be used to present HOV messages. We often talk about the need for HOV project champions. In most cases, project champions do not appear out of the blue. Thought should be given to nurturing and educating project champions. Try to identify potential project champions early in the planning process and work to educate and inform them. Let them know how important they are. I think developing project champions is an area where we could all do better. I challenge you to identify people in your area who could be project champions and think about ways to nurture their support.

Presenting the HOV message is more then just producing a newsletter. It is important to match the appropriate technique to the various markets. I would suggest you think about focusing on four elements. Prioritize, personalize, pursue, and enlist in developing your information technique for each market.

To prioritize you should match the success evidence to the interest of the audience. For example, the success measure that HOV lanes move more people than the general-purpose lanes can be tailored to different markets. With elected officials you might want to add that HOV lanes have a high taxpayer approval rating. With adjacent neighborhood groups you might want to stress the land use sensitivity of HOV lanes. With policy makers you might want to highlight that HOV lanes are consistent with, and support regional transportation visions.

To personalize a message, include examples of how the prioritized evidence directly relates to the audience. For example, with law enforcement officials you might stress that when violations creep above 12 to 13 percent it leaps quickly to 25 to 30 percent, which is why it is important to keep violation rates at around 10 percent. With elected officials, you might want to stress the percent of HOV approval in their district. Always look for the spin that touches the heart of your audience.

You need to pursue your market. Go where your audience goes and talk to people your audience talks to. With elected officials, talk to their aides, attend committee meetings, and schedule briefings. With policy makers, meet with their staff, comment on draft policies, and present “white paper” analyses of existing policies. With community groups, talk to their officers and attend meetings. Meet with the board of directors of special interest groups, media, editorial boards, and provide briefings for law enforcement and judicial officials.

The last step is to enlist their support. Ask them for a specific action and follow-up to make sure it happens. With elected officials you might ask for support for existing policy or propose new legislation or funding. With policy makers you may ask for support for existing programs, propose new policies, and monitor activities and funding sources. With community groups and special interest groups you can ask them to lobby elected officials and policy makers to extend support to HOV facilities or educate their constituency about HOV facility benefits and successes. The media may be asked to support HOV policies through editorials. Law enforcement and judicial representatives can support HOV safety and utility through enforcement and by upholding fines and penalties in court.

In closing, remember to first define HOV success from the perspective of the HOV system, users, and taxpayers. Embrace HOV success by educating and informing elected officials, policy makers, community groups, special interest groups, the media, and law enforcement and judicial

representatives. Prioritize, personalize, pursue, and enlist support from these groups.

Managed Lanes – Survival of the Fittest?
Hall Kassoff
Parsons Brinckerhoff

My comments this morning focus on embracing a broader set of management tools for HOV facilities through managed lanes. If there if too little demand for an HOV facility, single-occupant vehicle drivers are frustrated. On the other hand, if there is too much demand in a lane, HOV users are frustrated. Both of these conditions can lead to political action, which can frustrate transportation professionals.

Other speakers have stressed the importance of having accurate data to respond to these situations. The lack of adequate performance data frustrates rational decisions. The bottom line is that if HOV lanes are terminated, changing to general-purpose lanes is kind of a one-way street that will frustrate any future managed lanes options.

As other speakers have mentioned, a main justification for HOV lanes is moving more people in less time than the general-purpose lanes. Some of the essential criteria for HOV lane success include congestion in the general-purpose lanes and the potential for travel time savings. Adequate HOV demand must exist in a corridor. When these factors are not present, HOV lanes will not succeed.

One of the ironies of HOV lanes is that too much demand can result in the failure of a successful facility. Too little demand at a 2+ occupancy level can result in a failure, while too little demand at a 3+ demand occupancy level is even more of a dilemma. The challenge is to achieve the correct balance. This goal is not easy to accomplish as HOV lanes have an inherent instability of success. Too little demand, of lower than 800 vehicles an hour, may result in political failure. Too much demand, of 1,800 or more vehicles an hour, can result in operations failure. The challenge is how to maintain demand at approximately 1,500 vehicles an hour.

One possible approach to improving the odds of success is to think of HOVs as just one special application of managed lanes. Converting HOV lanes with low use levels to managed lanes may improve the chance of success. This approach offers dedicated lanes for one or more use classes. This approach manages use to achieve a higher level of peak period service and maximizes the use of scarce resources. User groups may include carpools, vanpools, buses trucks, toll paying vehicles, and other categories. Ultimately, the decision to sustain HOV lanes, to move toward managed lanes, or to move toward managed lanes with value pricing will be a political one.

One example of this approach is converting an overused HOV lane with a 2+ occupancy requirement to a combination 3+ and HOT lane. Managed lane options may serve different user groups based on occupancy requirements, express trips, buses, commercial vehicles, zero emissions vehicles, high energy efficiency vehicles, and pricing.

Examples of current managed lanes include the bus and truck lanes on the New Jersey Turnpike, the I-5 truck lanes in Los Angeles, and the Express Lanes on SR 91 in Orange County, California. Managed lanes provide use with options that go well beyond the original creation of HOV lanes. Maybe it is time for the TRB HOV Committee to change its name to the Managed Lane Committee.

Transit and HOV Lanes – A Great Combination
Dave Schumacher
San Diego Metropolitan Transit Development Board

It is a pleasure to have the opportunity to talk about HOV lanes from the perspective of a transit operator. I think HOV and transit represent a great combination. Thus, the title of my presentation. Transit operators have historically been slow to learn the advantages of HOV and managed lanes. Most transit operators are focused on implementing their vision for the future. The current regional transportation plan for San Diego includes high speed transit lines and local service. Our Transit First strategy focuses on creating a spine of high speed transit service throughout the region. I think more metropolitan areas in North America are realizing the important role transit can play in helping address regional mobility.

Increased congestion is pressuring transit to assume a greater role in addressing regional mobility issues. The emergence of BRT provides opportunities for HOV facilities to help assume this larger role. A number of characteristics distinguish BRT from more traditional bus operations on HOV lanes.

First, BRT provides rail-like vehicles that have features to improve comfort, speed, and safety. There is also more attention to station design that creates pleasant and attractive places for riders. BRT has distinctive designs, styling, and graphics that provide the look and feel of rail transit.

BRT pays attention to the little details that will help attract new market segments to transit. BRT uses multiple door, low floor vehicles for ease of boarding. It includes Smart Card fare collection to speed fare payment and to make it easier for passengers. It also includes advanced technologies, such as next-vehicle information.

As you all well know, congestion in the mixed traffic lanes also causes delays and slows travel speeds for buses. Millions of dollars are spent annually to keep buses on time due to congestion. For transit to be effective, speed and reliability are essential. The success of transit in attracting new riders greatly depends on implementing transit priority measures.

In seeking solutions to this problem, it is important to consider all parts of the transit trip. Thus, freeways, access ramps, stations, park-and-ride lots, and arterial streets all need consideration. A wide range of arterial street transit priority measures can be used, including signal priority, curb lanes, median lanes, and guideways.

I think Houston really pioneered the development of transit use of freeway HOV facilities. Houston uses direct access ramps to ensure easy access to transit stations. BRT can build on the experience with freeway HOV facilities and add to it with the local street components.

The I-15 corridor in San Diego provides an example of multi-modal systems planning. The facility includes an eight-mile reversible HOV lane, which has been expanded into a HOT lane. Express bus service operates on the lane. Ridership growth has occurred with increases in service. Further, approximately 80 percent of the passengers are choice riders who have an automobile available for the trip, but elect to use transit.

The future of the I-15 freeway is planned to be a 20-mile managed lane facility. The cross section includes four bi-directional lanes and a movable barrier. Direct access ramps to transit stations will be provided. State-of-the-art transit coaches will be used. The facility represents a $700 million capital investment. This approach creates a cost-effective, multi-modal facility, one that helps to broaden support for HOV and managed lanes.

It is interesting to see the change in thinking of many residents and community groups. When the planning process started, most groups favored LRT in the corridor. Once they had a better understanding of all the BRT elements, they began to favor BRT over LRT. One community requested

Caltrans to widen a freeway bridge deck as part of the freeway construction, to better accommodate a transit station, transit-oriented development, and adjacent land uses. It also included a gateway plaza to provide a focal point for the community. The community is very excited about the project, which shows the potential of BRT.

The North I-15 corridor managed lanes/BRT project will be completed in sections. Stage One construction is set to begin in 2003, with completion estimated in 2007. The regional transportation plan includes an HOV and managed lane system.

We hope to accomplish a number of objectives with these improvements. Transit currently does not serve many of the suburban activity centers in the region. There is an increase in transit services in many of these areas to address growing levels of traffic congestion. We think the HOV and managed lane system combined with BRT can have a significant influence helping reduce traffic congestion and increase mobility in these areas. We think we can increase transit mode split in suburban activity centers to around 20 percent.

PLENARY SESSION — THE FUTURE OF HOV FAICLITIES: EVOLUTION OR REVOLUTION

Paula Hammond, Washington State Department of Transportation, Moderator

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State Transportation Agency Perspective

Connie Niva
Washington State Transportation Commission

Rather than start by telling you what I will cover this morning, I will tell you what I will not talk about. I will not talk about the revolutionary concept discussed the in first session or a HERO Hot Line to report vehicles in the general-purpose lanes that qualify for the HOV lane. I am sure many of you have wished an HOV would get over into the HOV lane and stop taking up the capacity of the general-purpose lanes.

We have not experienced having an HOV facility taken away because it was managed poorly. The dedesignation of the HOV lanes in New Jersey had a significant effect on the Washington legislature, however. There was a good deal of interest in introducing legislation to open the lanes to general-purpose vehicles based on the situation in New Jersey.

A related concept that seems to have little support with the driving public is to convert a general-purpose lane to an HOV lane. There are some groups that continue to promote this approach. The experience with the Santa Monica diamond lane seems to indicate that this concept can do more damage than good.

HOV lanes are inherently controversial because they give travel priority to some groups over others. Space on freeways in all parts of the country has become very dear to commuters. Since not everyone can choose to use the HOV lanes, some groups will always question their application.

Recent surveys in the Puget Sound region seem to indicate that there is less support for HOV facilities today than there has been in the past. The lack of investment in alternatives, as well as additional infrastructure, may be resulting in a negative backlash toward the HOV lanes. At the same time, transit agencies and other transportation providers strongly favor maintaining the HOV facilities. These groups are some times critical of WSDOT for examining alternatives, while legislation is directing that the Department conduct the examination.

It is no secret that the nation's growth in infrastructure has not kept up with the growth in the demand for travel. The gap between infrastructure and demand is evident in almost every metropolitan area in the world. In the Puget Sound region this gap is putting more pressure on all elements of the transportation system, including HOV facilities.

During my nine years as Transportation Commissioner, I have witnessed a significant growth in the complexity of the environment in which decision makers work, both politically and economically. I recently read an article "The New Politics of Mobility," by Robert Atkinson. The premise of the article is that the key to solving the nation's mobility problem is political. He also suggests that the loss of our mobility is directly related to the rise of different coalitions opposing transportation policies. Herein I believe lies the revolution. I do not think this situation existed when I was appointed to the Transportation Commission in 1993. At that time there was more support for advancing the transportation agenda.

I think there are a number of reasons for this change. First, are the anti-tax conservatives that see

public transportation polices as wasteful. HOV hours of operation was a major debate at the annual convention of one of the political parties in the state. I would not think HOV operating hours would be that high on the political party's agenda, especially compared to issues like how to address the $2.3 billion state deficit.

On the other end of the political spectrum there is an alliance of environmentalists, urban planners, and academics who blame transportation policies for encouraging sprawl, greater reliance on the automobile, and the rapid disappearance of green spaces. Whenever HOV lanes are presented as a way to get people to change their behavior, opposition picks up as most people think they make rational decisions.

These positions have polarized in the policy debate over transportation. This polarization is evident in the debate over Referendum 51, which is on the ballot in next week's election. I think HOV systems will only weather these challenges in the long run if they are not presented in an ideological way. The high ground will be held by those who can articulate their position based on facts, not as unwavering political philosophy.

Many speakers have stressed the value of communication. Every traveler on the freeways and local roadways is an owner of the system. We need to ask their opinions and we need to listen to their answers, even if we might not like what we hear. We also heard a number of success stories related to HOV projects, BRT, and managed lanes. I am not sure we have done a good job of communicating these success stories to the public or to legislators and other public officials. The Puget Sound region has had great success with commuter trip reduction. There are some businesses in downtown Seattle that have almost 90 percent of their employees using modes other than driving alone to get to and from work. I think these numbers are amazing.

Speakers have also pointed out the importance of building support. A few legislators who were strong supporters of HOV facilities in Washington recently retired. Who will take their place in advocating for HOV projects is not known at this time.

The point that we manage what we measure was also made by other speakers. I would suggest that efficiency is the most important measure. It certainly is right now here in Washington. Efficiency is key to identifying the transportation strategies that best address transportation needs. We have to squeeze more utility out of every current transportation element and optimize the utilities of every new transportation component. It is hard to promote HOV facilities if you do not have data on how they compare to the general-purpose lanes to show the public.

Another theme we have heard throughout the conference is how to make changes when needed rather than having change legislated. How do you know when changes are needed? To take a proactive role in addressing issues and concerns may not be easy, but it will pay off in the long run. Compromise may sometimes be needed. In the Puget Sound region and other areas studies have often been conducted at the request or direction of the legislature.

I believe by these three things – communication, performance evaluation, and evaluation of potential changes – you can address the critics of HOV facilities. There is an old saying "you always do what you always did, you always get what you always got." I do not think we want a revolution with HOV facilities right now. Rather I think we want to keep evolving. Thank you.

Federal Perspective
Jon Obenberger
Federal Highway Administration

Thank you, Paula, for the introduction. It is a pleasure to have the opportunity to address the question of "evolution or revolution" for HOV facilities. I would first like to thank TRB and the TRB HOV Systems Committee for sponsoring this conference on behalf of FHWA. Most importantly, I would like to thank the many individuals from WSDOT, Sound Transit, local agencies and other interests who hosted and worked to make this conference a success. This conference would not have been possible without your commitment, energy, and hard work.

Prior to addressing the theme of this panel, I would like to provide a few perspectives on some of the key issues and challenges that HOV systems are facing around the country. If you look at the length of time that HOV lanes have been in existence, the use of occupancy as an operational strategy should still be considered in its infancy. Over the past 30 years, the use of occupancy as an operational strategy has increased significantly, from only three facilities operating as tests or demonstration projects in 1970, to over 2,500 lane-miles in operation today in over 31 metropolitan areas.

The use of occupancy as an operational strategy is expected to continue to grow at a significant rate into the future, with over 3,700 lane-miles projected to be in operation by 2010, accounting for an increase of approximately 50 percent. Initially deployed on freeways located within radial corridors servicing the central business districts of only the largest metropolitan areas, today over half of the lane-miles where occupancy is being used as an operational strategy are located on non-radial freeway corridors.

At the same time, the route-miles of general-purpose roadway capacity has increased a rate of slightly more than 1 percent, while the vehicle-miles of travel have increased 72 percent over the past 20 years. These trends have contributed to significant increases in congestion that has resulted in reduced mobility, decreased productivity, and inability to meet the public's demand to travel or expectations for reliability. Traffic congestion is a problem that we are all facing, which requires action on a number of fronts.

From a pure roadway perspective, where we may have the most immediate and direct ability to influence traffic congestion, we need to employ strategies that include: 1) increasing roadway capacity when and where appropriate, 2) proactively managing the operation and use of roadways; and 3) managing the publics demand to travel in the most effective and efficient manner possible. All of these approaches should embrace and include the consideration of occupancy as a key strategy that is integrated and used in all of the decisions and actions that may be taken throughout the life cycle of a roadway facility.

FHWA has, and will continue to serve into the future as a champion to promote the values and benefits of HOV systems. FHWA strongly supports the consideration of occupancy, or HOV facilities, as a regional or system wide strategy, to help move more people along congested urban and suburban corridors. The use of occupancy is a proven, cost-effective, environmentally friendly, and efficient operational strategy to improve the mobility, accessibility, and productivity of the surface transportation system, specific corridors, or facilities.

Throughout this conference there have been sessions, presentations, and perspectives offered that provide unique perspectives and insight on how to answer the question of "evolution of revolution" related to the use of occupancy as an operational strategy. Prior to addressing this question, I would like to mention some of the innovative techniques that have been presented at this conference. The following examples provide an excellent "roadmap" for agencies and metropolitan areas on approaches to integrate the consideration of occupancy as an operational strategy throughout the policies, programs, strategic planning, services provided, and decisions that are made throughout the life-cycle of roadway

facilities:

- understanding, measuring, and continuously tracking the expectations of our customers;
- establishing measures that can be used to assess the performance of occupancy as an operational strategy across the region and along specific facilities;
- documenting and reporting on the benefits of using occupancy and how HOV facilities contribute or influence agency and regional goals and measures;
- continuously monitor, evaluate, and report on the performance of HOV facilities;
- proactively manage and operate HOV facilities;
- provide the resources that are appropriate to manage, operate, and provide the necessary services that are critical to the successful operation of HOV facilities;
- integrate the use of occupancy as a key strategy in the strategic transportation plans of each agency and the region;
- HOV facilities should be cooperatively managed, decisions made, and resources provided by all of the key interests within a metropolitan area;
- develop and maintain an long-range plan for the ultimate build-out of the HOV system;
- develop and maintain a multi-year HOV system plan that identifies the support services, improvement projects, functions to be provided, and resources required to manage the HOV system; and
- continuously market the value of HOV facilities to the public, elected officials, public agency managers, and the media.

My answer to the question posed to this panel, is that HOV facilities are facing both an evolution and a revolution, both nationally and within every metropolitan area. Every time a new HOV facility is planned within a corridor, or for the first time an HOV lane is opened for operation in a metro area, it may be considered a revolution. Modifications in the operation of HOV facilities for the first time may be considered a revolution in some metropolitan areas. Evaluating and documenting the benefits of the performance of HOV lanes for the first time, may also be considered a revolution in some metropolitan areas. Understanding that HOV facilities are actually over prescribed and additional HOV lanes are needed or an increase in the occupancy level for the first time may be considered a revolution in some metropolitan areas.

For each difficult issue that arises, it may appear to be a revolution and significantly influence or change the course of direction related to a particular HOV system. However, from a national perspective, hopefully these are all viewed as mini-revolutions in the natural progression and growth with use of occupancy.

Transit Perspective
Agnes Govern
Sound Transit

Thank you Paula. It has been a very productive conference. The Conference Planning Committee did a great job organizing very interesting and informative sessions. Over 200 people attended the conference from 17 states and three other countries. It truly has been an international conference. I have learned a great deal from listening to the presentations. It is interesting to hear the applications being used in different areas and the challenges being faced. I thank you all for your participation in the conference.

I have been asked to provide a perspective from the public transportation sector, specifically on the challenges transit is facing and the ways that HOV facilities and transit can work together. From a

personal perspective, I have been a member of the TRB HOV Systems Committee for four years. Initially it was a fairly daunting group to join. At the conference, one of the breakout group tracks was devoted to BRT, and transit was a key element in the other tracks. So, when I think of evolution, I think of both my own personal involvement with the HOV Committee and the increased interaction between transit and HOV operations.

The challenge facing transit today is to increase ridership. A number of speakers addressed this issue and presented approaches for greater interaction between HOV and transit operations to increase ridership.

Presentations highlighted projects that were able to show the number of new riders attracted because of the benefits offered by the HOV lanes. As Dave noted earlier, there is a natural connection between HOV facilities and transit. Patrick deCorla-Souza indicated in his presentation that there might be public resistance to managed lanes because people see them as a weak solution. If you want to promote a managed lanes project, highlighting the transit aspects and the transit benefit may help.

There are a few things I would suggest we all think about as we work to implement and operate HOV projects. First, the concept of total trip time is important for transit riders. Many times we focus on the time savings for just the freeway HOV segment. Expanding our thinking to consider the need for arterial street HOV lanes, signal priority for buses, or direct access ramps from park-and-ride lots will help focus on the total trip, not just the freeway portion.

Second, I would like you to think of the concept mentioned by Grace Crunican at Monday's luncheon of HOV as a third mode. Involving transit agencies in the early development of HOV facilities can ensure that transit is an integral part of a project. A few speakers at the breakout sessions indicated difficulty with getting transit agencies to operate bus service on HOV lanes. This situation may exist in some cases because transit was not considered in planning for the facility or the HOV lane may not be located in an area with bus service. I think if you include representatives from transit agencies early in the planning process they will become champions for the projects. HOV facilities can greatly enhance bus operations.

It is also important to consider all the elements needed to support HOVs as the third mode. The lack of supporting elements appears to be a key reason for the problems associated with the I-287 HOV lane in New Jersey. Consideration should be given in the planning process to all of the components needed for a successful HOV facility, including transit.

Considering HOV as a third mode should also be continued into the performance measurement and evaluation process. Including bus riders, along with other HOV user groups in surveys to measure support for HOV is important. Bus riders are usually significant supporters of HOV facilities.

The third point I would like to highlight addresses the integration of modes. In addition to buses, carpools, vanpools, and general-purpose traffic, we also need to consider bicycles and pedestrians. We should not forget these last two transportation modes. There is a lot we can learn from approaches in Europe and other parts of the world on low cost solutions that encourage integration of all modes.

Finally, partnerships are critical to the success of HOV facilities. Key players include FHWA, FTA, state departments of transportation, transit agencies, and local jurisdictions. The regional HOV policy advisory committee established a few years ago by the Washington Transportation Commission provides a good example of the multi-agency coordination that is needed for successful HOV facilities. This committee includes representatives from transit agencies, FHWA, local jurisdictions, the American Automobile Association, and other groups. All of the key stakeholders are involved in the committee,

which helps advise the Transportation Commission on HOV policies.

Given the nature of HOV projects, it is natural that FHWA and state transportation agencies are often thought of first. FTA and transit agencies should also be actively involved. Local jurisdictions are key players with arterial street HOV facilities and for linking freeway and local facilities.

In terms of the Conference title – Evolution or Revolution – I would suggest that it is evolution and revolution. The challenge we face as HOV facilities evolve is to ensure that any changes are part of a long term commitment. We need to respond to short term issues keeping the long-term goals of HOV facilities in mind.

Consultant Perspective
Chuck Fuhs
Parsons Brinckerhoff

The other speakers have done an excellent job of providing perspectives from the state and federal levels and from public transportation. Having attended all 11 HOV conferences, I will focus my comments on both a look backward and a look forward.

Over the years, I think we have seen a generational shift in the practitioners of HOV activities related to planning, designing, and operating HOV facilities. We have also seen a generational embracing of the HOV concept. The results from a number of surveys that have been conducted in different metropolitan areas over the past few years shows strong support for HOV facilities. The results from these surveys show acceptance of HOV facilities ranging from 70 to 90 percent among residents and general-purpose drivers.

The theme I would like to leave you with this morning is to keep your eye on the prize. Often when we get too caught up with a specific issue or problem, we may forget to focus on larger goals and objectives. Other speakers have highlighted the major goals and objectives of HOV facilities. Providing travel time savings, trip time reliability, and moving more people than the general-purpose lanes are frequently cited goals of HOV facilities. We may ask ourselves how much travel time is needed to justify a project or how many more people should be carried.

I would suggest that the ultimate goal of HOV lanes or any type of dedicated lane is to do more. Those two simple words – do more – should be repeated to very stakeholder. These two words are flexible, however. Doing more in the peak hours may mean one thing, while doing more in the off-peak or for multiple user groups may mean entirely different strategies.

You only need to review the themes for previous conference to see how far we have come. The theme from one of the first conferences was *HOV Lanes – A New Alternative*. The theme from the third conference in Minneapolis was *HOVs – Coming of Age*. The theme for this conference is *HOVs – Evolution or Revolution*.

Many of the presentations at this conference focused on how to enhance the operation of HOV facilities. I think these presentations reinforce the notion that we are continuing to strive to do things better.

One term that was used a few years ago was “build it and they will come.” Another comment you might have heard previously was “if a project is justified, you can always find funding.” One final comment you might have heard was “if you were not sure, let’s call it a demonstration.”

I am also surprised that, as we look back, many of the things we thought were going to be revolutionary turned out to be just bumps in the road. At the time, many people thought that what happened with the Santa Monica Diamond Lane or the two HOV lanes in New Jersey were going to be revolutionary. Looking back, both did not result in major changes to HOV lanes throughout the country. Every one of the bumps helped the local areas look at things more innovatively and creatively.

Those projects were challenges, but they were also opportunities. The use of buffers really came out of questions raised by different groups in southern California. There are many more opportunities that will emerge from the challenges we face. It will be years from now before we know the outcome of these opportunities.

The use of advanced technologies also holds numerous opportunities. We have smarter roadways and better use of technologies. We also have much more knowledge about performance measures and operations.

Providing mobility is at the core of HOV lanes, managed lanes, BRT, and other approaches. Change is inevitable. It is how we manage and embrace change that is important. I encourage you to keep your eye on the prize as you deal with change in your area. Thank you.

HOV Systems Track

Monitoring and Applying Performance Standards

Kevin Haboian, Parsons Transportation Group, Moderator

HOV Midday Use: A Surprising Finding from Recent Performance Monitoring

Chuck Fuhs
Parsons Brinckerhoff

Mr. Chuck Fuhs discussed the use of HOV lanes during the midday. He summarized the results of recent studies in Los Angeles, Orange County, and Seattle that show relatively high levels of midday use of the HOV lanes in those areas. Mr. Fuhs covered the following points in his presentation.

- Currently, approximately half of the concurrent flow HOV lanes in the country operate 24-hours a day, seven days a week (24/7). All day operations are most typical in southern California and the Puget Sound region. Both areas have extensive systems of HOV lanes.

- A recent examination of the HOV lanes in Orange County, California, sponsored by the Orange County Transportation Authority (OCTA), showed high levels of midday use. Weekday midday volumes on the HOV lanes averaged 750 vehicles an hour. Weekend midday volumes in the HOV lanes averaged 1,500 vehicles.

- The HOV Performance Study sponsored by the Los Angeles County Metropolitan Transportation Authority included extensive data collection activities on use of the HOV lanes in the county. Weekday midday HOV use levels averaged around 750 vehicles an hour, although there was variation among the different facilities.

- The ongoing monitoring studies of HOV lanes in the Puget Sound region records midday utilization levels. Although variation exists, the average midday use is 700 vehicles an hour.

- For all the three areas, weekday off-peak use of the HOV lanes averages 30 to 50 percent of daily use. Weekend midday use levels are higher than on weekdays. It appears that during the off-peak times the main benefit from using the HOV lanes is trip time reliability rather than travel time savings. In most cases, these off-peak benefits are not accounted for in project planning.

- These results indicate a number of trends worth considering. First, there may be generational acceptance fueling reliance on HOV lanes. Second, trip time reliability, in addition to travel time savings may cause spatial shifts. Third, these results may provide more justification to expand HOV hours of operation or to maintain 24/7 operation.

Central Puget Sound Freeway HOV Lanes Hours of Operation Evaluation

Charlie Howard
Washington State Department of Transportation

Mr. Charlie Howard discussed the HOV lane hours of operation study conducted by the WSDOT. He summarized the background to the study, the analysis process, the study results, and the anticipated next steps. Mr. Howard covered the following points in his presentation.

- The HOV lane hours of operation analysis was initiated at the request of the Washington House Transportation Committee. While WSDOT periodically reviews the performance of the HOV system with stakeholders, this study provided an extra focus on the hours of operation. There is currently a high level of public interest in the HOV operating hours.

- The HOV hours of operation analysis was initiated in March 2002. The technical analysis was completed in August 2002. The Puget Sound Regional Commission (PSRC) HOV Policy Advisory Committee provided comments on the analysis in October 2002. WSDOT staff will present the study conclusions to the Transportation Commission in November 2002. A public comment period will be provided from November 2002 to January 2003.

- The analysis was designed to address two specific questions. The first question addressed how the HOV lanes are currently performing. The second question examined the feasibility of opening the HOV lanes to general-purpose traffic during the off-peak periods.

- Specific segments of the Puget Sound region freeway HOV system were analyzed in the study. Segments included in the study were I-5 North between Northgate and South Everett; I-405 from Bellevue to Lynnwood; SR 520 from Bellevue to Redmond; I-90 from Bellevue to Issaquah; I-405 from Tukwilla to Bellevue; SR 167 from Auburn to Renton; I-5 from South Des Moines to Seattle; I-90 from Seattle to Bellevue; and SR 520 from Medina to Bellevue.

- A number of facilities were not considered due to operational limitations. The facilities not being considered include arterial HOV lanes; HOV bypasses at ramp meters; freeway HOV queue jumps; Sound Transit direct access ramps; and specific segments of SR 520, I-90, and I-5.

- A number of work tasks were completed as part of the study. Reports were prepared on these elements, which included HOV and general-purpose lane usage, HOV lane travel time and reliability performance, transit and vanpool operations, safety/operations issues, environmental considerations, experience in other states, financial obligations and impacts, costs, and public attitudes and opinions.

- Four preliminary alternative hours of operation were explored. The first option was to open the HOV lanes to general-purpose traffic at night from 8:00 p.m. to 5:00 a.m. The second alternative was to allow general-purpose traffic to use the HOV lanes during the midday from 9:00 a.m. to 2:00 p.m. The third option was to open the HOV lanes to general traffic on weekends. The fourth option was to open the HOV lanes when the general-purpose lanes are not congested. Under this option corridor-specific HOV operating hours would be established based on facility performance.

- The analysis examined the use of the HOV lanes during the peak and off-peak hours. During the weekday peak periods, the HOV lanes provide a travel time advantage in all corridors. The HOV lanes are most heavily used during peak commute times. The HOV lanes move more people, generally, than the adjacent general-purpose lanes during peak periods. The HOV lanes on SR 167 and I-90 do not currently move more people than the general-purpose lanes, but use is growing. The HOV lanes on SR 520 work well as a limited shoulder bypass, largely for transit. It is the only HOV lane that requires 3+ occupancy. In general, the HOV lanes do not perform as well in the “reverse commute” direction.

- The HOV lanes do not provide a travel time advantage between 8:00 p.m. and 5:00 a.m. The HOV lanes experience a decrease in volume after the evening peak and use drops during the midday in all corridors. The use of HOV lanes on weekends tends to mirror general-purpose lane conditions.

- Transit use of the HOV lanes was examined and the effect on transit of opening the lanes to general-purpose traffic was explored. In general, transit service and ridership decrease dramatically after 8:00 p.m. and the HOV and general-purpose lanes flowing freely after this time. Transit travel speed and reliability could be affected in high volume locations during the midday if the HOV lanes were opened to general traffic. Transit ridership and service levels on the weekends are far below weekday levels. A high percentage of vehicles using the freeways are HOV eligible on weekends.

- The possible effects on vanpools from opening the HOV lanes to general-purpose traffic were examined. The freeway HOV system is an important factor in encouraging vanpooling in the region. Approximately 90 percent of vanpools operate during the peak hours. Vanpool use is growing in the region.

- The possible effects on safety and operations were explored in the study. The analysis indicated that there would be a negligible affect on merging collisions if direct access ramps remained restricted to HOV traffic only. The potential for an increase in run-off-the-road collisions could be offset by safety improvements.

- The environmental analysis indicated that the environmental impacts of opening the lanes to general-purpose traffic was minor or non-existent. No air quality conformity issues are anticipated. PSRC modeling of air quality indicates negligible increases in emissions, which would be well within the regional emissions budget. Air quality impacts must be documented for federal and state regulatory agencies. No commitments from prior freeway HOV projects have been found that would preclude part-time HOV lane operations. The I-90 operating agreement would require concurrence from signatory agencies if a change is proposed for I-90.

- The assessment examined the experience in other sates with HOV operating hours. This assessment showed that both peak hour and all-day HOV policies are used. Large metropolitan areas with extensive interconnected systems tend to have uniform HOV policies, either all 24/7 or all peak-period. Larger systems tend to have few system-wide changes. Changes in HOV operating policies have usually been toward less restrictive policies.

- The funding and financial effects of opening the lanes were examined in the study. The assessment found that FHWA must agree with changes in major HOV lane operation. It appears that no FHWA sanctions would be imposed as long as HOV lanes are reserved for HOVs during the peak hours. The FTA formula funding would not be lost with peak hour HOV lane operation. Sound Transit has expressed concern about their investment in direct access ramps.

An estimate was made of the costs associated with new signing and other changes necessary to implement part-time HOV operations. A total of $6 million was estimated for implementing opening the HOV lanes at nights and on weekends. Approximately $2 million of this amount would be for fixed signs and $4 million would be for safety improvements. Opening the

HOV lanes during the midday may require additional safety improvements and additional funding. More sophisticated signage, like dynamic signs, required to open lanes to all traffic whenever conditions allow would cost much more, with estimates upwards of $55 million.

- Public attitudes toward HOV lanes were examined in the study. Maintaining the HOV lanes during commute hours enjoys overwhelming support. Public opinion on opening the HOV lanes to all traffic in off-peak hours is sharply divided. People who drive alone are more likely to favor opening HOV lanes to all traffic during off-peak hours.

- According to a 1999 household survey conducted by PSRC, 42 percent of the respondents disagreed that the HOV lanes should be open to all traffic during the off-peak hours, while 46 percent agreed. A 1999 panel survey conducted by PSRC found that 40 percent disagreed with only enforcing the HOV lanes during the peak periods, while 48 percent agreed. Surveys of HOV lanes users conducted by the Washington State Transportation Center (TRAC) at the University of Washington annually from 1994 to 1998 found that slightly over 80 percent disagreed that the HOV lanes should be open to all traffic. Surveys of single-occupant vehicles over the same period included less support for opening the HOV lanes, with approximately 60 percent disagreeing that the HOV lane should be open to all traffic.

- There was more support among both user groups to opening the HOV lanes during non-commute hours. Approximately 40 percent of the HOV lane users support opening the lane in non-commute hours, while slightly over 40 percent disagreed. Approximately 60 percent of the single-occupant drivers agreed with opening the lanes during non-commute periods, while a little over 40 percent disagreed. Responses to the 1999 PSRC household survey indicated that 37 percent of the respondents agreed that more HOV lanes were needed, while 32 percent disagreed, 28 percent were neutral, and three percent did not respond.

The study results will be presented at the November 2002 Transportation Commission. Action may be taken by the Commission at that time. A public comment period would follow any proposed action. Final Commission action would probably occur in early 2003. The Legislature would have to fund the costs associated with changing the hours of operation.

Options for HOV Lane Performance Monitoring, Data Collection Analysis, and Reporting
Mark Hallenbeck
Washington State Transportation Center

Mr. Mark Hallenbeck discussed HOV lane performance monitoring. He described why it is important to monitor the performance of HOV facilities, the types of data that may be available, and other resources that may be used to obtain additional information. He noted that there is no formal HOV performance monitoring conducted at the national level. Mr. Hallenbeck covered the following points in his presentation.

- The basic need is to monitor HOV facility use and performance over time. Common elements examined include vehicle use, person use, travel speeds and travel times, and trip time reliability. Some of the measures typically of interest include a comparison of HOV and general-purpose travel times, the on-time performance of buses, changes in mode split, and changes in vehicle-occupancy levels. Other items of interest may include public attitudes, accident rates, and violation rates. Use levels during different times of the day, on weekends, and during special events may also be of interest.

- Performance monitoring programs should provide for the collection of adequate information at the lowest cost. Monitoring programs should allow for comparison to be made between modes and strategies to be made, as well as the tracking of policy decisions. A number of data types and sources are used in most performance monitoring programs. Data on vehicle volumes, vehicle speeds, occupancy levels, transit ridership, incidents, and public attitudes are frequently collected.

- Permanent counters are typically used to collect vehicle volumes. Permanent counters provide information on variation over time, which is key for understanding the public's real experiences. Vehicle volumes for both HOV lanes and general-purpose lanes are needed. Loop detectors or other technologies such as cameras may be used. Freeway management data may be available in some areas that can be used. Transit operators may maintain records of bus volumes and ridership and changes in the number of buses and passengers over time.

- Data collection locations are important. Usage varies by location and facility performance varies by location. The effects of congestion and merging on data accuracy and utility must be considered.

- Existing detectors may be able to be used to provide speed and travel time data. They may also help provide a picture of the frequency and the location of congestion. Other speed and travel time data sources may also be available. These include data from transit automatic vehicle location (AVL) systems and probe vehicles with global positioning systems (GPS) or toll tags. Travel time runs represent another technique to collect travel time information.

- In examining speed and travel time data consideration must given to corridor travel times compared to detailed segment-by-segment travel times. Permanent, routine data collection is needed to learn about reliability, variation from day-to-day, and the influence of special events.

- Collecting vehicle-occupancy data is staff intensive. Limiting the number of locations can help reduce costs and maintain consistency. Locations should be carefully selected to ensure the ability to see and the safety of personnel. Data collection locations should also be representative of the corridor. It is best if the transit ridership can be obtained from the transit authority. It is important to remember that vehicle-occupancy is a highly variable number. The same count program can provide the measurement of compliance or the violate rate.

- Mode split is another important performance measure. Person volume is equal to vehicle volume data plus vehicle-occupancy data plus transit ridership data. Comparisons of HOV person volumes to person volumes in the general-purpose lanes are typically made.

- Accident and incident information is also desirable. Data on the time of the occurrence, the duration of occurrence, and the location of occurrence is beneficial. This data is often difficult or impossible to obtain.

- Information on special event traffic including the time and the location of the event and any special transit services is of help. Public attitudes are typically measured through surveys. Approaches may include random surveys of area residents, on-board surveys of bus riders, and surveys of HOV and general-purpose lane users. HOV users and motorists surveys are typically conducted by recording vehicle license plate numbers and sending mail out/mail back surveys. Infractions, such as the number of tickets issued or calls to HERO programs, may also be part of ongoing monitoring programs.

HOV Project Case Studies

Chris Wellander, Parsons Brinckerhoff, Moderator

The Twin Cities HOV Study

Paul Czech, Minnesota Department of Transportation
Krista Jeannotte, Cambridge Systematics

Mr. Paul Czech and Ms. Krista Jeannotte discussed the results of an HOV study conducted in the Minneapolis-St. Paul metropolitan area. The study, which was mandated by the Minnesota State Legislature during the 2001 legislative session, was conducted to determine the potential effects of opening the HOV lanes in the area to general traffic. The study, which was conducted by Cambridge Systematics for the Minnesota Department of Transportation (Mn/DOT), was completed from September 2001 to March 2002. Mr. Czech and Ms. Jeannotte covered the following points in their presentation.

- The study examined the HOV lanes on I-394 to the west of downtown Minneapolis and I-35W to the south of Minneapolis. The I-394 facility includes both two-lane reversible barrier separated HOV lanes and concurrent flow lanes. Concurrent flow HOV lanes operate on I-35W. A 2+ vehicle-occupancy requirement is used on both facilities and the HOV lanes operate in the peak hours.

- In 2001, the Minnesota State Legislature directed Mn/DOT to study the effects of opening the HOV lanes to general traffic and to report the study findings during the 2002 legislative session. The legislation specifically prohibits Mn/DOT from physically opening the lanes if it will jeopardize federal funding.

- The HOV study objectives were to estimate the impacts of opening HOV lanes to all vehicles using a non-intrusive approach, which did not actually open the lanes to all drivers. The impacts included those on the I-394 and I-35W exiting carpool segments and on the region as a whole. Other study objectives included the compilation of research regarding the benefits and costs of HOV lanes, identifying the public's perception of opening the HOV lanes, researching congestion pricing, and reporting and documenting results for the 2002 legislature.

- A number of major findings emerged from the study. First, the study results indicate that the HOV lanes are not operating at their full potential during the entire morning and afternoon peak periods. Second, when congestion is at its peak, the HOV lanes are moving more people than the general-purpose lanes. Third, the situation is forecast to be similar in the future, but the model does not account for many potential changes. Fourth, the lanes do provide significant time, reliability, and cost savings to users. Fifth, opening the lanes would result in a net positive benefit/cost ratio, but total one-time costs range from $40 to $41 million or approximately $4.7 to $6.4 million annually. Sixth, the lanes experience high violation rates due to design constraints on enforcement. Seventh, users of the lanes are highly supportive, non-users have mixed views, and no group favors opening the lanes to general-traffic.

- The study included a number of recommendations. The first recommendation was to continue to reserve the lanes for HOVs and to maintain long-term advantages for transit and carpools. The second recommendation was to apply the lessons learned to existing and/or

new lanes related to enforcement, design, and eligibility.

- The I-35W HOV System consists of 5.7 miles northbound from Burnsville Parkway to 86th Street and 7.5 miles southbound from 66th Street to Trunk Highway 132. There are plans to extend both the north and the southbound lanes to 46th Street in Minneapolis. The HOV lanes operate in both directions weekdays from 6:00 a.m. to 9:00 a.m. and from 3:00 p.m. to 6:00 p.m. All traffic may use the lanes at other times. Unlike I-394, the non-peak direction is still restricted to HOVs during the hours of 3:00 p.m. to 6:00 p.m.

- The I-394 HOV System consists of 10.4 miles eastbound from CR 101 to I-94 and 8.8 miles westbound from I-94 to Carlson Parkway. Approximately three miles are reversible, barrier separated lanes, and the remainder is concurrent flow HOV lanes. The HOV lanes operate eastbound weekdays from 6:00 a.m. to 9:00 a.m. and westbound from 3:00 p.m. to 8:00 p.m. All traffic may use the concurrent flow HOV lanes at other times, but not the reversible lanes. Operating hours for the reversible lanes are eastbound from 6:00 a.m. to 1:00 p.m. and westbound from 2:00 p.m. to Midnight.

- Violation rate counts were conducted on both facilities as part of the study. Violation rates on the barrier-separated lanes on I-394 were 6 percent eastbound in the morning at Penn Avenue, 12 percent in the afternoon westbound direction. The violation rates on the concurrent flow facilities on I-394 and I-35W ranged from a low of 19 percent on I-394 to a high of 41 percent on I-35W.

- An analysis was conducted of the peak period travel time and mode shift impacts without HOV lanes in 2000 and 2020. Travel times for carpoolers and bus riders on both I-394 and I-34W would increase if the HOV lanes were open to all traffic. Travel times for single-occupancy vehicles on both I-394 and I-35W would decrease if the HOV lanes were open to all traffic. Some 6 percent of bus riders would change modes on I-35W if the HOV lanes were open to all commuters and 11 percent would change modes on I-394. A total of 21 percent of the carpoolers would change modes if the HOV lanes were open to all commuters.

- A benefit/cost analysis was conducted to examine the cost of opening the HOV lanes to all traffic. This analysis indicated that there was a positive benefit/cost ratio to opening the lanes to all traffic in 2000 and 2020. The benefit/cost ratio was examined with and without having to pay back federal funding used to construct the HOV lanes.

- Surveys of HOV lane users were conducted in both corridors. The results indicate that the sample was mobile, as well as educated, with high income levels. Most of the respondents were between 18 and 49 years of age. Between half and three-fourths of the sample was college educated. There was a high level of vehicle ownership, with a majority owning two or more cars. Nearly half to two-thirds of the sample report an annual household income greater than $65,000. Downtown Minneapolis is the destination of choice for bus and carpool riders. Travelers in the general-purpose lanes and random population samples had more varied destinations.

- Individuals were asked if they thought the HOV lanes should be continued, modified, or opened to all traffic. On I-35W, 67 percent of the carpoolers and 62 percent of the bus riders using the lanes favored continuing current operations, compared to 27 percent of the random survey respondents and 16 percent of the single-occupancy vehicle drivers. The random respondents and single-occupant travelers were more likely to favor modifying the operation

of the lanes or opening them to all traffic. On I-394, 75 percent of the carpoolers and 72 percent of the bus riders favored maintaining the current operations compared to 27 percent for both travelers in the general-purpose lanes and the random sample.

- A total of 11 percent of the bus riders on I-394 and 6 percent of the riders on I-35W responded that they would change modes if the HOV lanes were discontinued. Some 16 percent of the carpoolers on I-394 reported they would change to driving alone and 8 percent said they would change to taking the bus if the HOV lanes were discontinued. A total of 15 percent of the carpoolers on I-35W said they would change to riding the bus.

- The main conclusion from the surveys was that people who use the lanes like them; people who do not use the lanes are much more mixed in their views. I-35W commuters are in general less supportive than I-394 commuters. Most people who carpool and ride the bus do so for cost and time savings. Most people who do not carpool or take the bus believe they cannot do so for jobs, family, or other reasons. There is not clear-cut support for any specific modification strategy. Any change would require major educational and marketing efforts. Removing the HOV requirement would result in some mode shifting but less than predicted by the model.

- At a national level there are some 2,500 miles of HOV lanes in North America. Lane miles are expected to double in the next 25 years. On average HOV lanes carry 3,400 to 4,000 persons/lane. The Minneapolis HOV lanes carry about 2,300 to3,000 persons/lane. Violation rates are in the 10 to13 percent range, which is lower than in the Minneapolis experience.

- Keys to successful HOV projects appear to include high level of congestion, strict enforcement, and few alternate routes. Synergy with parking, transit, and ridesharing policies, trip reduction ordinances, and public and policy maker support are also important. The most significant deployment of HOT lanes are in California, with SR 91 and I-15. These two projects appear to have high usage, low violation rates, increasing popular support, and minor income disparities among users.

- The major recommendations from the study were to preserve the lanes for HOV use to continue to provide advantages for transit and carpooling. The second recommendation was to consider the lessons learned in designing new lanes and opportunities. These elements include the increase use of barrier separation, providing left shoulder enforcement areas, increasing violation fines, adjusting hours of operation, using lanes during major incidents, making geometric improvements at access/egress points, and developing strategies for increasing person throughput including HOV lanes.

- Mn/DOT and HOV stakeholders are in the process of jointly developing an HOV Operations Management Plan that will comprehensively evaluate options for improving the HOV system including hours of operations, law enforcement, geometric improvements, types of vehicles allowed, and marketing.

HOV Experience in the Portland, Oregon and Vancouver, Washington Region
Chris Christopher, Washington Department of Transportation
Dennis Mitchell, Oregon Department of Transportation

Mr. Dennis Mitchell and Mr. Chris Christopher discussed the pilot HOV lane project on I-5 in

the Portland/Vancouver metropolitan area. They described the design and operation of the lanes, the current performance of the lanes, and the experience to date. They highlighted the following points in their presentation.

- The Vancouver I-5 southbound HOV lane complements the Portland northbound HOV lane. The lanes provide commuters with faster and more reliable trips between home and Portland employment centers. Additional HOV lanes are being considered in the area.

- There are eight goals for the Vancouver HOV lane. These eight goals are moving more people per lane, travel time reduction, minimize impacts to other traffic, increased use of HOV modes, maintain safety, provide adequate enforcement, provide HOVs with travel time reliability, and maintain and improve public opinion. Currently five of these eight goals are being met. The HOV lane is not currently moving more people per lane, although use levels have been increasing. It is also providing only partial travel time reductions and public opinion appears mixed.

- The experience with the Vancouver HOV lane points out the importance of park-and-ride facilities to the success of HOV projects. The hours of operation are also important. The project also illustrates the importance of the support and involvement from local policy makers.

- A decision on the future of the Vancouver HOV lane on I-5 should be made by the end of the year. One question will be what should be done if the decision is made to dedesignate the HOV lane. Other topics that may need to be considered are allowing the system to mature and considering HOT lanes.

- There are four goals for the HOV lanes on I-5 in Portland. These goals are to increase person throughput, reduce peak period travel time for HOV users, understand public opinion regarding HOV lanes, and maintain current levels of traffic operations.

- The experience with the HOV lanes in Portland highlights the importance of enforcement, addressing operational concerns, and public support. Enforcement issues include providing adequate funding and personnel for effective enforcement. Operation issues focus on safety concerning incidents and transitions for the lanes. Public support can be determined through surveys and violation rates.

- There are also some issues that must be addressed by both states. These concerns include the limitations of the I-5 Bridge over the Columbia River and the hours of HOV operation.

HOV System Implementation Plan for the Atlanta Region
Carol Carter, Parsons Transportation Group

Ms. Carol Carter discussed HOV projects and activities in the Atlanta region. She described the Georgia Department of Transportation (GDOT) HOV System Implementation Plan that is under development. She summarized the study background, the scope of work, the development of HOV systems guidelines, and the HOV project analysis, ratings, prioritization, and implementation strategy. She noted the assistance of Mr. Tommy Crochet, McGee Partners, with the presentation. Ms. Carter highlighted the following points in her presentation.

- The provisions for HOV lanes in Atlanta were included in the reconstruction of the

downtown freeways in the mid 1980s. None of the designs were implemented, however. Thirty-eight miles of two-way concurrent HOV lanes were implemented in preparation for the 1996 Olympics on I-20, I-75, and I-85. The lanes on I-85 were extended for 12 miles. The expansion of the HOV system is an integral part of the current 2025 Atlanta Regional Transportation Plan (RTP).

- This study was undertaken in response to a number of issues. First, air quality non-attainment restrictions indicated a need for greater investment in alternative modes. Second, increased traffic congestion and longer commutes have become a way of life in the region. Third, recommendations are needed for 2030 RTP Update. Fourth, extended and updated HOV facilities are needed to compliment expanded regional bus service. Finally, the Governor's Transportation Choices Initiative announced in 2001 emphasizes alternative modes, included accelerating expansion of the HOV lane system.

- The scope of work included a number of tasks. Major activities included conducting a multi-city scanning tour of HOV facilities, developing guidelines for the system implementation, identifying needed projects, and prioritized these projects. Further, for each project identified, the typical section, access locations, and access types were determined, and cost estimates and schedules were prepared. The major environmental impacts were also identified for each project. The two final tasks were to develop enforcement guidelines and to develop a financially sound implementation plan.

- The development of the HOV system guidelines was led by the Texas Transportation Institute. National experience and a national HOV scanning tour of Dallas and Houston, Texas and Orange County and San Diego, California, were used to assist with this task.

- Seven HOV system goals were identified. These goals are to reduce and manage traffic congestion; to improve air quality; to maximize the use of carpools, vanpools, and transit; to ensure integration with transit; to attain positive public perception; to plan for a complete HOV system that is integral and critical to the entire transportation network; and to maintain the integrity of general use lanes. The measures of effectiveness (MOEs) associated with these goals focus on person throughput, travel time reliability, travel time savings, vehicle occupancy, violation rates, and accident rates.

- A level of service (LOS) HOV warrant was also developed. The warrant is a LOS E and/or 50 percent of the posted speed in the general lanes for a minimum of one hour, four out of five days. The warrant also includes providing a travel time savings of a minimum of one minute per mile and at least a total of five minutes of time savings. For HOV lane operation, a LOS is C on four out of five days is acceptable. If the acceptable LOS is exceeded, consideration should be given to adding capacity or increasing vehicle occupancy requirements.

- Typical sections were developed for different types of HOV facilities. Reversible lanes were identified for use only where the directional split is greater than 60-40. Further, reversible lanes were recommended for consideration in constrained areas. Barrier separation was identified as the most desirable for separation between HOV and general use lanes. Buffer separated lanes with vertical delineators were identified as acceptable, pending test studies. Striped buffers with concurrent flow lanes were identified as a minimum. The designs should include flexibility for expansion, reconfiguration, and other possible changes.

- Access guidelines were also developed. Access point locations should be consistent with land use in the area and preference should be given for transit connections. Direct access ramps and slip ramps are desirable. HOV direct access to transit facilities and park-and-ride lots should be strongly considered.

- HOV access considered for terminal treatments and intermediate points included direct merge access and slip ramps. Direct access ramps, such as drop ramps, t-ramps, flyover, wishbone, and y-ramps were examined. System-to-system ramps were also explored.

- The HOV system enforcement guidelines included development of a maximum violation rate of six percent, which is the existing guideline. Provisions for enforcement should be included in the design of an HOV facility. Other enforcement guidelines focus on incorporating ITS into all HOV facilities, reviewing legislation to address enforcement issues, and using a comprehensive monitoring program.

- Project prioritization was accomplished by a consensus of planners and engineers in partnership with GDOT, FHWA, the Atlanta Regional Commission (ARC), and the Georgia Regional Transportation Authority (GRTA). A total rating was developed for each project based on planning ratings, constructability ratings, and other RTP projects in the corridor. Interim project rankings were prepared in February 2002. Final prioritization is due in December 2002, with projects prioritized by tier. The rating categories in planning included peak-period congestion, connections to major activity centers, system connectivity, transit and express bus connectivity, travel time savings, and safety. Rating categories for constructability were available right-of-way, typical cross-section considerations and costs, bridge replacements, and environmental impacts.

- The implementation plan will include a series of recommendations for phasing the HOV projects, which will be listed by tiers in order of priority. Elements of the implementation program beyond the scope of this study included refining the typical cross-section and access design during the project development process, a detailed enforcement plan, and the data collection, monitoring and reporting on the measures of effectiveness. Marketing and education efforts are also beyond the scope of this project. Strong partnerships will be required between GDOT, FHWA, GRTA, transit agencies, enforcement agencies, and the judicial system for the success of HOV facilities in the Atlanta region.

San Francisco Bay Area HOV Lane Master Plan
Bill Loudon
DKS Associates

Dr. Bill Loudon described the development of an HOV Lane Master Plan for the San Francisco Bay Area. He noted the assistance of Doug Kimsey, Metropolitan Transportation Commission, with the project. Dr. Loudon summarized the project purpose and background, described the evaluation of system performance and the HOV lane speed estimation process, and highlighted the study recommendations.

- HOV lanes have been in operation in the San Francisco Bay Area since the 1980s. Most lanes operate with a 2+ vehicle-occupancy requirement, although some use a 3+ requirement. The lanes allow continuous entry and exit and operate with the HOV designation only during the peak-periods.

- This project represents the third HOV master plan for the Bay Area. The first plan was completed in 1990 and a second plan was undertaken in 1997. In 1990 there were four HOV facilities in the region, accounting for about 60 lane miles. By 1997, HOV lanes were in operation on nine freeways, accounting for some 260 lane miles. Both lane miles and use levels have increased since 1997.

- The current planning effort re-evaluated the policies relating to HOV facilities in the area. Vehicle occupancy requirements, hours of operation, enforcement practices, and opportunities for value pricing were all examined. Assessing possible system expansion was also a major focus of the study. Potential expansion includes gap closures, new corridors, express bus networks, and supporting facilities. The study further examined the air quality effects of the HOV lanes including maximum benefits, variation by alternatives, and policy implications.

- Five key performance measures were used in the study. Lane use was measured by HOV eligible vehicles and people per hour. Lane productivity was measured by HOV lane people per lane per hour compared to the mixed flow lanes people per lane per hour. Travel time benefits were measured by time savings per mile. Violate rates were examined. The final measure examined user characteristics and attitudes.

- The performance of the HOV lanes in the area varies. The vehicles per hour in 2001 ranged from a high of slightly over 2,000 on US 101 to a low of about 600 on SR 4. There are four HOV lanes that carry between 4,000 to 5,000 persons per hour. There are 11 HOV facilities had lane productivity indexes above 1.0, while three were at 1.0 or below. The I-880 HOV lanes save users the greatest amount of time, approximately 2.6 minutes per mile. Only the HOV lanes on SR 4 do not provide travel time savings. Violation rates range from a low of 2 percent on US 101 to a high of 11 percent on I-880. A total of 10 of the 14 HOV lanes have violation rates lower than 4 percent.

- The California Highway Patrol (CHP) is responsible for enforcement of the HOV lanes. There are few enforcement areas or shoulders on most of the HOV lanes. Enforcement is conducted by regular safety patrols, plus targeted supplemental enforcement. Caltrans funds the overtime pay of two officers for the supplemental enforcement. There is no electronic surveillance or ticketing and only limited citizen reporting.

- Survey results indicate that some 78 percent of the HOV lane users are making work trips. The survey results also indicate that 60 percent of the carpools are comprised of family members. The HOV lanes are important factors in the decision to carpool, with 69 percent indicating that the HOV lanes greatly influenced their decision to rideshare.

- A number of recommendations for further analysis emerged from the study. First, the need to move to a 3+ occupancy requirement over the next 20 years was identified. Second, the need to expand the hours of operation as appropriate to a consistent maximum was recommended. Third, photo surveillance was recommended for further consideration as a supplemental enforcement tool. The fourth recommendation was to consider low-cost HOT lanes as an interim measure when shifting to a 3+ occupancy requirement. Expanding the Bay Area express bus network was also recommended. Finally, expanding the HOV system and support facilities was recommended.

- Currently, 98 additional miles of HOV lanes are included in the Transportation Improvement

Program (TIP) and 139 HOV lane miles are included in the Regional Transportation Plan (RTP). The recommendations from the 2002 HOV Master Plan include 70 new HOV lane miles, new freeway-to-freeway HOV connections, and three new direct access ramps. Other recommendations include two major on-line freeway express bus stations and 17 new minor express bus stations and park-and-ride lots.

Performance and Policy in Southern California

Darren Henderson, Parsons Brinckerhoff, Moderator

Overview of Southern California HOV Activities

Darren Henderson
Parsons Brinckerhoff

Mr. Darren Henderson provided an overview of recent HOV-related activities in southern California. He described the exiting HOV system, recent legislation influencing HOV facilities, and current performance studies and monitoring efforts. Mr. Henderson covered the following points in his presentation.

- The HOV system in southern California developed rapidly during the 1990s. Currently, there are approximately 715 lane miles of HOV facilities in operation in southern California. The HOV system is only partially completed, with more projects underway. The HOV lanes in the area typically operate on a full-time basis. The concurrent flow lanes are separated from the general-purpose lanes by a buffer. A 2+ occupancy requirement is used on all but one facility. Performance and policy questions have been raised recently by the legislature and other groups.

- Recent legislation has focused on HOV operations. Some measures have passed, while others have not. Senate Bill 63 lowered the occupancy requirement on the El Monte Busway to 2+ and Assembly Bill 769 changed it back to 3+ during the peak-periods. Assembly Bill 1871 recommends part-time HOV operation on SR 14. Assembly Bill allows Inherently Low Emissions Vehicles (ILEVs) to use HOV lanes. Senate Bill 545 requires evaluating HOV lane performance. Assembly Bill 2582 would allow paratransit vehicles to deadhead in HOV lanes, and Assembly Bill 44 would convert all HOV lanes to mixed-flow.

- Much of the recent interest in HOV lanes was generated by a report from the Legislative Analyst Office (LAO). The report suggested that many HOV lanes are operating below capacity and that air quality benefits from HOV lanes are unknown. The report also suggested that the HOV lanes are not being adequately evaluated. In addition, questions have been raised over variations in operating policies. There has been some negative media coverage related to the HOV facilities in the area.

- Caltrans has an ongoing HOV monitoring program. The Caltrans districts in southern California prepare annual reports on HOV facilities that includes data on vehicle volumes, occupancy levels, violation rates, and travel times.

- The Los Angeles Metropolitan Transit Authority (MTA) recently sponsored the development of an HOV performance program for the county. The four major elements of the study included establishing an ongoing monitoring program, identifying the benefits accrued to date from the HOV lanes, assessing the impacts of the HOV facilities, and developing policy recommendations.

- One of the first activities of the MTA HOV performance program was to refine the goals and objectives for the HOV lanes in the county. The five major objectives for the HOV facilities focus on increasing person movement capacity, encouraging carpooling and transit use, providing travel time savings, providing air quality benefits, and promoting cost

effectiveness.

- Measures of effectiveness were defined for each of the objectives. Data collection activities were begun to obtain the information needed to assess the measures of effectiveness. Information was collected on physical characteristics, vehicle volumes, occupancy levels, travel times, violation rates, transit use levels, and public attitudes. Data limitations had to be addressed for some of the measures.

- The performance of the HOV lanes was assessed based on survey results, mobility measures, cost-effectiveness, and air quality. The study, including data collection and analysis, was coordinated with Caltrans and other agencies.

- A number of key findings emerged from the study. First, there is widespread support for HOV lanes in the county. Second, all of the HOV lanes in the county provide travel time savings to users. Third, the HOV lanes move more people then general-purpose lanes and encourage carpooling. Fourth, the HOV lanes are a good investment. Fifth, many HOV lanes are nearly full. Finally, the HOV lanes help air quality.

- The Southern California Association of Governments (SCAG) initiated a related HOV study in three other counties in the region. This study builds on the MTA performance program by examining HOV facilities in Orange, Riverside, and San Bernardino counties. It will be used to help guide region-wide HOV policies.

- The Orange County Transportation Authority (OCTA) recently completed an HOV operations policy study. This study reviewed HOV performance, addressed policy variations, identified best practices, and developed a decision-making framework. Key findings from the study included high peak utilization, high off-peak/weekend utilization, and extremely low violation rates. The implications of changing HOV operating policies were also identified.

- In general, the HOV lanes in southern California are popular with travelers and are a good investment. Media coverage has improved recently. The HOV facilities are being expanded and gap closures and connectors are being prioritized. An ongoing performance monitoring program is in place and the agencies are committed to review operational policies as necessary.

Southern California HOV Performance and Policy – Caltrans Perspective
Antonette Clark
California Department of Transportation

Ms. Antonette Clark discussed the HOV performance monitoring conducted by Caltrans in Southern California. She also highlighted Caltrans activities related to responding to legislative directives and other program. She covered the following topics in her presentation.

- Caltrans and other transit agencies continue to focus on maximizing the performance of investments made in the state's roadways, while preserving safety and promoting cleaner air. HOV facilities represent one approach being used to respond to growing traffic congestion, declining mobility levels, and air quality and environmental concerns. Caltrans tries to communicate to the public that HOV facilities are not the single solution to those issues, but they are part of the solution.

- A comprehensive and coordinated system of related strategies is needed to combat traffic congestion. In addition to HOV facilities, other elements include BRT, ramp metering, park-and-ride lots, transit hubs, on-line stations, freeway-to-freeway connectors, drop ramps, and other facilities.

- Ongoing dialog about HOV effectiveness and the vision for HOV facilities is needed. With the turnover in elected officials, ongoing information programs and one-on-one dialogs are needed. Improved public information and education is also a need.

- Caltrans HOV operation policies vary between northern California and southern California. Freeway commute patterns differ widely throughout the state with respect to level of congestion, length of the peak and off-peak periods, and number of peak periods in the day. Maintaining consistent HOV hours of operation on a corridor basis as well as a region-wide basis are needed to avoid motorist confusion.

- Studies and demonstration projects have shown that full-time HOV operations provided greater benefits in relieving the rate of congestion, providing rideshare incentives, and making enforcement easier. As a result, HOV lanes in southern California typically operate on a full-time basis, although part-time demonstration projects are being investigated.

- Conversely, areas with commute patterns generally consisting of two short definable peak commute periods separated by a long midday off peak traffic period do not meet the basic traffic criteria for full-time HOV operations. As a result, HOV lanes in northern California are more likely to operate during the peak-periods.

- Formalizing a team of regional HOV stakeholders who would meet on a regular basis would benefit southern California. This group could agree on a set of performance measures and monitor the results of ongoing data collection and analysis studies. A statewide focus would be less helpful as conditions vary greatly across the six major metro areas in California.

- A number of things could be done to improve data collection and performance monitoring. First, there is a need for consistent and more accurate continuous loop data. Second, consistent and regular analysis of data, trends, and measures of effectiveness would help. There is also a need for automated violation enforcement systems. Additionally, there is also a need for calibrated air quality models to accurately measure HOV air benefits.

- Caltrans is conducting a number of activities to maximize the efficiency of HOV lanes, including expanding public information efforts. Immediate strategies include press releases, HOV facility grand openings, showcasing of study findings, more HOV information on maps, and the HOV information on the Internet. Longer-term strategies include public surveys and public information campaigns. Caltrans is conducting studies to encourage transit utilization and recently completed a park-and-ride/HOV facility 5-Year Master Plan and Program of Projects.

The Los Angeles County Metropolitan Transportation Authority HOV Performance Program
Ray Maekawa
Los Angeles County Metropolitan Transportation Authority

Mr. Ray Maekawa summarized recent HOV monitoring activities conducted by the Los Angeles Metropolitan Transportation Authority (MTA). He highlighted the recently completed HOV Performance Program. Mr. Maekawa covered the following points in his presentation.

- The MTA recently reorganized into six area teams. Each team is responsible for multimodal planning and programming within a specific geographical area. Although each area has approximately 2 million people, the development patterns and nature of the areas are very different.

- The MTA sponsored an HOV Performance Program study. The study was part of the ongoing development of the HOV system in the country. This effort provides a systematic and technical basis for completion of the HOV system. Developing an HOV planning and marketing program to selectively increase transit ridership and ridesharing is another important activity. Establishing an ongoing monitoring and evaluation HOV program represents another key outcome of the study.

- Although the MTA provided the funding, the study represented a joint effort of the MTA and Caltrans District 7. Caltrans staff provided assistance with data collection, analysis, and establishing an ongoing monitoring program. The study was more than just a one-time snapshot of the performance of the HOV system. The ongoing monitoring and evaluation program is a key element of the study. The study also examined ways to improve the HOV system.

- The study also included surveys of HOV lane users, motorists in the general-purpose lanes, and area residents. Interviews were also conducted with key stakeholders. Even though data indicates that the HOV lanes in the county are meeting the identified objectives, there are still people who question their effectiveness. Ongoing information programs are needed to help continue to educate people on the benefits of HOV facilities.

HOV Cost Effectiveness
Brent Baker
Parsons Brinckerhoff

Mr. Brent Baker discussed the HOV cost effectiveness analysis conducted as part of the MTA HOV Performance Program. He described the analysis methodology and some of the key findings. Mr. Baker covered the following points in his presentation.

- Cost-effectiveness has many different meanings. For the Los Angeles study, a benefit-cost analysis was conducted to help assess if the HOV lanes were a good economical investment. A benefit-cost model developed for Caltrans on a different project was used in this study. The Cal BC model is the standard used by Caltrans to evaluate projects.

- Usually, a benefit-cost analysis is conducted to assess the feasibility of alternatives of a project. This study involved a change in perspective of looking backwards at completed projects to assess if they were good investments. The analysis involved looking backward and predicting what the situation would have been without the investments. Since HOV lanes are often directional specific, the model also had to be adjusted to account for this factor.

- A total of 15 HOV segments were evaluated in the cost-benefit assessment. The data requirements are typical of benefit-cost models and include items such as capital, maintenance, and enforcement costs. These costs were escalated to 2000 dollars. The time period used in the model is the conception duration and a benefit period of 20 years. Benefits were only measured for the peak period. The analysis of net present value had to consider that the lanes had different construction years and different construction year dollars. Other input data included project length and lane configuration; Average Daily Traffic (ADT) before construction, the opening year, and the first full year of operation; the current year; and the percent of trucks. A forecast was also developed for the opening year and the opening year plus 20. The actual growth in traffic was used for the period of time from the opening of the lane to the present. The MTAs travel demand forecasting model was used to project forward; using the assumption that HOV traffic would grow at the same rate as general traffic. The other inputs were the duration of the peak periods, HOV volumes, Average Vehicle Occupancy (AVO) before and after the project.

- A conservative approach was taken in considering possible benefits. The benefits included in the assessment were travel time savings, operating cost savings, and impacts on the general-purpose lanes. Possible safety and air quality benefits were not considered in the analysis. Induced demand was also not considered.

- Typical benefit-cost evaluation measures were used in the study. These evaluation measures included net present value, economic rate of return, and benefit-cost ratio. A new measure, the year of economic feasibility was created for the study. This measure represents the year that the present benefits of lanes exceed the project cost or the year the benefit-cost ratio is greater than one. Approximately half of the HOV lanes in the study have already passed their year of economic feasibility. Some 14 of the 15 projects had benefit-cost ratios in excess of one. One segment of the I-110 HOV lane did not have a benefit-cost ratio greater than one. This facility had a benefit-cost ratio of about 0.9, largely due to high capital costs.

The Santa Monica Diamond Lane Evaluation
John Billheimer
Systan, Inc.

Dr. John Billheimer described the evaluation conducted on the Santa Monica diamond lane project in 1976. He summarized the project, the evaluation, and some of the results. Dr. Billheimer covered the following points in his presentation.

- The Santa Monica HOV lane, called the diamond lane, was implemented in 1976. The

project, which converted a general-purpose lane into an HOV lane, was strongly criticized in the media and by local politicians. As a result, Caltrans rescinded the HOV-designation after 22 weeks of operation.

- The evaluation of the project showed that there were benefits from the HOV designation. The freeway carried three percent fewer people in 10 percent fewer vehicles and the corridor carried one percent more people in five percent fewer vehicles during the project. Carpools with three or more people increased by 65 percent, bus ridership more than tripled, and travel speeds in the diamond lane were faster and more consistent.

- The evaluation also showed there were numerous negative effects from the diamond lanes. Accident rates increased, motorists in the general-purpose lanes lost more time than carpoolers gained, and public opinion was strongly against the project.

- The experience with the Santa Monica diamond lanes influenced the development of HOV facilities in southern California and other areas of the country. Although there are 750 miles of operating HOV lanes in southern California today, none have been created by taking an existing general-purpose lane. This trend holds true for most HOV lanes throughout the country. There are only a few examples of HOV facilities created by taking an existing general-purpose lane.

- There were some unrealized impacts associated with the Santa Monica project. There was an increased in fuel consumption shortly after the project started and no air quality improvements were documented.

- The media was critical of the project. There were frequent editorial cartoons criticizing the diamond lanes. The press conducted their own data collection activities and reported the results in stories and articles.

- There was a good deal of data collected during the project. There has also been an ongoing HOV data collection effort in southern California. A study started after the MTA project is examining the HOV lanes in Orange, San Bernardino, and Riverside counties. This study is just beginning. There appears to be a lack of data on many of the HOV lanes in these three counties. For example, Caltrans stopped collecting data on the Orange County HOV lanes in 1994 primarily because the HOV facilities were assumed to be part of the freeway system. As a result, there is little data on the impact of the HOV lanes during this period including the freeway to freeway HOV connectors. Caltrans has started completing annual reports on the HOV lanes again, but elements such as speed runs are still lacking in Orange County. Preliminary vehicle count data indicates that the HOV lanes in Orange County are carrying close to 1,650 vehicles in the peak hour. These high volumes raise a question if the HOV lanes are providing travel time savings over the general purpose lanes.

- Over the past 25 years there has been a change from a relatively few HOV lanes in southern California and a good deal of data on them to numerous projects with less available data. There has also been a change in public perceptions toward HOV lanes from the criticism of the Santa Monica project to fairly widespread support today. The media still appears to be critical of the HOV lanes at times.

Enforcement, Incident, and Event Management

Dave McCormick, Washington State Department of Transportation, Moderator

The Truth about HOV Enforcement

John O'Laughlin
PB Farradyne Systems

Mr. John O'Laughlin discussed enforcement of HOV operational requirements, including vehicle-occupancy levels. He described the goals and objectives of enforcement programs, HOV regulations, enforcement issues, staffing needs, and enforcement strategies and tools. Mr. O'Laughlin covered the following points in his presentation.

- Typical goals of HOV enforcement programs are to ensure motorist and officer safety, to provide reliable enforcement levels, and to help ensure motorist adherence with operating requirements. Typical objectives include maintaining a specific compliance rate and maintaining motorist acceptance. Other objectives may be to provide non-intrusive, but highly visible, enforcement and to maintain consistent applications.

- Enforcement focuses on ensuring that HOV operating requirements are met and not abused. Typical regulations that need to be enforced include vehicle-occupancy requirements and hours of operation.

- A number of issues typically need to be addressed in developing and carrying out an HOV enforcement program. Weather, visibility, and lighting may all be issues. Speeds, sight distances, and glide paths all need to be considered in developing enforcement areas and patterns. Enforcement approaches also need to be sensitive to avoid causing choke points, incidents, and congestion. Possible issues with seeing inside a vehicle to determine vehicle-occupancy levels include tinted windows, the use of dummies, children in carseats, and reclining passengers.

- Public information is an important element of enforcement programs. Targeting information to the news media and the public is important. The HERO self-enforcement concept has been used in some areas. The policy on public vehicle use of an HOV lane will influence enforcement approaches and the use of motorcycles or patrol vehicles will influence the enforcement techniques. Clean shoulders and emergency lights are also important elements.

- Enforcement staffing is an important consideration. Issues that need to be addressed with staffing include providing consistent coverage, providing consistent enforcement with multiple officers, and the halo effect.

- There are four basic types of enforcement strategies. These strategies are routine, special, selective, and self enforcement. A number of tools can be used to enhance these enforcement methods. These tools include video, photographs, spotters, motorcycles, and unmarked patrol cars.

- Enforcement should enhance HOV operations and effectiveness. Enforcement is also important to help ensure ongoing public support.

Incident Management in Washington State

John Bruun
Washington State Department of Transportation

Mr. John Bruun discussed the WSDOT incident response service. He summarized the mission of the service, the approaches used, the services provided, and the benefits of the program. Mr. Bruun covered the following points in his presentation.

- The mission of WSDOT's incident response service is to assist drivers and to clear roadways faster. Quick response is provided to help traffic control and to assist motorists, to reduce incident duration, and to avoid secondary collisions. The major focus of the program is on the peak traffic periods, but service is provided 24 hours a day on state highways.

- Service is provided in response to requests from the Washington State Patrol (WSP). Roving patrols also cover the freeways, especially during the peak periods. There is a 90-minute clearance goal to help reduce traffic congestion. Elements of the WSDOT incident response service include response planning, incident detection, traffic flow management, incident command and coordination, incident clearance, and staff training.

- There are 44 units statewide, 40 of these are roving units, and four are on-call units. A variety of vehicles are available to help address incidents and crashes that are blocking or impeding the normal flow of traffic. Major functions focus on traffic control and incident clearance.

- Hazardous materials response is also a service. Services that may be needed to address a hazardous materials spill or incident include traffic control, specialist for dealing with petroleum and other products, unified incident command, and control and confinement. In some cases, vehicle-to-vehicle diesel fuel transfer may be required.

- A number of services focus on helping address traffic congestion. These services include contracted service patrols, enforcement of no parking zones, the steer-it-clear-it policy, joint interagency operational agreements, and roving patrols.

- Interagency coordination and cooperation is key to the incident response program. Agencies participating in the coordinated approach include WSP, local police, local public works departments, local fire departments, and the U.S. Department of Energy. The media is also a key group for disseminating information on problems or incidents. Interagency training is provided to help ensure a coordinated approach.

- Key elements of the WSDOT incident response program are providing quick response and controlling traffic at the scene. Coordination, cooperation, and communication among agencies is critical to the success of the program. The WSDOT incident response program has been successful at clearing roads and helping drivers.

Bus and HOV System on I-278 in New York City – Pre and Post 9/11

Ed Mark
New York Department of Transportation

Mr. Ed Mark discussed the bus and HOV system on I-278 in New York City before and after September 11, 2001. He described the development of HOV facilities in the area and recent activities. Mr. Mark covered the following points in his presentation.

- In 1976 the New York City Department of Transportation implemented a concurrent flow bus/taxi lane on the Gowanus Expressway between 72nd Street and the Shore Parkway Interchange. In 1980, the New York State Department of Transportation and the Triborough Bridge and Tunnel Authority implemented a contraflow bus/taxi lane between the Prospect Expressway and the Brooklyn Battery Tunnel. In 1992, the contraflow lane was converted into a median bus/taxi lane.

- In 1996 the Gowanus Expressway bus/HOV 2+ lane was implemented. It includes a contraflow lane from 54th Street to the Brooklyn Battery Tunnel. The bus-only concurrent flow lane from 73rd Street to 65th Street was converted to bus/HOV 2+. In 1998 the bus-only ramp to the Staten Island Expressway (SIE) was opened. In 2000 the bus/HOV 2+ lane was extended to include the section from the Varrazano Narrows Bridge to 72nd Street.

- The I-278 corridor mobility system includes the Gowanus Expressway bus/HOV lane, the SIE bus lane, Staten Island park-and-ride facilities, SIE Advanced Traffic Management System (ATMS), and Commuter Link TDM services.

- The eastern portion of the SIE concurrent flow lane to the Varrazano Narrows Bridge is one mile in length. The western two-mile section is currently under design. The Gowanus Expressway contraflow lane is approximately five miles in length from 92nd Street to the Brooklyn Battery Tunnel.

- The I-278 facility operates from 6:00 a.m. to 10:00 a.m. on weekdays. It is only open to vehicles equipped with an E-Z pass, buses, taxis, vehicles with at least two occupants, and other authorized vehicles. There are a high proportion of express buses in the HOV lane. Approximately 500 vehicles use this lane in the peak hour entering Manhattan, including 275 buses. These vehicles carry approximately 16,000 passengers in the peak hour.

- The Gowanus Expressway bus/HOV lane was opened to buses and HOV 2+ vehicles from 1996 to September 11, 2001. After September 11, 2001 it was open to only emergency vehicles. It was re-opened for buses and authorized vehicles only in October 2001. On April 1, 2002 buses, HOV 3+ vehicles, and authorized vehicles were allowed to use the lane.

- Prior to September 11, 2001, approximately 1,285 vehicles used the Gowanus Expressway bus/HOV lane in the morning peak hour from 7:45 a.m. to 8:45 a.m. The vehicle mix was approximately 220 buses, 805 2+ carpools, and 180 3+ carpool. Some 3,425 vehicles were in the general-purpose lanes during the same time period. From October 2001 to March 2002 during the bus and emergency vehicle-only operation, some 510 vehicles used the lane. From April 2002 to the present, 690 vehicles use the lane in the morning peak hour, including 240 buses, 130 2+ carpools, and 110 3+ carpools. General-purpose lane volumes were 2,360 vehicle during that same period.

- A comparison of vehicle speeds on the Gowanus Expressway indicates a change before and after September 11. Prior to September 11, travel speeds in the bus/HOV lane were 34 mph, compared to 12 mph in the general-purpose lanes. During the bus-only operation from October 2001 to March 2002, speeds in the lane were 44 mph compared to 8 mph in the general-purpose lanes. With the return to bus and HOV operation from April 2002 to the present, travel speeds in the lane have been 49 mph compared to 14 mph in the general-

purpose lanes.

- Bus ridership levels have increased since the lane was opened in 1996. From 1996 to 2000, bus ridership increased by 50 percent and ridership in the months prior to September 2001 was 43,600 to 44,100. Ridership levels declined to 22,700 in September 2001, but returned to 43,881 in October 2001. Weekday ridership from January to June 2002 averaged between a low of 43,910 and a high of 47,279. From May 2001 to May 2002, weekday express bus ridership from Staten Island increased 7 percent from 34,127 to 36,511 and ridership from Brooklyn increased 10 percent from 8,961 to 9,866.

- A number of enhancements to the I-278 mobility system are planned. First, an extension of the bus median shoulder concurrent flow lane to Slosson Avenue with exclusive bus entry ramps is in the planning stage. Second, expansion of the Staten Island park-and-ride facilities is planned. Currently, there is one lot with 190 spaces. There are two lots, with 400 spaces, under construction and four lots with 410 spaces are in the planning stage. These additions will bring the total number of lots to seven and the total number of parking spaces to approximately 1,000.

- There are arterial bus enhancements underway to support BRT implementation and integration. Elements include the Church Street Busway in Lower Manhattan, new BRT shelter designs and passenger amenities, arterial street bus priority and signal prioritization connecting to I-278 to the bus lane, multimodal transfer facilities, and multi-agency partnerships to develop a highway/local street BRT system.

- The bus/HOV system elements on the I-278 corridor are being implemented by NYSDOT working closely with other agencies. The I-278 bus/HOV mobility system is being built section by section as opportunities and resources become available. Cooperation among agencies and stakeholders, as well as a system orientation, have been critical elements in the process. Improving mobility on an ongoing system permits a more effective and flexible operation in both emergency situations and under normal conditions.

Evaluating HOV in Salt Lake City, Utah
Joseph Perrin
University of Utah

Dr. Joseph Perrin discussed the HOV lanes in Salt Lake City. He noted that Mr. Peng Wu and Mr. Peter Martin assisted with the evaluation information presented. Dr. Perrin provided an overview of the HOV lanes in Salt Lake City and the results of the recent monitoring efforts. Dr. Perrin covered the following points in his presentation.

- Utah's first HOV lanes were opened on I-15 in May of 2002. The 16 miles of concurrent flow HOV lanes are separated from the general-purpose lanes by paint stripes. A 24/7 designation is used on the HOV lanes, which are opened to 2+ carpools, vanpools, buses, and motorcycles. There are also HOV ramps at some locations.

- HOV lanes have been implemented throughout the country to maximize the person-carrying capacity of existing freeways, offering travel-time savings and trip reliability benefits. However, their performance is often controversial. The Utah State Department of Transportation (UDOT), in conjunction with the University of Utah and Mountain Plains Consortium, conducted a two-year study, which began before the HOV lanes opened and

continued throughout the first year of operation. The research objectives were to measure the effectiveness of HOV lanes by comparing them with national experience and to recommend any changes to the existing HOV operations policies or procedures.

- The study employed two types of evaluation methods, With/Without and Before/After. Several measures of effectiveness were used including vehicle and passenger volumes, travel-time savings and trip reliability, violation rates, and AVO.

- A variety of data sources were used in the study. Volume and speed data were obtained from the automated traffic monitoring system (ATMS). These data were supplemented by manually obtained volume and speed information and an AVO survey, travel time runs, and violation rate surveys were conducted. The morning peak-period is 6:30 a.m. to 8:30 a.m. northbound and the afternoon peak-period is 4:00 p.m. to 6:00 p.m. southbound.

- During the morning peak-period the HOV lanes carried 52 percent fewer people and 76 percent fewer vehicles than the general-purpose lanes. In the afternoon peak-period the HOV lane carried the same number of people in 56 percent fewer vehicles as the general-purpose lanes.

- The percentage of vans and buses on the HOV lane is higher in the general-purpose lanes. The express buses operated by Utah Transit Authority (UTA) use the HOV lane during the peak periods. Buses comprise 2.5 percent of traffic on the HOV lanes, and only 0.1 percent of traffic on the general-purpose lanes. Buses carried 27.6 percent of the people on the HOV lane and one percent of people in the general-purpose lanes.

- The Salt Lake City Winter Olympic Games were the largest Winter Olympic Games ever held. The Olympics included 78 events. Over 1.5 million tickets were sold for the Olympic events and over 500,000 visitors attended the games. These numbers created unprecedented travel needs in the area. The I-15 corridor with the HOV lanes played an important role in moving people for the Olympic Games. During the Olympic Games northbound vehicle volumes in the HOV lanes increased by 16 percent, while volumes in the general-purpose lanes increased by 3 percent. In the southbound direction HOV volumes increased by almost 19 percent, while volumes in the general-purpose lanes increased by only 4 percent.

- The national average AVO declined from 1.4 in 1977 to 1.14 in 1995. The AVO on I-15 with HOV lanes increased from 1.1 to 1.3, while the AVO decreased slightly on freeways without HOV lanes.

- Vehicle travel speeds on the HOV lanes are higher than speeds in the general-purpose lanes throughout the day. During the afternoon peak-period, the average speed on the HOV lane is 63 mph, which is significantly greater than the 51.5 mph on the general-purpose lanes. On average, HOV lane users experience a travel time advantage of nearly seven minutes during the afternoon peak-period over the adjacent general-purpose lane users.

- Violate rates vary by location and by congestion levels. The HOV ramps have the highest violation rates. The violation rates are higher during the afternoon peak-period when congestion is worse. The highest violation rates were experienced during the first month of operation. Violation rates decreased from 24 percent in July 2001 to 18.7 percent in July 2002.

- The HOV lanes provide a 30 percent travel time savings during the afternoon peak-period and a 13 percent time savings during the morning peak-period. The advantages of the HOV lanes generated new carpoolers, raising the AVO in the I-15 corridor from 1.1 to 1.3. During the two hour afternoon peak-period, the HOV lanes move 3,671 persons, the same number of persons as each general-purpose lane carries, but with only 44 percent of the vehicles. During peak-periods, however, the violation rates exceed the national norms. At the selected HOV on-ramp, violation rates exceeded 20 percent. Along the I-15 corridor the violation rates range from 5 percent to 13 percent. The Salt Lake experience shows that the HOV lanes are successful in their current operations. As the congestion in the area increases, it is anticipated that the HOV lane value will also increase.

Direct Access – The Puget Sound Experience

Jim Edwards, Sound Transit, Moderator

Jim Edwards provided background information on the Regional Express direct access projects. He noted that the projects included five direct access facilities in east King County, two facilities in south King County, and three ramps in Snohomish County. The Lynnwood direct access project in Snohomish County involved the design and construction of a "T" ramp to provide direct access for buses and carpools between the Lynwood park-and-ride lot at 44th Avenue SW and the HOV lanes on I-5. The Renton HOV improvements in east King County included constructing an HOV interchange on I-405 at North 8th Street and evaluating the feasibility of HOV improvements in south Renton. The Mountlake Terrace in-line station project in south King County involved constructing an in-line station at I-5 and 236th Street SW with a pedestrian connection to the Mountlake Terrace park-and-ride lot. The estimated capital cost for the 10 facilities is approximately $425 million in 2003 dollars. Construction on the projects started in 2002 and all facilities should be completed by 2007.

Evaluation of TSM and TDM Alternatives of Sound Transit HOV Direct Access Program

Chris Wellander
Parsons Brinckerhoff

Mr. Chris Wellander discussed the evaluation of Transportation System Management (TSM) and TDM alternatives to the Sound Transit HOV direct access program. He recognized the contributions of Andrea Tull, Sound Transit; Kathy Leotta, Parsons Brinckerhoff; and Scott Rutherford, University of Washington on the project. Mr. Wellander covered the following points in his presentation.

- Voters in the Puget Sound region approved the Sound Move program. The major elements of the program are commuter rail, LRT, and regional express buses. The regional express program consists of regional express bus services, HOV direct access ramps, and community connection projects, which include transit centers and park-and-ride lots.

- The HOV direct access program includes 14 HOV direct access ramps in two counties. The total estimated budget in 1995 dollars was $370 million. The direct access ramps address one of the primary Sound Move objectives, which is to improve speed, reliability, and ridership on public transportation in the central Puget Sound region. The HOV direct access ramps are effective at improving bus speed, reliability, and ridership. Sound Transit also wanted to assess alternative TDM/TSM strategies to examine if these approaches could provide similar benefits at lower costs.

- The Sound Transit TDM/TSM Study included three major activities. These activities were a systems level assessment, a sub-area case study, and extensive committee involvement. Groups involved in the process included local, regional, and state agencies, environmental and public interest organizations, and businesses. The purpose of the systems level analysis was to assess system wide effectiveness of direct access ramps and to compare the costs of direct access ramps to equivalent expenditures by sub area of TSM and TDM alternatives. The study examined two alternative TDM emphasis options and a TSM emphasis option, along with a baseline option.

- The baseline alternative included the HOV direct access program outlined in Sound Move. The analysis indicated that this alternative provided significant benefits compared to the no-build scenario. The option generated some 431,000 additional daily transit trips, accounting

for a 51 percent increase.

- The main elements of the TDM alternative included increased transit service, decreased transit fares, additional park-and-ride lots, and added buses and services to maintain headways. The TSM alternative include arterial street HOV lanes, transit signal priority, signal queue-jump lanes for buses, increased transit service, additional park-and-ride lots, and added buses and service to maintain headways.

- A number of criteria were used in the analysis. These criteria included quantitative and qualitative measures. The FTA new starts criteria measures from *NCHRP Synthesis 201: Multimodal Evaluation in Passenger Transportation* and elements reflecting local interests and conditions were all applied in the analysis. The Sound Transit model was used to estimate ridership and travel time impacts. Results from previous studies were reviewed and a weave impacts analysis was conducted. Qualitative measures were also identified based on input from the study committee.

- The systems analysis results indicated that the HOV direct access ramps perform better than the TDM and TSM alternatives with respect to transit speed and reliability. The TDM option performed slightly better than the direct access ramp in terms of ridership, while the TSM alternative performed slightly worse.

- The purpose of the case study analysis was to demonstrate and document how a TSM/TDM alternative at a project or sub-area level could be developed and evaluated. The Ash Way/Swamp Creek area was selected for the analysis focusing on HOV direct access ramps to two separate park-and-ride lots. There were four alternatives developed that were compared to a no-build baseline. The four options were an HOV direct access alternative, a TSM alternative, a flyer stop TSM alternative, and a TDM alternative. The same criteria used in the systems level analysis was used in the case study analysis.

- The case study conclusions suggested that HOV direct access ramps provide greater travel time savings and trip reliability for this sub area. The TDM alternative encouraged higher transit ridership.

- The overall study findings and recommendations indicated that system-level HOV direct access ramps are effective. A prototypical approach for sub-area or project-level analysis was recommended. Policies for consideration by the Sound Transit Board were also recommended.

Direct Access Design Issues
Denise Cieri
Washington State Department of Transportation

Ms. Denise Cieri discussed the HOV Direct Access Design Guide. She summarized the background to the development of the guide, HOV access types and locations, direct access geometrics, traffic design elements, and design resources. She noted the assistance of Mr. Theodore Focke, WSDOT, with the presentation. Ms. Cieri highlighted the following points in her presentation.

- The guide addresses the design of highway facilities that provide direct access for HOVs between HOV lanes and flyover stops, transit centers, park-and-ride lots, and other facilities. It supplements the current Design Manual and provides guidance for the design of left-side

access facilities and other HOV access facilities with extremely limited width constraints. The current manual addresses right-side access, which is the traditional freeway access location.

- The chapters in the guide cover references, definitions, HOV access type and location, direct access geometrics, passenger access, and traffic design elements. HOV access types and locations covered include freeway connection locations, ramp terminal locations, ramp types, transit stops, and enforcement areas.

- Direct access geometrics include design vehicles, design speeds, sight distance, ramp widths, on-connections, off-connections, vertical clearance, flyer stops, and "T" ramps. Different approaches are available to examine the access point decision process. The approaches include the FHWA eight points, the WSDOT process, and the Sound Transit template.

Direct Access Design Case Study – Kirkland
Manuel Feliberti
David Evans and Associates

Mr. Manual Feliberti described the HOV direct access design case study in Kirkland. The project is located in the I-405/Totem Lake area of Kirkland. He noted the assistance of Mr. Thomas McDonald, David Evans and Associates, with the presentation. Mr. Feliberti covered the following points in his presentation.

- The existing design of I-405 includes six general-purpose lanes and two HOV lanes. There is no bridge at NE 128th Street. There are two transit flyer stops at NE 132nd Street. The Kingsgate park-and-ride lot is located west of I-405. The Totem Lake area is characterized by commercial development.

- The proposed project would provide direct access ramps at NE 128th Street and at NE 124th Street. The design of the direct access ramps would include new bridges over the freeway at both locations and ramps from the center of the bridges to the HOV lanes on I-405. Transit stops could be provided on the bridges.

- A number of potential issues and elements are examined in the study. These elements include design and operational issues associated with the access ramps. The impact of the ramps on the operation of the local street system was examined, as it was a significant concern to the local area.

Community Coordination Case Study
Eric Widstrand
David Evans and Associates

Mr. Eric Widstrand discussed the community coordination process with the HOV direct access studies. He summarized the groups involved, the decision-making process, the Kirkland Case Study, and the operational issues examined. He covered the following points in his presentation.

- Stakeholder groups involved in the direct access projects included Sound Transit, WSDOT, local transit providers, and local jurisdictions and communities. The transit agencies in the region include King County Metro, Community Transit, and Pierce Transit.

- The decision-making process included a number of steps. The NEPA/SEPA process, with

focuses on the purpose and need, scope, and budget, was followed. The project management team and technical staff were involved throughout the process. An executive advisory committee, comprised of elected officials and public agency representatives, was also involved. Public involvement was accomplished through a number of methods.

- The Kirkland case study included an HOV direct access ramp to the I-405 HOV lanes, a new bridge over I-405 with queue jump lanes, and connections to two streets on either side of I-405. A proposed pedestrian/bike corridor over I-405, which was included in the Kirkland Comprehensive Plan, was also examined.

- Operational issues examined in the case study included level of service at key intersections, queuing between intersections, turning movement operations, bus stops on bridge, bike lanes, pedestrian access, and enforcement.

- The case study results highlight the need to create a win-win solution. The project was coordinated with the Totem Lake Master Plan. Elements emerging from the involvement process were to allow general-purpose traffic on the bridge at all times, to prohibit left turns eastbound and westbound at Totem Lake Boulevard, and to provide bus stops on the bridge, a pedestrian walkway between Kingsgate park-and-ride, and in-line flyer stops. A memorandum of agreement would provide for the ongoing monitoring of traffic operations.

Developing the HOV Market

Jeanne Acutanza, CH2M Hill, Moderator

Estimating Changes in Travel Habits From HOV Lane Implementation

Chuck Green
Parsons Brinckerhoff

Mr. Chuck Green discussed a recent study conducted in the I-5 corridor in the Portland, Oregon, and Vancouver, Washington region. The study was conducted by Parsons Brinckerhoff for WSDOT and the Oregon Department of Transportation (ODOT). Mr. Green covered the following points in his presentation.

- The study examined travel behavior changes of users of the I-5 HOV lanes between Vancouver and Portland. Possible travel behavior changes include changes in mode choice, route choice, and trip scheduling.

- Current use of the I-5 HOV lanes includes 340 vehicles and 1,020 persons in the peak hour in Vancouver. Peak hour use in Portland is 900 vehicles and 2,600 persons. Groups surveyed included HOV lane users in Portland, C-TRAN bus riders using the HOV lane in Portland, and commuters in the HOV lane in Vancouver. Responses include 388 Portland HOV lane users, 609 C-TRAN riders, and 200 Vancouver HOV lanes users.

- Of the Vancouver respondents, 21 percent indicated the HOV lanes had changed their commute habits, while 70 percent reported it did not. The changes reported were change in route or travel pattern (43 percent), carpool (24 percent), leave earlier or later (21 percent), change work schedule (7 percent), and take the bus (5 percent).

- Of those individuals reporting a change in travel behavior, 28 percent indicated their travel time was faster than before the HOV lane, 12 percent reported slower travel time, and 62 percent reported no change. Of those indicating no change in their travel behavior, 13 percent reported faster travel times, 53 percent noted slower travel times, and 34 percent reported no change.

- Of the Vancouver respondents reporting a change in behavior, 40 percent favored permanently adopting the HOV lane, while 57 percent did not favor it, and 3 percent had no opinion. Of the respondents not reporting a change, 51 percent favored a permanent HOV designation, 47 percent did not support it, and 2 percent had no opinion.

- A total of twenty-two percent of the C-TRAN riders indicated they were taking the bus due to the HOV lanes.

- The survey results in Vancouver indicated that 21 percent of the respondents changed travel habits and that the HOV lane contributes to mode shift. Changes in work schedule or trip time were the most frequently noted change. There was some change in travel route.

- The survey results of the bus riders and HOV lane users in Portland indicate the HOV lane did change travel habits. There was a slight increase in bus use and a significant increase in carpool use. Changes in trip schedule or route were also reported. More than half of those surveyed reported a change in travel habits due to use of the HOV lane.

- The overall survey finding seems to indicate that Vancouverites are more likely to change habits than do Portlanders. It also appears that there is a significant likelihood to affect travel habits if the HOV lane is eliminated. There appears to be significant support for the HOV lane.

- The overall findings indicates that the HOV lanes have changed travel habits, that both have changed mode split, that travel times and work schedules have been affected, and that both have effected change in travel routes.

The Rideshare Group – Catalyst for HOV Advancement
Andrea Maillet
King County Metro

Ms. Andrea Maillet discussed the Rideshare Group, which provides ridesharing services in the Puget Sound region. She described the mission of the group, the services offered, and current projects. She noted the assistance of Syd Pawlowski, the Rideshare Group, with the presentation. Ms. Maillet covered the following points in her presentation.

- The mission of the Rideshare Group is to foster, encourage, and enable ridesharing. Sharing rides can save time, money, and other limited resources. Ridesharing can help traffic flow and can be used for commuting and for other trips. It can help address air and water quality concerns and it can enhance accessibility. Ridesharing can assist with employment and training opportunities, and it can help in disasters and other emergencies.

- There are a number of services and activities that focus on enabling shared trips in the Puget Sound region. These activities include RideshareOnline.com, CarPool, VanPool, VanShare, Rideshare Plus, custom bus services, community vans, the HERO program, and incentives to promote sharing rides. Coordination among agencies and groups further support regional ridesharing activities.

- RideshareOnline.com is an on-line commuter ride matching system provided through a regional partnership. The extensive database is continuously updated. The system can be used by employers or by individuals. It also provides event matching capabilities.
- CarPool Services offers a comprehensive program that includes ridematching, a guaranteed ride home (GRH) program, park-and-ride and park-and-pool facilities, and preferential parking for carpools. Carpool registration and verification services are provided.

- The Puget Sound region has one of the largest vanpool programs in the country. Currently, approximately 671 vans are in operation in the area. The average monthly fare for vanpools in the region is $58. Over 2.8 million passenger trips and 10 million vehicle miles are saved through the vanpool program. Vanpools use the HOV lanes extensively.

- VanShare is a demonstration connecting HOV modes, including commuter trains, express routes, and ferries. It also promotes bicycling. Reserved parking for HOVs at park-and-ride lots is provided.

- Rideshare Plus partners include employers and local jurisdictions. It is known as the employer's best friend. Services include ride matching, data analysis, and personalized follow-up. HOV lanes in the area provide a significant incentive for carpoolers.

- Custom express routes can be developed and operated to serve major employers and independent schools. Customer Bus provides premium priced services, which rely heavily on the HOV lanes.

- Community vans serve seniors, disabled individuals, employers, and employees. They can be used for special, shared, or business transportation. All of these approaches support HOV lane use.

- The HERO program is a partnership of the local transit agencies, the WSP, WSDOT, and communities. The program focuses on educating HOV lane violators. The HERO program has public support. The HERO program enhances HOV lane viability.

- A variety of improvements to existing programs and new activities are planned for the future. Planned enhancements include more on-line resources and a greater emphasis on retaining current carpoolers and vanpoolers. Expanding and improving support systems and services is underway. Regional promotions and broader outreach activities will also be undertaken. The HOV lanes are a key element to the success of these efforts.

Successful TDM for HOV Access
Jonathan Dong
City of Bellevue, Washington

Mr. Jonathan Dong discussed the City of Bellevue's involvement in promoting carpooling, vanpooling, riding the bus, and using the HOV lanes in the area. He summarized the interest of local communities in increasing HOV use. He described Bellevue's goals for HOV lanes, the approaches being used to encourage ridesharing, current activities, and upcoming challenges. Mr. Dong covered the following points in his presentation.

- Bellevue uses a number of approaches to help develop HOV markets. Regulations that support HOV use include land use and zoning ordinances, transportation concurrency regulations, and the state Commute Trip Reduction law.

- The City provides numerous services and facilities that support transit, vanpooling, and carpooling. Examples of these services and facilities include transit centers, regional and local transit services, HOV direct access ramps, and ridematching services.

- Bellevue is active in promoting transit, ridesharing, and HOV facilities in the area. Recent marketing efforts include the Access Downtown Rideshare campaign, the One Less Car campaign, and the BRAVO campaign.

- The City is exploring areas for further improvements to existing programs and new activities. These efforts include making HOV alternatives more competitive with driving alone and changing citizens' attitudes about ridesharing and transit. Other activities focus on increasing employer support for TDM, restricting parking for commuters, and providing additional incentives for HOV travel.

- New initiatives to increase HOV use are underway. One initiative focuses on expanding the commute trip reduction requirement to a larger commuter audience, including residential sites. A second initiative is working to make new developments more transit-oriented. Increasing marketing efforts, including improving web technology, are also underway. The transit Flexpass program is also being expanded city wide.

CommuterLink: Alternative Transportation Management
Ed Mark
New York Department of Transportation

Mr. Ed Mark discussed CommuterLink, which provides TDM services in New York City. He highlighted the types of programs provided, the benefits of different services, and plans for future activities. Mr. Mark covered the following points in his presentation.

- CommuterLink provides a wide range of services. These services include carpool formation assistance, door-to-door commute transit itineraries, and a guaranteed ride home program. Transit advocacy and improvement services include providing assistance with flexible work hours, telecommuting, parking incentives, business relocation, and on-site commuter programs. CommuterLink also manages the Ozone NY Action Plan, the *It Adds Up to Cleaner Air* program, and the TransitCheck program.

- Outreach efforts include on-site employee assistance, community events, and public service

announcements. CommuteLink maintains an Internet site (www. COMMUTERLINK.com) and an ozone alert Internet site (www.OZONENY.org). Billboards, changeable message signs, and other outdoor signs are used to promote ridesharing and bus use, and to notify the public of ozone actions.

- Specific outreach efforts are targeted toward implementing the New York Ozone Action Plan. The plan is a ground-level ozone pollution awareness effort encompassing New York City, Long Island, and the Hudson Valley. Marketing includes direct mail, radio spots, billboards, print ads, an Internet site, community presentations, cinema slides, and gas pump ads. Middle school air quality curriculum with activities was also developed. Partnering businesses have increased from 39 to over 300 in the 2002 ozone season.

- CommuterLink provides a wide range of on-site assistance. CommuterLink staff meet with business and public agency personnel, providing free transit maps and schedules, answering questions, and providing promotional giveaways. Interested employees complete a short application for free commuter services. The applications are processed, and the requested information is then mailed, faxed, or e-mailed to the employees. Computerized ridematching services are provided. Commuter transit itineraries are developed providing up to date, door-to-door directions using transit from home to work for each applicant. Commuter transit itineraries include the latest transit maps and schedules.

- After September 11, 2001, unsolicited carpool applications increased 19 fold for September, and nine fold for October. The average monthly Internet and phone applications increased to 220 in September and 100 applications were received in October. Incoming toll-free calls increased 47 fold in September and 13 fold in October. The average monthly calls increased from 15 to 700 calls in September and to 190 in October. CommuterLink continues to act as one of the clearinghouses for information on the revised single-occupancy vehicle ban. Internet site visits also tripled in September.

- The I-278 Mobility Project implemented a 2+ HOV lane to lower Manhattan at East River Crossings below 30th Street. The project resulted in a 73 percent increase in carpool applications since it was instituted compared to the first 5 years of TDM marketing. Transit applications over the same period showed an increase of 70 percent. For the first month and a half after September 11, carpool applications increased eight fold while transit applications increased four fold.

- Concentrated marketing efforts on the I-278 Mobility Project included a direct mail campaign targeting lower Manhattan businesses, providing CommuterLink services and contact information in E-Z Pass monthly statements, working with transportation agencies to display posters at tolled river crossings, and advertising TDM services in selected local newspapers. Other efforts underway include expanding highway rideshare signs throughout New York City, concentrating on planned construction locations. Broadcasting construction updates to member businesses is also planned, along with a Mobility Solutions campaign, on-line ridematching, the New York City Commuter Enhancement services, and the Environmental Protection Agency (EPA) Commuter Choice Leadership Initiative.

Expanding HOV Lane Use for Express Buses
Joe Story
DKS Associates

Mr. Joe Story discussed the role well-designed bus service can play in enhancing the effectiveness of HOV facilities. He highlighted research demonstrating the benefits of express buses using HOV lanes. He described the experience with express bus services in the I-80 Corridor and surrounding areas of the East Bay Region. Mr. Story covered the following points in his presentation.

- Research demonstrates the benefits of express bus use of HOV lanes. HOV lanes are designed for speed and reliability. They provide buses with faster travel times, especially when direct access maps and ramp meter bypasses are provided. Shorter dwell time for buses may also be accomplished by enhancing fare collection through the use of passes and other techniques.

- Examples from existing operations illustrate the beneficial relationship between HOV lanes and express bus services. The HOV lane and access ramps on Route JX from the Hercules park-and-ride lot to the Del Norte BART Station allow buses to travel 10 miles in approximately 16 minutes. Service is provided on 15-minute headways. Currently, buses carry some 37 passengers per hour. Route 300 from the Hillcrest park-and-ride lot to the Bay Point BART Station provides an example of buses operating in congested mixed-flow traffic. It takes buses 34 minutes to travel 10 miles on this route. Service is provided on 30-minute headways. Ridership is seven passengers-per-hour.

- Providing good connectivity is a challenge for many non-BART transit trips. Buses traveling from San Pablo to downtown Martinez, a distance of 18 miles, take almost 100 minutes. Buses traveling from downtown Martinez to Bishop Ranch, a distance of 19 mines, take 81 minutes. In both cases, passengers may wait 25 to 60 minutes for connecting buses.

- An express bus expansion plan was begun to provide input to the sales tax reauthorization efforts. The current sales tax expires 2008. Regional analysis recommended express bus expansion, as BART expansion is costly and longer-term. The state provided a one-time allocation to add express bus services in the Bay area.

- Information on demographics, existing conditions, service options, origins and destinations, cost, ridership, support facilities, and service effectiveness were examined in the development of the express bus expansion plan. Financial models, operator roles, fares, and phasing were also explored. Housing and employment distribution, travel patterns, park-and-ride lot constraints, and HOV and transit center access issues were all examined.

- An enhanced express bus scenario with support facilities was developed. Benefits and costs were developed to provide a realistic perspective on the investment required to implement the plan. Operational and capital cost estimates provided a perspective on the funding need for the plan. Capital costs elements included buses, freeway and ramp improvements, parking facilities, and ITS.

- Institutional issues that might hamper regional express bus strategies were also identified. Examples of potential institutional issues included territorial concerns and perceptions, leadership needed to integrate operations, disparities in size among large and small operations, and funding and cost sharing concerns.

Bus Rapid Transit

Integrating BRT with Freeway HOV Lanes

George Pierlott, Mundle & Associates, Moderator

Integrating Freeway and BRT Operations—Experience and Lessons Learned from Canada, New Zealand, and Australia

Sean Rathwell
McCormick Rankin

Mr. Sean Rathwell discussed the experience with integrating BRT and freeway operations in Ottawa, Ontario; Auckland, New Zealand; and Brisbane, Australia. He noted the assistance of Mr. Ken Gosselin, McCormick-Rankin, with the presentation and background work. Mr. Rathwell covered the following points in his presentation.

- The Ottawa Transitway has been in operation since 1982. HOV and BRT elements have been added to the system over the years. The Ottawa freeway BRT features include shoulder bus lanes and ramp connections. Park-and-ride lots are located at some interchanges. Direct bus access is provided to the freeway from some park-and-ride lots and the transitways. There is also a demand for service indicating system (DSIS).

- Brisbane in Southeast Queensland has a number of bus priority treatments. The Southeast Busway connects downtown Brisbane and Eight Mile Plaines. Buses also operate on the freeway from Eight Mile Plaines to Loganholme.

- The Brisbane freeway BRT allows extension of the busway rapid transit services without the need for exclusive right-of-way. Proposed system elements include online stations with direct access ramps, dedicated ramps from adjacent shopping centers, and park-and-ride facilities.

- The North Shore busway is being developed in Auckland, New Zealand. Buses currently use the shoulder lane along the freeway. In addition to transit vehicles, the North Shore Busway will accommodate a limited of HOVs.

- The Auckland freeway BRT includes shoulder bus lanes as a staging step to a busway. Insufficient width at some bridges will require buses to merge back into the general traffic lanes for short segments. Park-and-ride facilities are also planned.

- The three cases studies identify some elements to consider when integrating BRT and freeways. First, direct access from adjacent land uses and transit facilities benefits both the general-purpose traffic and buses. Direct access to the HOV or BRT facilities is essential for successful park-and-ride facilities. With shoulder bus and HOV lanes, emergency breakdowns need to be removed quickly to avoid delays. Direct access ramps can help enhance transfers to other transit services. Demand for service indicating systems can enhance bus operations and customer acceptance.

BRT Freeway Station Design: San Diego I-15 Project

Dave Schumacher
San Diego Metropolitan Transit Development Board

Mr. Dave Schumacher described the design of BRT stations that are part of the I-15 managed lanes/BRT project in San Diego. He provided an overview of the I-15 corridor and current projects in the area, the study process, and the proposed BRT station design. Mr. Schumacher covered the following points in his presentation.

- The I-15 corridor serves travelers in northeastern San Diego. The freeway includes general-purpose lanes and a two-lane reversible, barrier separated HOV facility in the center median. The study examines alternatives including reconfiguring the HOV lanes, developing BRT, and extending the LRT line.

- Both BRT and LRT alternatives were examined for the I-15 corridor. There is successful commuter express bus service in the corridor. There is a need for both short-term and long-term improvements to the system. The suburban land uses in the corridor are more conducive to BRT operations than to LRT. A decision not to convert the HOV lanes means that a separate rail right-of-way would be needed, resulting in higher capital costs.

- The conclusions from the Alternative Analysis was to pursue the HOV/BRT alternative for the short- to mid-term and to retain LRT as possible long-term strategy. The HOV/BRT alternative was seen as a multi-modal solution.

- One of the issues with BRT is how to achieve breakthrough service or how to create rail-like service with BRT. A number of elements need to be addressed in creating service comparable to rail with BRT. Elements examined in the study included:
  - Mode/Seating – Seat availability, vehicle type and design, and seating design.
  - In-Vehicle Time – Network structure, vehicle speeds, stops and dwell time, and route obstacles.
  - Access – Location, frequencies, reliability, and transfers.
  - Fare – Core affordability, value-added services, and sponsored passes.
  - Attitudes – Speed-connectivity, system look and feel, and environmental and cost-based promotion.

- Site visits were made to Houston, Ottawa, and Pittsburgh as part of the study. Ideas from the HOV and busway systems in each city were incorporated into the proposed I-15 project.

- A number of design issues were explored with the I-15 HOV/managed lanes. These issues included ensuring free-flow conditions for BRT, extending the FasTrack value pricing program, responding to traffic emergencies, and designing for long-term needs. The conclusions were to pursue a four-lane managed lanes facility with a moveable barrier, to extent the FasTrack value pricing program, and to incorporate direct access ramps and BRT stations as an integral part of the project.

- Direct access ramps and stations are being planned at Rancho Bernardo, Sabre Springs, and City Heights. Different design treatments are being used at each location. Park-and-ride lots will be incorporated into the Rancho Bernardo and Sabre Springs facilities. The City Heights facility will feature a transit plaza and station located over the freeway.

- The success of the I-15 corridor study has lead to system-wide coordinated HOV and transit plans. LRT, BRT, HOV lanes, managed lanes, and value pricing are all important elements in these plans.

Integrating HOV and BRT in the Toronto Area

Stephen Schijns
McCormick Rankin

Mr. Stephen Schijns discussed BRT planning activities in the Greater Toronto area. He provided an overview of the HOV system in the area, the approach being considered for BRT, and possible projects. Mr. Schijns covered the following points in his presentation.

- Both the BRT plan and the HOV strategy for the Toronto area are currently under development. The information presented provides a snapshop of activities today. The busway and HOV lane plans presented today are concept-level proposals only, and will be subject to refinement as they proceed further through the planning process.

- Transit is an important mode in Toronto, along with freeways and roadways. Transit mode share to the central business district in the morning peak period in 1996 ranged from 49 percent to 59 percent in the major travel corridors. Transit modes include rail, subway, LRT, and bus. Transit market shares in other corridors in the Central Toronto area range from 5 percent to 23 percent.

- The vision for BRT in the Greater Toronto area is a system of dedicated separate bus-only roadways that would be implemented in stages over a decade or more. The BRT planning strategy would utilize available transportation corridors, provide stations at intersections with major roadways and commuter rail lines, and provide connections at other major activity centers.

- The BRT system would be coordinated with HOV lanes on freeways. A variety of approaches could be used to match the opportunities and the limitations in specific corridors. Buses could operate on adjacent separate busways or they could operate in reserved bus-only lanes on freeways. Direct ramps could be provided or connections could be made via interchanges where BRT lines crossed freeway HOV lanes.

- Opportunities may exist to develop BRT roadways parallel to HOV facilities on some freeways. Busways may also be provided in the freeway median or buses could operate in shared HOV lanes. There are challenges to this approach. It is difficult to reconcile BRT needs to serve intermediate stations and park-and-ride lots with median HOV lanes. There may also be funding questions related to investing in bus priority on freeways if separate facilities are going to be constructed at a later time. Right-side bus or HOV operations may conflict with entry and exit ramps and not all freeways are able to accommodate HOV lanes. Adequate right-of-way may not be available for both BRT and HOV facilities in some corridors.

- An approach focusing on bus use of freeways also has opportunities and challenges. Opportunities include establishing precursor service and routing, lower cost and less disruption, able to implement as part of minor widening, and easier to integrate right-side bus lane operation with stations and connections at interchanges. Challenges to this approach include providing functional stations at interchanges, providing and maintaining transit priority though interchanges, providing all-direction bus movement at interchanges, and competition for use of freeway shoulder lanes.

- Providing connectors where BRT crosses HOV lanes also offers opportunities and challenges. Opportunities include the ability to retrofit controlled bus-only links, to use existing transfer points and stations, and to intercept radial services to extend the reach of the BRT system beyond existing spine corridors. Challenges to this approach include highway designs that do not protect or provide for BRT, problems and costs associated with providing all movements, and possible cost-effectiveness issues if bus volumes are relatively low.

- Opportunities associated with BRT crossing HOV lanes at freeway-to-freeway interchanges include providing stations for buses operating in all directions. Challenges include limited freeway and arterial access, the cost of retrofitting infrastructure, possible constraints on high-speed bus operation due to geometry, and the potential lack of property for park-and-ride lots.

- The development of the Toronto area BRT strategy demonstrates that where a BRT facility shares a corridor with a freeway HOV lane, the opportunities to coordinate the facilities are surprisingly limited. Stations are critical to BRT, but are difficult to accommodate with median HOV lanes. BRT operates at a high frequency in both directions, while HOV lanes are often directional. HOV lanes may sometimes be difficult to implement in the first place, without retrofitting additional BRT ramps and links. BRT station access can be a challenge for buses, park-and-ride patrons, and walk-in passengers. There appears to be little incentive to invest in direct ramps and station access if right shoulder bus lanes are to be upgraded to a separate facility in the future.

- HOV lanes can help establish the market for long-distance express bus service in a corridor, as a precursor to BRT implementation. HOV lanes on freeways that cross a BRT spine are beneficial to providing radial bus services and allowing passengers to transfer to BRT.

HOV and Transit Priority Solutions on I-90 in Seattle
Don Samdahl, Mirai Associates
Andrea Tull, Sound Transit

Mr. Don Samdahl discussed the I-90 HOV and transit project in Seattle. He provided an overview of the project, the alternatives being considered, and some of the tradeoffs between HOV, transit, and general purpose traffic. Mr. Samdahl covered the following points in his presentation.

- The two goals of the I-90 project are to provide efficient two-way transit and HOV operation on I-90 and to minimize impacts to other users of the corridor. The project involves numerous partners with multiple interests. Participants include Sound Transit, WSDOT, Metro Transit, the City of Mercer Island, the City of Seattle, the City of Bellevue, and the U.S. Department of Transportation.

- Sound Transit operates a high capacity transit program for the Puget Sound region. This system includes bus, light rail, and commuter rail. Sound Transit has regional responsibility for transit services and facilities, transit centers, and park-and-ride facilities.

- The I-90 corridor links Seattle, Mercer Island, and Bellevue. It provides access across Lake Washington for the southern part of the metropolitan area. I-90 is heavily traveled, especially during the peak periods.

- The I-90 Memorandum of Agreement, which was signed in the 1970s, stipulated the current

design of the freeway. The Agreement reduced the planned facility from 14 lanes to eight lanes. The design allowed for three general-purpose lanes in each direction and a two-lane reversible center roadway for HOVs and single-occupant vehicles from Mercer Island. The design of the current facility provides a number of challenges in considering future options. These elements include the terminus in Seattle, the curves in the Corwin area, the Rainier Avenue station and slip ramps, the Mount Baker Ridge tunnel, the Lake Washington floating bridges, and the Mercer Island access ramps.

- A number of factors are influencing the need to re-examine the corridor. First, traffic volumes are reaching 150,000 vehicles a day. Second, transit ridership continues to grow in both directions of travel. Third, the current terminus of the HOV lanes requires HOVs to merge back into the general-purpose lanes. Fourth, traffic volumes in the HOV lanes are increasing, causing delay for carpools, vanpools, and buses. The reliability of the HOV travel times has suffered as a result. Finally, HOV demand is strong and growing in both directions.

- Four alternatives are being examined for I-90. These alternatives include a no-build option, a two-way center roadway option, a transit shoulder option, and a reversible center roadway with HOV lanes on the outer roadway option.

- The no-build alternative would maintain the current design, which includes the two-lane reversible center roadway and three lanes in each direction on the outer roadway. The second alternative would convert the center roadway to two-way operation. One lane would be provided in each direction of travel and the lanes would be barrier separated. Only transit and HOVs would be allowed to use the lanes. The third alternative would widen the outer roadway to create transit-only shoulder lanes. These lanes would operate eastbound in the morning peak period using the outside shoulders and westbound in the afternoon peak period using the inside shoulder. The final alternative would add an HOV lane in each direction on the outer roadways. The lane and shoulder widths would be reduced to accommodate the HOV lanes, with incremental widening where feasible.

- There are numerous tradeoffs between HOVs, buses, general traffic, and pedestrian and bicycles in the corridor that must be considered in the examination of the alternatives. The key factors being evaluated include travel time savings, trip time reliability, person throughput, person hours, and safety.

- The second alternative, which would convert the center roadway to accommodate bi-directional travel, provides benefits for reverse peak HOVs and transit travel, but peak direction travel times would be slightly worse. New ramps would also be needed. Creating bus shoulder lanes would help peak period bus reliability, but it would put buses closer to the bicycle lanes on the Lake Washington Bridge, would not serve HOVs, and would only operate in the peak period. The last option, which would add HOV lanes on the outer roadway, would benefit transit and HOVs, but might increase the potential for incidents. It also moves traffic closer to the bicycle lanes.

- A number of safety issues are being examined with the alternatives. These concerns include the physical constraints that limit options and possible geometric compromises. The mix of user groups including HOV, transit, general-purpose traffic, pedestrians and bicycles is also

being examined. Finally, issues related to added capacity versus design compromises are being considered.

- Currently, agency staff are working to develop a consensus on the preferred alternative. Reaching a consensus involves balancing multiple interests in the corridor. Maintaining transit speed and reliability, addressing HOV needs in the reverse-peak direction, providing access for Mercer Island residents, maintaining general traffic quality, and maintaining safety are all important issues. A multi-agency steering committee is guiding these decisions. Currently, the necessary environmental studies are being completed.

Integrating BRT with Arterial HOV Facilities

Dick Hayes, Kitsap Transit, Moderator

Arterial Bus Rapid Transit for Santa Clara County

Kevin Fehon
DKS Associates

Mr. Fehon discussed BRT activities being pursued by the Santa Clara Valley Transportation Authority (SCVTA). DKS Associates is assisting SCVTA with several elements of the BRT program. He described the various project elements, which include vehicle improvements, bus stop enhancements, and traffic signal priority improvements. He also summarized the current status of BRT activities in the area. Mr. Fehon recognized the assistance of Ms. Deborah Dagang, DKS Associates, with the project and the presentation. Mr. Fehon covered the following points in his presentation.

- The major arterial street BRT project in Santa Clara focuses on the Line 22 demonstration. Line 22 is the backbone of the SCVTA route structure. The route is 27 miles long. Buses operate on 10-minute headways during most of the day. It has the highest passenger loadings of any route in the system, carrying some 23,000 daily riders. Many buses are near capacity. The route connects with the LRT system, regional rail services, and 55 other SCVTA routes.

- The vision for the demonstration project is to operate Route 22 as a BRT corridor. SCVTA is implementing a number of improvements to provide faster, more reliable service and to provide passenger amenities and better security at bus stops.

- A number of vehicle improvements are being made as part of the BRT demonstration project. These improvements focus on purchasing new higher capacity articulated vehicles, which feature doors that provide for faster loading and unloading. The buses will also be equipped with automatic vehicle location (AVL) systems.

- A number of enhancements are being made at bus stops along the route. Some bus stops will be relocated and bulbouts will be added at major bus stops. Bulbouts reduce dwell times for buses at stops. Bulbouts also provide more space for passengers waiting for buses. New bus signs and kiosks will be added. Passenger waiting shelters with a common BRT theme will be added at strategic stops.

- Improvements at signalized traffic intersections represent a second major component of the project. Improvements include traffic signal priority and bus queue jump lanes. Traffic signal priority will be provided for buses operating on coordinated routes. Priority will be applied only when a bus is late. The “window stretching” approach will be used to provide priority. Queue jump lanes, which allow buses to travel around areas of congestion, will be used at strategic intersections.

- Much of Route 22 operates on El Camino Real, which is a state highway. The signal priority includes call and checkout detectors at intersections and on-board transponders. The software was developed by Caltrans. The system uses Model 170 controllers, AB3418 protocol, and on-street masters. “Super masters” are used for data collection and management. The implementation of the signal priority system resulted from negotiations with Caltrans, and it represents the first time Caltrans District 4 has provided bus priority at signals under their control.

- An evaluation will be conducted of the Line 22 BRT demonstration project. The evaluation will focus on the effects on bus passengers, parallel traffic, and other traffic movements. The detailed scope and work plan for the evaluation has not been completed yet.

- Currently, the signal priority software and the transponders are being field tested. New buses with AVL and transponders installed are being delivered. Several queue jump lanes have been installed. The evaluation is proposed to start in the spring of 2003.

Rapid Bus or Rapid Busway on Wilshire Boulevard
John Stutsman
Korve Engineering

Mr. John Stutsman described the development of the Wilshire BRT project in Los Angeles County. He summarized the background to the project, the major elements of the system, and some of the lessons learned with the project. Mr. Stutsman covered the following points in his presentation.

- The Wilshire corridor runs from downtown Los Angeles east to Santa Monica. The corridor is approximately 13 miles in length. In June of 1999, the Mid-City/Westside Transit Corridor Study was initiated. In November 1999, local decision makers visited Curitiba, Brazil and toured the extensive BRT network there. In June 2000, metro rapid service was initiated in the Wilshire-Whittier corridor and on Ventura Boulevard. In March 2001, preliminary engineering was initiated on two options and in July 2001 the MTA Board adopted the Wilshire BRT as the locally preferred alternative. In August 2002 the final Environmental Improvement Record was approved for a peak-hour curb lane.

- The Mid-City/Westside Transit Corroder Re-Evaluation/Major Investment Study considered a number of alternatives. The study examined options in both the Wilshire corridor and the Exposition corridor. The recommendation for the Wilshire corridor was to carry forward BRT into environmental clearance to San Vicente and to continue consideration of the Wilshire subway in the Long-Range Plan. The recommendations for the Exposition corridor were to carry forward both BRT and LRT into environmental clearance to Santa Monica, with consideration of phased extensions to Crenshaw, La Cienega, and Venice/Robertson.

- The BRT concept includes a number of key attributes. Service attributes include simple route layouts, frequent service, limited stops, level boarding, and color-coded buses and stops. Capital and operating strategies include enhanced station stops, signal priority, exclusive lanes, high capacity buses, and multi-door entry and exit. Other elements may include fare prepayment, bus feeder network, and coordinated land use.

- A number of elements were considered in the Wilshire BRT project. Examples of these elements include new larger transit buses to provide more seats and carry more people, enhanced shelters at 15 metro rapid station stops, and exclusive on-street operations.

- A number of lessons have been learned from the project. First, there is a need for support from key elected officials. Second, approaches to address diverted traffic and the possible loss of on-street parking must be considered. Third, priority signal systems and their affect on cross-street traffic flow will need to be considered. Fourth, at least 40 to 60 BRT vehicles per hour appear necessary to justify lane conversion. Fifth, consideration must be given to the fact the most transit agencies do not own guideways or stations. Last, a well thought out

implementation strategy is needed. Curitiba represents a 38-year success story. Elements of the Curitiba approach should be appropriate for other areas.

Veirs Mill Road BRT Study
Rob Klein
Montgomery County Department of Public Works and Transportation

Mr. Rob Klein discussed the Veirs Mill Road BRT study in Montgomery County, Maryland. He described the existing conditions and transit services in the corridor, the alternatives considered in the study, the evaluation process, and the results. Mr. Klein addressed the following points in his presentation.

- The primary objective of the study was to identify potential BRT improvements on Veirs Mill Road between the Rockville and the Wheaton Metro stations. The second objective was to identify the possible benefits from the BRT improvements and the costs associated with the enhancements.

- The Veirs Mill road corridor contains a mix of suburban land uses, including residential developments, strip commercial buildings, and park lands. Traffic is congested in the morning and the afternoon peak hours with a LOS F on most sections. The right-of-way is limited at critical intersections. There are local service roads in the corridor.

- Currently, six bus routes operate in the corridor. Approximately 34 buses operate in the corridor during the afternoon peak hour. The average headways on the routes vary from 10 to 30 minutes. The average bus stop spacing is 900 to 1000 feet. The average bus speed is 14 mph in the afternoon peak hour. Approximately 25 to 30 percent of bus trips in the afternoon peak hour are late more than 10 percent of the time.

- There were three bus lane alternatives considered. The first option was a median location with a lane in each direction. The second alternative was a reversible median lane. The third option used the curb lane in each direction.

- The proposed conceptual design included a combination of treatments. Approximately 39 percent of the corridor would include dedicated bus and right-turn lanes, curb lanes and frontage roads would be used in 27 percent of the corridor, buses would operated in the general-purpose lanes in 23 percent of the corridor, and buses would be rerouted to local streets in 11 percent of the corridor. Queue jump lanes would also be provided at key intersections and enhanced bus stations would be constructed at six stops. The enhanced bus stations would include unique design elements. New BRT service would be operated using 60-foot articulated vehicles.

- The scenarios were examined in the modeling evaluation. The evaluation modeled the existing conditions, the 2025 baseline including improvements identified by the State Highway Administration (SHA), and the 2025 forecast with the BRT project. The total travel time and delay per bus were assessed. The reduction in bus delay time at intersections was modeled and the total time savings per bus was estimated. Ridership gains due to BRT and bus priority were estimated for 2025. Factors influencing ridership gains were improved frequency, improved reliability, and reduced travel time. The cumulative effects of these changes resulted in some 3,100 new weekday drips.

- The estimated ridership gains for the 2025 baseline with BRT was 22,600 trips per day. The total additional trips a day with BRT were 3,100, or a 14 percent increase. The total 2025 ridership with BRT was 25,700 trips a day. The annual operating savings for non-BRT routes in 2025 were also examined. The hours saved were 783 for Ride-On and 4,482 for WMATA. The cost reduction in 2000 dollars was $15,101 for Ride-On and $171,736 for WMATA. The number of peak buses required for existing WMATA bus routes was reduced by four buses. The annual rider benefits in 2025 were estimated at 580,000 hours for base riders and 48,000 hours for new riders. Using a $14 an hour value of time, these figures translate into some $8.8 million.

- The proposed BRT system will create added capacity for transit vehicles without decreasing general purpose capacity. It provides increased benefits for transit and automobile users. It also provides time savings and operating cost benefits. Additional study is needed to refine the design, ridership impacts, and traffic operations.

Traffic Control and Transit Priority: San Fernando BRT Project
Brent Ogden
Korve Engineering

Mr. Brent Ogden described the traffic control and transit priority elements of the San Fernando BRT project. He summarized the main elements of the BRT project and described the traffic control and transit priority features. Mr. Ogden covered the following points in his presentation.

- The San Fernando BRT project is part of the Los Angeles County Metropolitan Transportation Authority's Phase IIB Metro Rapid project. The project includes 13 miles of dedicated busways. Other BRT elements include distinctive vehicles, off-vehicle fare payment, and unique bus stations and stops.

- All intersection movements are signal controlled. There are activated warning devices that indicate when a BRT vehicle is approaching an intersection or cross street, as well as passive signing. Pedestrian and bike pathways are signal controlled as well.

- Allowable speed criteria for BRT is based upon the type of guideway facility. At exclusive guideway/gated crossings the allowable speed is based on the alignment. At semi-exclusive guideway/fenced crossings the allowable speed is 45 mph at signal with activated devices and 35 mph at signals without activated devices. At locations with street running guideway/curb barriers with parallel traffic allowable speeds are up to 35 mph. Allowable speeds are 20 mph on bus/pedestrian malls.

- Field components of the transit priority at traffic signals include loop detectors and bus transponders. The 2070 controllers run the transit priority software. The central control is provided by Automated Traffic Surveillance and Control (ATSAC) software and the schedule database. Priority will be granted if a bus is behind schedule or if the bus headway variance exceeds the predetermined threshold.

- Various types of guideway alignments are utilized such as a guideway running parallel to an arterial with a "pre-signal" for automobiles on cross streets upstream of the arterial, a one-way "H" configuration for a median guideway, a "triangle" alignment for a high-volume cross street, and a "diamond" alignment as an alternative to a grade-separation.

- Transit signal priority includes early green, where priority is granted when a bus is approaching a red signal. The red signal is shortened to provide a green signal sooner than normal. Green extend priority is granted when a bus is approaching a green signal that is about to change. The green signal is extended until the bus passes through the intersection. Free hold is used for low-volume cross streets. Priority is used to hold a signal green until the bus passes through the intersection during non-coordinated (free) operation. Phase call brings up a selected transit phase that may not normally be activated. This option is typically used for queue jumper operation, or a priority left turn phase. The signal priority system is not just concerned with BRT/auto priority conflicts but also directional BRT vehicle priority conflicts. Proposed enhancements being explored include bus prediction with variable offset and enhanced recovery from early green.

Transit Priority Treatments in King County

Ellen Bevington, King County Metro, Moderator

Development of Business-Access and Transit Lane Concept for Aurora Avenue in Seattle

Tim Bevan
CH2M Hill

Mr. Tim Bevan provided an overview of the Aurora corridor project in the City of Shoreline, located to the north of Seattle. He summarized the background of the project, described the business access and transit lane concept, and highlighted some of the concept considerations and benefits. Mr. Bevan covered the following points in his presentation.

- Aurora Avenue is a major north/south roadway. It is highly congested and has high accident rates. Sidewalks are limited along the roadway and the general aesthetics of the corridor are poor. The roadway conditions are generally non-supportive for transit.

- The goals of the Aurora Avenue project are to improve safety for traffic and pedestrians, to optimize safe and efficient movement of people and goods, and to support increased use of transit. Other goals are to balance local and regional travel movements, to meet long-term travel needs, to improve aesthetics, to support a comprehensive plan, and to preserve neighborhoods in the corridor.

- A number of alternatives were examined in the study. These alternatives included bus and HOV lanes, landscaped medians, and center turn lanes.

- The preferred alternative contains a number of elements. Roadway elements included expanding intersection capacity, providing business access and transit lanes, providing transit signal priority, addressing safety and access management issues, and providing left turn lanes and U-turn lanes. Sidewalk and aesthetic elements include seven-foot sidewalks, landscape buffers, pedestrian crossings, landscaped medians, and additional illumination. Other elements include placing utilities underground and storm water management.

- A typical business access and transit lane striping signing plan was developed. Elements of the plan include far side bus stops, bus lanes approaching the stops, and signs with “Right Lane Must Turn Right/Except Buses.”

- Safety benefits of the preferred alternative were also considered. Currently, driveway densities are very high along the avenue, with an average of 60 per mile. The proposed alternative would combine some access points and eliminate others, reducing driveway-related accidents. It would also address business concerns regarding ease of customer access.

- Traffic operations benefits of the preferred alternative include improved traffic flow, accommodation of right turn traffic volumes at intersections, and increased corridor traffic capacity, reducing average delay time. Transit benefits include increasing transit speed, improving reliability, and increasing corridor person-movement capacity.

- The business access and transit lane concept represents part of a comprehensive solution to a unique problem. The concept provides several types of benefits to numerous user groups.

Arterial BRT Plan Development
Matt Shelden
King County Metro

Mr. Matt Shelden discussed King County Metro's BRT program. He described the BRT elements currently provided, as well as those under development. Mr. Shelden covered the following points in this presentation.

- Metro is already employing many BRT elements. These elements include frequent limited stop and express bus services, transit priority lanes, and automated traveler information systems. Examples of priority treatments included the downtown Seattle bus tunnel, HOV lanes, and signal priority at some intersections. My Bus and BusView provide real-time bus information to riders.

- Other BRT elements are being developed and tested. Examples of these elements include SmartCard electronic fare payment and enhanced security tools, such as on-board cameras. Hybrid buses are also being examined. While these elements are in use or are being planned, Metro has not yet combined all of these elements together in a distinctive total BRT corridor package.

- Metro's approach to BRT focuses on a number of concepts and elements. The approaches will focus on arterial BRT applications similar to the system in Los Angeles. It will start with one corridor to test elements and evaluate the potential for other applications. Initially implementation is occurring within current Metro budget and revenue sources. Opportunities for additional funding are being explored. The system will be enhanced as funds are available.

- Metro's BRT program focuses on four major objectives. The first objective is to increase transit ridership and all-day market share. The second objective is to improve rider satisfaction. The third objective is to strengthen existing partnerships and to build new partnerships with other jurisdictions. The fourth objective is to assess the effectiveness of focusing and packaging transit service and facility improvements at the corridor level.

- There are five criteria are being used in the corridor selection process. The criteria are: 1) high travel demand corridors with the potential for significant transit ridership gains; 2) potential for significant improvements in transit reliability and/or travel time; 3) easy integration with existing transit system; 4) supports local and regional growth management efforts; and 5) affected jurisdictions are committed to making supportive traffic operations and facility decisions.

- The initial BRT activities focus on five basic elements. The primary defining element is providing service levels so that riders do not have to worry about schedules. Other elements are using a single-service pattern with limited stops and adding transit priority for improved reliability and travel speed. Distinctive service and facility branding with supporting marketing is also an element, along with the provision of real-time schedule information at transfer points.

- A number of possible future enhancements are being considered. These elements include wider use of real-time schedule information, off-vehicle fare payment, dedicated state-of-the-

art vehicles, dedicated rights-of-way, enhanced stations, and vehicle guidance.

- Characteristics of the service pattern include less frequent stop spacing where BRT is added as an overlay service and more frequent stop spacing where BRT is the primary service. BRT service will always stop less frequently than local service.

- Basic elements of the transit priority treatments include a focus on transit signal priority and the use of available HOV lanes. Future enhancements include expanding the use of dedicated bus lanes.

- The BRT approach curently uses Metro's existing fleet of standard high-floor buses. In the future, new low-floor articulated diesel-electric hybrid buses will be assigned to BRT service.

- Basic elements of BRT stations in the near-term will use augmented standard shelters, with additional lighting. Real-time schedule information at selected locations will also be provided. Future enhancements may include new shelter designs, distinctive wayfinding, separate stops, guided vehicles, SmartCards, and greater use of real-time information.

- The Aurora Avenue corridor is being used to test BRT elements and marketing. The results from the Aurora Avenue project will be applied elsewhere. Metro will expand successful elements to other corridors as funds are available.

TSP Interactive Model

John Toone
King County Metro

Mr. John Toone discussed the transit signal priority interactive model (TIM). He discussed the development of the model and provided examples of its application. Mr. Toone covered the following points in his presentation.

- TIM is a planning and pre-design tool for estimating the benefits of transit signal priority. It was developed at King County Metro in the spring of 2002. PB Farradyne provided review assistance. The model uses Microsoft® Excel and Visual Basic. It is applicable to transit signal priority systems using non-preemption priority.

- The model provides a consistent methodology for evaluating the benefits of transit signal priority (TSP). It has the flexibility to analyze multiple time-of-day signal plans and multi intersectional corridors.

- The time benefit to an individual bus is determined by the TSP settings and the point of arrival in the signal cycle in the intersection model. The benefit at a single point of the cycle is determined by the settings. The time of arrival can be generalized into the probability of needing priority. The average benefit when priority is granted and the probability of needing priority determine the expected benefit per trip.

- The intersection model includes four inputs. The phase split is the normal (not programmed) duration of each phase. The transit maximum is the force maximum duration of each phase when transit priority is activated. The green extension is the additional time a green light will be held when transit priority is activated. The progression efficiency is the probability an approaching bus will arrive during a green light, determined by phase splits if no value is entered.

- Inputs to determine the travel time savings include the number of priority-eligible trips-per-day and average passengers-per-trip of the average passenger load. There are three outputs provided. Benefit-per-trip is the expected or average time savings per event. Transit time savings is the total seconds of transit benefit-per-day. Passenger time savings is the total seconds of passenger benefit-per-day.

- There are four outputs provided for the transit travel time benefits. First, a summary is provided of the averages per trip. Second, a daily summary is provided of the transit, passenger, and total time and dollar benefit-per-day. Third, an annual summary provides transit passenger and total time and dollar benefit per year (250 weekdays per year). Finally, the marginal annual benefit is calculated of the annual benefit minus the annual operating cost.

- The three inputs to the benefit/cost analysis are capital and operating costs, inflation and discount rates, and equipment life. The outputs provided by the benefit/cost analysis include net present value (NPV) of capital and operating costs, NPV of transit and passenger benefits, net benefit, and benefit/cost ratio.

- The model results indicate there are two types of successful TSP projects. One is the creation of special conditions for transit, which are not very common and second is the

accumulation of small effects, which are more common. Transit signal priority settings with the biggest impact are green extension and transit maximization of the phase preceding the green.

- TIM can be used in planning and in pre-design. In planning, the model can be used to identify TSP locations with favorable benefit/cost ratios and to identify the level of commitment required for successful TSP. In pre-design it can be used to estimate schedule changes. The model will continue to be refined with the incorporation of clearance timings and extended documentation.

King County Signal Priority Program
Ron Atherley
King County Metro

Mr. Ron Atherley discussed transit signal priority efforts in the Puget Sound region. He provided an overview of the basic steps in a TSP. Mr. Atherley covered the following points in his presentation.

- The three basic steps in TSP are detection, priority request, and control. Transit signal priority spans multiple subsystems. Priority requests may be generated by vehicles, transit management systems, and traffic management centers.

- Available detector technology includes loops, optical, infrared, radio frequency (RF), and AVL. Detector input types may be point, zone, and continuous. Bus detection messages may be simple vehicle detection or they may be data-specific messages depending on route, run, trip, lateness, ridership, and estimated time of arrival.

- Priority request generation (PRG) may be as simple as "if bus, then request priority." Priority requests may also be conditional based on route, time of day, correct direction, lateness, passenger load, or other factors.

- Recommended transit signal priority input/output (I/O) parameters include functions of both PRG and controller, enable/disable, priority override, TSP detection lock/memory, and delay. Other parameters may include mappable, assignable, number of available I/O, reservice time, and max time-out.

- Examples of priority request messages include contact closure–controller input 24v and serial message (NTCIP SCP 1211). The later is more complex, and may be based on request identification, vehicle identification, vehicle class type, vehicle class level, service strategy number, time of service desired, and time of estimated departure.

- Priority control strategies are not preemption control strategies. Preemption transfers normal control of a signal and may disrupt normal traffic operations. Preemption is usually used only with emergency vehicles or with railroads. Transit priority provides preferential treatment without interrupting signal timing. It is non-emergency use and is usually not found in all controllers.

- Examples of the basic requirements for TSP include extending green time or shortening red time. Priority treatments should not shorten minutes, shorten clearances, skip phases, or break coordination. Priority control strategies may include green extension, early green,

phase rotation, special phase, and phase skipping.

- Recommended TSP features include alternate splits for non-TSP phases, phase extension for TSP phases, keeping signal coordination, lead/lag operation, and coordinated and free. Desirable TSP featured include logging, TSP output for verification, programmable inhibit, front panel display TSP status, upload/download, and flexibility in settings.

- The TSP system equals detection, priority request logic, and TSP strategies. There is a need to understand the desired strategies and to understand system capabilities. The appropriate operational requirements can then be developed. It is also important to specify system components to match requirements and to keep within available budgets.

Evaluation of Signal Priority on Aurora Avenue
David Cantey
King County Metro

Mr. David Cantey discussed the evaluation of the TSP demonstration on Aurora Avenue. He summarized the evaluation process, the parameters used for granting signal priority to buses, and the evaluation results. Mr. Cantey covered the following points in his presentation.

- The Aurora demonstration project focuses on 20 intersections along a 6.2 mile segment of road. The intent of the study was to test the TSP system and to test traffic control strategies. All 20 intersections were included in the study. King County Metro received support from the City of Seattle and the City of Shoreline to examine alternative controllers and alternative control strategies.

- The evaluation methodology included a two week data collection period. One route with high ridership and frequent service was used. Schedules were “lifted” to avoid early service.

- The sample TSP parameters at North 105th Street in the morning peak period were 358 eligible vehicles in the southbound direction. The frequency of TSP request was five minutes. The green extension was 16 seconds and the return to early green was 21 seconds. In the afternoon peak period there were 358 eligible vehicles in the northbound direction. The frequency of transit signal priority request was five minutes. The green extension was 15 seconds and the return to early green was eight seconds.

- There were four measures of effectiveness used in the evaluation. The measures were bus travel time, bus travel time variability, average intersection bus delay, and average intersection person delay.

- The results from the demonstration indicated the potential benefits of TSP. The test reduced peak bus travel time by five percent and reduced bus delay at signalized intersections by 25 percent. The percentage of buses arriving on red during the peak period was reduced by 14 percent. Trips with travel times greater than 30 minutes were reduced by 40 percent. Person delay at signalized intersections was reduced by a range of zero to six percent. The daily savings in bus travel time was 101 minutes. The potential savings in annual service costs was $30,000. The daily savings in passenger travel time was 31 hours.

- The results of the benefit/cost analysis indicated that two intersections had benefit/cost ratios greater than 3.0, four intersections had ratios of between 2.0 and 3.0, four intersections had

ratios of between 1.0 and 2.0, and 10 intersections had ratios of less than 1.0.

- The demonstration results indicate the importance of focusing on corridors with high volumes of buses and passengers. It is also important to focus on intersections where buses experience delay. The results indicate a need to design for far side bus stops. There is also an ongoing need for traffic personnel to better understand transit operations and for transit personnel to better understand traffic operations.

BRT Flavor of the Month or Long-Term Solution?

Charles Prestrud, Washington State Department of Transportation, Moderator

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What's the Buzz about BRT?

Dennis Hinebaugh and Michael Baltes
Center for Urban Transportation Research

Mr. Dennis Hinebaugh and Mr. Michael Baltes discussed the various elements associated with BRT. They described the experience with recent BRT projects and the National BRT Institute. They covered the following topics in their presentation.

- BRT is defined as an integrated bus-based "rapid" transit system typically utilizing highly flexible service and advanced technologies to improve customer convenience and to reduce bus delays. BRT systems reflect a number of common traits. The physical infrastructure elements include a dedicated travel way, typically a busway or HOV lane, with stations and other facilities. BRT systems use distinct vehicles. The services and route structures are revised. Fare collection is made easier and faster. ITS and advanced technologies are incorporated to provide buses with additional priority and to provide passengers with real-time information on the status of buses.

- Ridership gains have been experienced by BRT projects. The transitways in Houston have attracted new bus riders. Between 18 to 30 percent of Houston riders on HOV lane buses indicate they did not use transit before the HOV lanes were open. The BRT routes in Los Angeles have experienced ridership gains of 26 to 33 percent, with one-third of these being new riders. Vancouver has seen 8,000 new riders, with 20 percent previously driving their cars and 5 percent new trips in the area. Adelaide experienced a 42 percent ridership gain with 14 percent previously driving. Leeds experienced a 50 percent gain in ridership and Brisbane saw a 45 percent gain in ridership.

- The travel time savings for BRT varies by the type of facility. Busways and freeway HOV lanes typically save 32 to 47 percent in travel times. The Metro Rapid in Los Angeles realized 23 to 28 percent improvement in bus travel times. The Brisbane Busway saves approximately 42 minutes for buses.

- The South East Busway in Brisbane has experienced a high level of public acceptance. The Busway provides direct, reliable, and convenient service. There has been a 45 percent increase in ridership with the opening of the busway. Some 866,556 additional passenger trips have been reported in southeast Queensland since the busway opened. The trip in an automobile takes approximately one hour, compared to 18 minutes on the busway in the peak hour. Property values have also increased along the busway.

- On the O-Bahn in Essen, Germany, patronage rose by 22 percent when the system first opened. Approximately 14 percent of these riders previously drove. Only 10 to 15 percent of riders need to transfer. The system experienced a 10.6 percent per annum growth in riders in the early years, compared to 1.4 percent per annum increase in ridership on other routes in the city. Patronage since 1991 has been relatively constant, while routes in other parts of the city have experienced declines.

- The TransMilenio BRT System in Bogotá, Columbia, has a capacity of at least 600,000

passengers a day. Currently it carries some 67,000 passengers in the peak hour, with 33,500 passengers in the peak direction of travel. The system provides 32 percent travel time savings for buses over the pre-BRT condition.

- BRT systems in many cities provide speeds that are comparable or better than LRT systems. Bus speeds on HOV lanes and busways in San Jose, San Diego, Pittsburgh, Dallas, and Denver are higher than LRT times in those cities. The LRT in Los Angeles operates at a higher speed than the BRT line in that city.

- BRT capital costs are typically lower than other fixed guideway options, including LRT. In 1999 dollars, the capital cost per mile for LRT was estimated at $34.8 million, compared to $13.5 million for busways, and $0.7 million for arterial street bus applications.

- Operating costs per-vehicle revenue hour and per-vehicle revenue mile were lower for the HOV and BRT systems than LRT system in 1999 for all but one of the six cities noted previously. In most cases the differences were significant. The LRT system in San Diego recorded lower operating costs per-vehicle revenue hour than the HOV facilities in that city. The operating cost per-unlinked passenger trip was lower for the bus elements in Dallas, Denver, Los Angeles, and Pittsburgh and higher in San Diego and San Jose.

- Both BRT and LRT can operate in exclusive rights-of-way and with mixed traffic. Station spacing for both typically tend to be at one-fourth to one-mile intervals. Vehicle seating capacity for BRT is usually 40 to 85 passengers, while LRT is 65 to 85 passengers. The average vehicle speeds for both modes 15 to 20 mph. The persons-per-hour for exclusive right-of-way are up to 30,000 for both LRT and BRT and up to 10,000 on arterial street applications of both modes. The right-of-way cost per mile for BRT typically ranges from $.02 million to $25 million compared to $20 million to $55 million a mile for LRT. Vehicle costs for BRT range from $0.45 million to $1.5 million compared to $1.5 million to $3.5 million for LRT. The costs for operating and maintaining BRT is $65 million to $100 million compared to $450 million to $200 million for LRT.

- The National BRT Institute (NBRTI) was established at the University of South Florida. Funding for the NBRTI comes from FTA, consortium agencies, Hennepin County, Minnesota, SCRA, and international consortium members.

- Current activities of the NBRTI include publication of a regular newsletter, workshops, technical assistance, and Internet site development and maintenance. The Institute is also conducting system evaluations of the Lynx Lymmo and the Metro Dade Busway. An action plan for a thriving BRT market is being developed and topics for ongoing research are being identified.

BRT Program Summary
Rick Krochalis
Federal Transit Administration

Mr. Rick Krochalis discussed the FTA's BRT program. He summarized the background of the program, funding sources, and project evaluation activities. Mr. Krochalis addressed the following points in his presentation.

- The FTA BRT program emerged partly in response to a lack of funding for rail systems and partly to address problems associated with traditional bus systems. A 1997 visit to Curitiba, Brazil, by government and transit officials provided a focus for the BRT programs. Follow-up meetings with transit industry representatives resulted in the formal BRT program. A competitive process to select BRT national demonstration models was started and the official announcement of consortium participants was made in June of 1999.

- There were originally 10 national demonstration sites. These demonstration sites included the following:
  - Metropolitan Boston Transit Authority (MBTA) – The Silver Line
  - City of Charlotte – Independence Corridor
  - Greater Regional Cleveland Transit Authority (GRCTA) – Euclid Avenue Transit Improvement
  - Virginia Department of Rail and Public Transportation – Dulles Corridor
  - Lane Transit District, Eugene-Springfield – Pilot East-West Corridor
  - Connecticut Department of Transportation – Hartford-New Britain Busway
  - City and County of Honolulu – City Express
  - Miami-Dade Transit Agency – South Miami-Dade Busway
  - Puerto Rico Highway and Transportation Authority, San Juan – The Rio Hondo Connector BRT
  - Santa Clara Valley Transportation Authority – Line 22 Rapid Transit Corridor

- The members of the BRT Consortium are:
  - City of Los Angeles Department of Transportation and Los Angeles County Metropolitan Transportation Authority, Los Angeles, California – Metro Rapid Bus
  - AC Transit – California Quality Bus Project, San Pablo Avenue Corridor
  - Capital District Transportation Authority, Albany, New York – Best Bus Program
  - Chicago Transit Authority – Neighborhood Express Bus Route System
  - Transit Authority of River City, Louisville, Kentucky – Transportation Tomorrow MIS
  - Port Authority of Allegheny County (PAT), Pittsburgh, Pennsylvania – West Busway
  - Montgomery County, Maryland – Veirs Mill Road Bus Priority Project

- Los Angeles was subsequently changed to a national demonstration member and funded for evaluation activities. Las Vegas was also added as a member of the BRT Consortium. The program was funded through the six-year life of TEA-21.

- Funding for BRT projects may come from a variety of sources. Research and technology program funds have ranged from a low of $160,000 in FY 1998 to a high of $1.7 million in FY 1999. Other program funds, including New Starts and Bus Discretionary, can be used for BRT projects. Grants of $50,000 were provided to the 10 demonstration projects to fund

evaluation and consortium activities. A number of research and technology sharing activities are also underway.

- Formal evaluations of the demonstration sites are being conducted. Program evaluation guidelines were developed and are central components of the demonstrations. A project evaluation plan was developed for the Honolulu program. There are four major contractors being used on the evaluations. The evaluations focus on the program benefits and the ultimate transferability of the various project elements.

- Information on the BRT program is available from a wide range of sources, including publications, an Internet site, and a video library. The FTA Internet site is http://www.fta.dot.gov/brt/. There is also a 2001 BRT Status Report and a General Accounting Office (GAO) report "Bus Rapid Transit Shows Promise."

Lessons Learned in Development of BRT Planning and Implementation Guidelines
Scott Rutherford
University of Washington

Dr. Scott Rutherford discussed a recent Transit Cooperative Research Program (TCRP) project, *Development of BRT Planning and Implementation Guidelines*. He highlighted the historical bus use of HOV facilities and recent BRT projects. He summarized the major findings from the TCRP report.

- Many of the early HOV projects were focused on bus-only operations. These projects included the Shirley Highway demonstration in Northern Virginia, the Blue Streak demonstration in Seattle, and the El Monte Busway in Los Angeles. The 1975 report on the Shirley Highway Bus-on-Freeway demonstration could be considered the first BRT report.

- The first key finding from the TCRP report is that the exclusive nature of the facility and reserving the facility or right-of-way for transit and HOVs is critical. Different types of exclusive lanes may be used. The importance is that they provide travel time savings and trip time reliability to buses.

- The second funding from the study is to match service to markets. Providing direct, high quality service is important. The Southeast Busway in Brisbane is served by multiple routes with minimum transferring.

- The third finding focuses on completing the full BRT package. BRT elements include stops, stations, real-time information systems, unique vehicles and other equipment, and a common identity.

- There should be numerous opportunities for BRT in the future. BRT offers a good product, but it is important not to oversell BRT. While BRT is typically lower in capital and operating costs than other fixed guideway options, it not inexpensive.

HOV Funding: Issues and Initiatives

Lorena Eng, Washington State Department of Transportation, Moderator

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State and Local Financing Issues

Chuck Fuhs
Parsons Brinckerhoff

Mr. Chuck Fuhs discussed funding issues related to HOV and managed lane facilities. He summarized the estimated funding needs for HOV projects, potential sources of financing, and examples of project funding. Mr. Fuhs addressed the following points in his presentation.

- Funding for HOV lanes from 1969 to 2000 in current year dollars has been estimated at approximately $9 billion. The estimates for HOV and managed lanes through 2025 indicate a shortfall in funding in every major city in the country. The 25-year current year costs are estimated to be at least triple the total of past investments. It appears that project delivery time is slowing and project readiness is slipping due to funding constraints.

- There are a number of local funding options that are currently being used or considered for HOV lanes and managed lanes. Examples include traditional state matches to federal programs and transit matching funds from local sales taxes and other sources. Some areas are using regional mobility authorities funded by sales taxes and bonds. Toll roads traditionally use bonding to pay for construction and operation. Value pricing programs in a few areas are using trip-based tolls and other innovative approaches are being considered in other areas. Examples of more innovative approaches include access enhancements in Orange County, managed lanes on I-10 Houston, and transit enhancements in Seattle.

- Access enhancements in Orange County include freeway direct access ramps. OCTA is sponsoring the projects in coordination with Caltrans. The access ramps are funded by sales taxes, bonds, and federal funding.

- Managed lanes are being planned as one element of expanding the I-10 West (Katy) Freeway in Houston. The current plans include four managed lanes in the center of the freeway. The county toll authority would provide approximately $300 million in funding. A guaranteed level of service would ensure that the lanes continue to provide buses and HOVs with travel time savings and trip time reliability. Anticipated financing sources include state and federal funds, and bonds issued by the toll road authority.

- Transit enhancements in Seattle are part of the Sound Transit referendum. There is a proposition for increasing the excise tax to support transit. Joint funding with participating cities is anticipated.

- A topic for further discussion relates to the need for revolution or evolution in funding programs and approaches. It appears that recent trends include a sharper focus on project justification, a greater reliance on partnerships, more project awareness and support, innovative strategies, and a commitment to a longer-term vision. The continued use of a wide range of funding sources will be important to the success of HOV lanes and managed lanes.

TEA-21 Reauthorization Update

Dan Mathis
Federal Highway Administration

Mr. Dan Mathis discussed the federal reauthorization process for the Transportation Equity Act for the 21st Century (TEA-21). He summarized the anticipated approach and schedule for reauthorization. He also highlighted how individuals can participate in the reauthorization process. Mr. Mathis covered the following points to his presentation.

- The approach to reauthorization is to build on the success of ISTEA and TEA-21. As such, the approach focuses on evolution rather than revolution. Ensuring adequate and predictable funding is a key premise of reauthorization, as is preserving funding flexibility. Other key elements include emphasizing the security of nation's surface transportation system and improving approaches to safety. Expanding and improving innovative finance program, simplifying federal transportation programs, and streamlining project approvals are also included in the reauthorization approach.

- The administration's proposal will be presented to Congress in January 2003. Congressional hearings should start in February. Ideally, new legislation will be passed by October. The process does not always meet this schedule, but all groups work toward these deadlines.

- Individuals, agencies, and groups can provide input into reauthorization. Send written comments to the U. S. Department of Transportation a the following address: Docket Clerk, USDOT, Room PL-401, Docket Number: OST-2002-12170, 400 7th Street, S.W., Washington, D.C. 20590. Comments can also be submitted through the USDOT Internet site at www.dot.gov.

FHWA Value Pricing Programs
Patrick deCorla-Souza
Federal Highway Administration

Mr. Patrick deCorla-Souza discussed FHWA's Value Pricing Pilot Program. He summarized the goals of value pricing, highlighted current projects, and described new initiatives. He also discussed some of the issues frequently associated with value pricing and potential future prospects. Mr. deCorla-Souza covered the following points in his presentation.

- There are three major goals for most value pricing projects. The first goal is to reduce congestion. The second goal is to reduce emissions and fuel consumption. The third goal focused on providing revenues to improve service and provide more transportation choices.

- FHWA's Value Pricing Pilot program started as the Congestion Pricing Pilot program, which was contained in ISTEA. TEA-21 renamed the program to the Value Pricing Pilot program and modified some elements. The program is a joint effort of FHWA's Operations and Policy offices.

- There are four types of projects that may be funded through the pilot program. TEA-21 established funding of $26 million for the program. The first type of project is variable tolls on toll facilities. New York's Hudson River crossing is an example of this type of project. The second type of project is converting an HOV lane to a HOT lane. The demonstration project on the Katy Freeway (I-10) in Houston is an example of this approach. Variable tolls on added lanes represent the fourth type of project. The Express Lanes on SR 91 in Orange

County, California, provide an example of this technique. Other pricing innovations may be considered in the final project category. Examples of possible projects in this category include parking cash out and mileage-based insurance and taxes.

- The demonstration projects and other efforts to date indicate that pricing works. Pricing can help reduce congestion, change travel behavior, and provide more travel choices. Pricing projects can provide revenues for expansion of transportation services. Pricing can be politically and publicly acceptable. Pricing can be controversial, however, with equity the biggest issue.

- Currently there are 32 projects underway in 12 states. Funding for these projects is approximately $26 million. The maximum number of projects allowed under TEA-21 is 15 agreements, with $11 million in funding authorized per year.

- Proposals for FY 2003 are due November 1, 2002. The application process will be open until the Appropriations Act is signed, however. There is a special solicitation for three types of projects. These three types of projects are integrating value pricing into the planning process, integrating value pricing with BRT, and freight-focused value pricing.

- A national outreach effort is underway focusing on the reauthorization. Symposiums were held with the Eno Foundation, with the Hubert H. Humphrey (HHH) Institute at the University of Minnesota, and with an FHWA freight pricing workshop. Outreach efforts have been conducted with 30 organizations.

- Equity concerns must be addressed for value pricing to become more widespread. Approaches to addressing possible equity concerns include packaging pricing with transit improvements, using life line toll credits or other compensation, and providing toll credits for motorists using the general-purpose lanes (FAIR lanes). Equity does not appear to be an issue where pricing has been implemented. The results from an opinion survey of I-15 motorists in San Diego indicated that 91 percent think the time-saving option is a good idea. Further, the results show that support for the I-15 lanes is higher among lower income motorist than the highest income motorist. A total of 89 percent of the motorists surveyed support the HOT lanes extension project. Recommendations from the Eno Foundation and the HHH Institute Symposiums include addressing tolling restrictions, encouraging implementation, and encouraging privatization.

- A future possibility is region-wide pricing. The toll zone proposed for central London is one example of this approach. A HOT or FAIR lane network in the Washington D.C. area provides another possible example. It has been estimated that this approach would have $2 to 4 billion in economic benefits to the region and $600 million in annual revenues to fund transportation projects in the area. There are both technical hurdles and political risks associated with possible region-wide pricing strategies.

- The experience to date with value pricing projects indicates a number of conclusions. First pricing does help reduce congestion and does provide new funds. Second, public approval is high in areas which have experienced value pricing. Third, value pricing remains highly controversial in areas which have no experience with it. Finally, additional promising innovative concepts are being explored and tested.

BRT Program Funding Opportunities

Rick Krochalis
Federal Transit Administration

Mr. Rick Krochalis discussed funding opportunities for the BRT program. He described the various programs that may be used to fund BRT components. He also summarized transit elements in the reauthorization. Mr. Krochalis covered the following points in his presentation.

- Funding for BRT projects may come from a variety of programs and sources. Currently at the federal level these sources cover the research and technology programs, demonstration grants, and other program funds. Beyond TEA-21, the T-3 incentives efforts focus on ridership performance.

- BRT project funding through the research and technology program started at approximately $160,000 for FY 1998. Finding has fluctuated since then from a high of $1.7 million in FY 1999 to a low of $84,000 in FY 2001. Other programs, such as the New Starts and the Bus Discretionary programs may be used to fund BRT projects. There have been grants to ten demonstration sites, averaging $50,000 per site for evaluation and consortium activities. A variety of research and technology sharing activities have also been funding recently.

- BRT project planning, capital, and operating costs are also eligible for funding under the 49 U.S.C. 5307 Urbanized Area Formula program. Other possible funding sources include the Surface Transportation Program (STP), transfers from FHWA, and Congestion Management Air Quality (CMAQ) program.

- Funding for the 49 U.S.C. 5309 Capital Investment Program may also be used for BRT. These programs include fixed guideway formula funds, bus earmarks by Congress, and New Starts funds.

- The core principle and values in the reauthorization include intermodal, flexible, and innovative financing. Other key elements include a predictable funding stream for grantees, providing local choice with sound business case, ITS, and a focus on ridership.

- FTA and other federal agencies have extensive outreach efforts on BRT and the reauthorization. Both the FTA and the FHWA Internet sites contain a good deal of information on reauthorization.

Bus Rapid Transit Corridor Studies

Dennis Hinebaugh, Center for Urban Transportation Research, Moderator

HOV Lanes on the Long Island Expressway: When Carpools Aren't Enough, Think Bus Rapid Transit

Marvin Gersten
Parsons Brinckerhoff

Mr. Marvin Gersten discussed the use of the HOV lanes on the Long Island Expressway (LIE) in New York. He provided an overview of the development of the lanes, current utilization, and future plans. He noted the assistance of Mr. Wayne Ugolik, NYSDOT, and Mr. Irving Perlman, Parsons Brinckerhoff, with the project and the presentation. Mr. Gersten covered the following points in his presentation.

- The HOV lanes on the LIE were first opened in 1994. Currently, 40 miles of HOV lanes are in operation during the morning and afternoon peak hours. Use of the lanes has grown over time. Eastbound afternoon peak hour volumes have grown from 370 vehicles in 1995 to 1,430 vehicles in 2002, a 64 percent increase. Westbound morning peak hour volumes have grown from 660 vehicles in 1995 to 1,170 vehicles in 2002, a 77 percent increase.

- A survey of HOV lane users was conducted in May 2001. The results indicated that the HOV lanes have influenced commuters to rideshare for some of their trips to take advantage of the travel-time savings offered by the lanes. HOV lane users reported typical travel time savings of 16 to 20 minutes. Approximately 85 percent of the HOV lane users and 53 percent of the general-purpose lane users favored extending the HOV lanes.

- The LIE HOV lanes move more people in fewer vehicles than the adjacent general-purpose lanes. Approximately 37 percent of travelers are in the HOV lane in the afternoon peak hour. The persons-per-vehicle in the HOV lane is 2.5, while in the general-purpose lane it is 1.1. The person-per-vehicle for all lanes has increased by 25 percent since 1993.

- Of the 1,430 vehicles in the HOV lane during the afternoon peak hour, 140 are 3+ carpools, 1,180 are 2+ carpools, and 65 are violators. Raising the vehicle-occupancy level to 3+ to address increasing use levels will be a difficult policy decision. An option to increasing the vehicle-occupancy level is implementing a BRT system.

- NYSDOT conducted a major investment study, the Long Range Congestion Management Plan for Long Island (LITP 2000), to examine these issues. The study examined current conditions and forecasts for the corridor. Currently each weekday morning between 6:00 a.m. and 10:00 a.m. more than 1 million trips start in Nassau and Suffolk counties. Only 11 percent of these trips are destined for Manhattan, while 77 percent end in these two counties. By 2020, there will be 25 percent more households, 30 percent more jobs, and 27 percent more travel during the morning peak-period in the counties. Without a congestion management plan it is estimated that traffic congestion will more than double.

- The LITP 2000 process involved a 40-member Technical Advisory Committee, which included representatives from towns, counties, agencies, and the public. There was also an extensive public involvement process, which included a two-hour live televised town hall meeting to kick-off the study in 1997 and subcommittee visioning sessions. Over 500

suggestions were received through these efforts. The study process involved screening and technical evaluation of multi-modal alternatives.

- The first screening phase include evaluating 13 regional, but single-mode solutions that focused on TDM, HOV lanes, highways, and transit. The results of this screening indicated that no single-mode solution worked. The best performing elements were combined into four multimodal alternatives that were evaluated in more detail. The first alternative included a rapid commute transit system, priority lane system, rapid commute vehicles (RCVs), HOV 2+, and complementary roadway widening extensions. The second alternative included rapid commute transit system, priority lane system, RCVs, HOV 3+, value pricing, parking charges at destinations, and complementary roadway improvements. Alternative three focused on roadway improvements with 2+ HOV lanes on the Southern State Parkway. Alternative four involved roadway improvements with HOT lanes on the Northern State Parkway.

- The four alternatives were evaluated by a number of different performance measures. These included miles of automobile travel, the number of automobile trips, miles of congestion, hours of congestion delay, people per automobile, transit speed, automobile speed, hours of truck delay, percent transit, and tailpipe emissions levels. The performance measures were evaluated using the 2020 forecast for the morning peak-period. Alternative one emerged as the most effective alternative for the funding.

- Elements of the proposed plan include using RCVs, which would be sleek, rubber tired vehicles to provide surface rapid transit for Long Island. The system would be responsive to the diverse travel patterns on Long Island and would provide additional travel choices for residents. It would be coordinated with other travel modes for maximum efficiency. The system would be comprehensive and flexible. Routes could be adapted to address unforeseen changes in demographics and traveler needs. Modern sleek vehicles, using clean fuel technology would be used. The system is key to achieving long-term sustainable congestion relief. It is estimated that more than 200,000 daily customers would use the system in the completion year.

- Priority treatments on roadways and at signalized intersections are also key elements of the proposed plan. These elements include 68 miles of new priority lanes, transit priority at selected traffic signals, and bypass lanes at key intersections on arterial roadways.

- Additional elements of the proposed plan include local bus system improvements, enhancements to the Long Island Railroad, roadway improvements, and ITS. The roadway improvements include 122 miles of arterial street widenings and six miles of extensions. Other elements of the proposal plan include intermodal rail/truck facilities, increased railcar clearances, bicycle and pedestrian facilities, TDM, local safe streets and traffic calming programs, and the Nassau Hub transportation system.

- Public outreach was an important part of the study. There were 12 public information open houses held with more than 400 people attending. Public input was also obtained through surveys at a local mall. A total of 337 questionnaires were completed at the mall. Approximately 92 percent of those surveyed said the LIRC Transit System was needed. Some 85 percent indicated they would use LIRC if it provided frequent service, saved time, had reasonable fares, and had modern, comfortable clean-fueled vehicles. Further, 86 percent supported roadway widenings and extensions.

- The next steps in the planning process involve releasing the draft plan and a staged implementation strategy, obtaining public review and comment, obtaining review and approval of the final plan by the appropriate committees, and incorporating the final plan into the Long-Range Plan.

- The implementation strategy includes a major focus on transit solutions. More than half of all planned general-purpose roadway improvements would be implemented after 2015. Development of a financial plan for the new LIRC transit system is needed to outline capital and operating costs and to identify an agency to operate the system. The transit system would be implemented in stages, focusing on serving major travel generators first and making use of the existing investment in LIE HOV lanes. Early initiatives might include local transit improvements, traffic calming, bicycle and pedestrian facilities, and TDM activities.

BRT and Arterial HOV Planning in Smaller Urban Areas – the SR 303 Corridor Study Experience

John Perlic
Parametrix

Mr. John Perlic discussed a project in the SR 303 corridor in Bremerton, Washington. The project combines arterial street HOV facilities, BRT, and local planning. He summarized the current conditions in the corridor, the study process, the alternatives examined, and the preferred alternatives. Mr. Perlic covered the following points in his presentation.

- The project is an example of combining arterial street HOV elements, BRT, and local land use planning. The SR 303 corridor is approximately 11 miles long. Silverdale, located at the north end of the corridor, includes commercial buildings, retail developments, and a major hospital. The south end of the corridor is in Bremerton, which contains the Puget Sound Navel Shipyard and the Washington State Ferry Terminal.

- Bremerton is experiencing significant redevelopment activities. A regional conference center is under development adjacent to the ferry terminal. A tunnel is also being planned to divert traffic to and from the ferry terminal away from the city streets. Traffic volumes in the corridor range from 30,000 in the north end to 42,000 in the south end.

- The study began with the development of 15 alternatives. An initial screening process reduced the number of alternatives to six. Elements in the initial alternatives included new bridge crossings, which were fairly controversial. Other alternatives included widening the 303 corridor, including the Warren Avenue Bridge and widening parallel arterials without increasing the bridge capacity.

- The study was funded through a four-agency partnership. The four agencies were WSDOT, Kitsap Transit, Kitsap County, and the City of Bremerton. A technical committee and a stakeholder committee helped oversee the study. These committees made recommendations to the policy committee, which was comprised of the Mayor of Bremerton, the Kitsap County Commissioner, the Director of Kitsap Transit, and the WSDOT Regional Administrator.

- The selected alternative focuses on adding arterial street HOV lanes between 11th Street and

Fairground Road. To address concerns expressed by business representatives in the corridor, a peak-period only HOV operation was recommended. Signal priority for buses was part of the selected alternative, as was elimination of some left turn lanes and U-turns.

- Once the preferred alternative was identified, consideration was given to integrating BRT into the arterial street HOV system. The current transit service in the corridor is somewhat disjointed and there are no direct routes from Bremerton to Silverdale. A BRT service plan was developed for the corridor. The service plan includes local feeder routes. Flex-routes were proposed as feeder service for some low density areas. Other elements of the plan include direct access for buses at the ferry terminal, transit centers, and improved park-and-ride facilities. There are also opportunities to integrate BRT into new developments in the corridor.

- It is envisioned that it will take 20 to 30 years to implement all aspects of the plan. Project elements will be phased to match available funding. The city is examining possible updates to its land use plan to support project elements. The partnership between the City of Bremerton, Kitsap County, Kitsap Transit, and WSDOT has been critical to advancing the project. The public outreach efforts throughout the study were also important to obtain support from community groups.

HOV, HOT, and BRT Analysis in Portland, Oregon

Alan Snook
DKS Associates

Mr. Alan Snook described recent studies and projects in Portland focusing on HOT lanes, HOV facilities, and BRT. He discussed the projects, the analysis methods used in the studies, and the results. He noted that Randy McCourt, DKS Associates, had developed the presentation but was unable to attend the session. Mr. Snook covered the following points in his presentation.

- The projects are located in three different corridors. The first project is in the Oregon 217 freeway corridor. The Oregon Department of Transportation (ODOT) sponsored study examined HOT and HOV treatments and the efficiency of the general-purpose lanes in a seven-to-eight mile segment. The second project, on US 26, is also under ODOT jurisdiction. A five mile section of US 26 was examined for possible HOT lanes. The third project is the South Corridor Draft Environmental Impact Statement (DEIS) study. This Metro project considered BRT, LRT, and busway alternatives.

- An analysis of HOT, HOV, and general-purpose lane options was conducted in the Oregon 217 Freeway study using the FREQ model. The assessment examined the performance of both HOV and HOT alternatives compared to general-purpose options, with widening of the facility by 2020. One of the biggest operational effects was capacity reduction on the freeway due to rain. The Portland area has about 250 days of rain a year, which requires calibrating the FREQ model to allow for seasonal variations. This adjustment reduces capacity by approximately 10 to 15 percent.

- The FREQ analysis examined user groups and trip lengths. The evaluation identified weaving problems associated with short trip lengths and substandard access spacing, which reduced the effectiveness of the HOV and HOT alternatives. Drop-in access would be important to reduce turbulence with weaving movements and to preserve operational benefits. Braided ramps became a key capital item. The frequency of access points is less then optimal for HOV and HOT operations, as the number of short trips limits possible benefits. Ramp meter bypass lanes and exclusive ramps were also identified as important. Finally, the analysis pointed out the benefits of a system-wide approach that considered facilities beyond Oregon 217.

- The US 26 HOT analysis focused on preliminary EMME/2 forecasts of tolling options in the corridor. The facility is currently very congested in both directions in the peak periods with travel speeds of approximately 20 mph. Current travelers experience 10 to 15 minute delays on the mainline with ramp meter delays of 5 to 10 minutes during the peak periods.

- The vehicle volumes in the 2020 forecast are 40 percent to 50 percent higher than existing levels, resulting in more congestion on the facility. The analysis indicated that toll lanes could achieve utilization up to 1,200 vehicle per hour (vph) at a relatively low toll of less than one dollar. The demand forecasts were very elastic to the toll level, with large demand reduction with higher tolls.

- One issue in the analysis was the location of the HOT lane. The assessment indicated that using the outside travel lane created problems with turbulence from vehicles merging through the lane. An analysis of the I-5 HOV lanes suggested issues associated with merge conditions. The more lanes on a facility the greater potential for impacts. Vehicles took 0.5

miles to merge through the first two lanes at speeds of 10 to 20 mph and 0.1 to 0.2 miles to merge across the last lane at speeds of 30 to 40 mph.

- The BRT, Busway, and LRT analysis in the corridor utilized the compute models VISSIM, Synchro, and EMME/2 to evaluate the operational effects of the options. Key issues with the BRT option included the length of the queue bypass, the impact on general-purpose traffic, and side street delay.

- The South Corridor study is still underway, but preliminary findings available using VISSIM provided an assessment with BRT and without BRT. The vehicle forecasts considered the build and no-build options. The value of queue jump lanes to bus transit operations is being assessed and pedestrian crossing impacts are being reviewed.

- A number of possible impacts from the BRT transit signal priority and queue jump are being examined. One preliminary result indicates a slight increase in side street delays. Queue lengths are reduced on the main line and increased slightly on side streets. Delays to transit vehicles are reduced. Vehicle travel times decreased on the main line and increased slightly on side streets.

Incorporating BRT into Alternatives Analysis
Roderick Diaz
Booz Allen Hamilton

Mr. Roderick Diaz discussed incorporating BRT into the alternatives analysis process. He summarized the unique characteristics of BRT, highlighted the development of BRT operating plans, and described approaches for incorporating BRT into the Alternatives Analysis process. Mr. Diaz covered the following points in his presentation.

- BRT incorporates many different transit solutions. BRT may address urban circulation, cross-town services, regional travel, and commuter services. BRT can serve many different markets.

- The building blocks of BRT can be implemented over time, which provides flexibility in system development. The main components of BRT include unique vehicles, some type of guideway or reserved lanes, control systems, passenger information systems, and fare systems.

- BRT operating plans provide flexibility through a toolkit approach. Elements of a BRT operating plan include the route structure, bus stop and station spacing, service frequency, span of service, and the network structure. BRT can be integrated with other transit services in the area.

- The BRT operation plan will dictate the appropriate building blocks. Vehicle elements include the size and length, floor height, propulsion system, and on-board diagnostics. Fare collection elements include the location of fare payment equipment and the method of fare validation.

- Factors to consider in determining the appropriate guideway include design speed, control of access, grade crossing control, links to vehicle location, illumination, and noise and safety barriers. Station design will need to consider platform length and height, canopy design, and

integration with desired amenities. Communication systems may include operator dispatch, passenger information techniques (PA/VMS), and security monitoring.

- An overlapping route structure with high frequencies indicates the need for a wide guideway with passing at stations. If all-door boarding is desired, off-vehicle ticket vending and fare validating machines will be needed.

- BRT can be developed incrementally over time. The BRT building blocks can be staged to match available funding and the needs of specific areas. BRT systems can move from initial bus rapid transit, to intermediate stages of BRT, all the way to full BRT.

- BRT has a mutually supportive relationship with urban development. Supporting qualities of BRT include accessibility, land use integration, and pedestrian access. Requirements of other modes are characterized more by mobility, land use separation, and vehicle access.

- The characteristics of BRT have implications for how it is incorporated into the Alternatives Analysis process. Bus Rapid Transit incorporates many different transit solutions and the building blocks of BRT can be implemented over time. The operating plan itself can also be flexible using a toolkit approach. The operating plan drives what building blocks are required. BRT can be developed in several stages. BRT has a mutually supportive relationship with urban development.

- The development of a BRT operating plan can be accelerated. Elements of the operating plan can be matched with advanced technologies to provide additional priority treatments for buses and real-time information to passengers. Different levels of service can be evaluated to capture the range of options. A combination of building blocks can be identified and evaluated for each BRT alternative. For example, true low-floor vehicles and partial low-floor vehicles may be considered.

- The benefits of the different building blocks on improved service can be evaluated. AVL and TSP can result in greater reliability and reduced delay at stops. Low-floor buses, limited stops, and partial prepayment of fares can result in reduced dwell time and improved service and image. Separate lanes or rights-of-way and traffic signal preemption provides faster speeds, greater reliability, and improved safety. Full prepayment of fares, articulated vehicles, and reduced number of crossings results in greater capacity, increased user friendliness, and faster speeds. Full grade separation, electric propulsion, and electronic guidance provide maximum speeds, smoother rides, and a stronger service image.

- The synergies with other modes should be considered with the realization of different needs and requirements. For example, there are synergies with BRT and HOV. High- density corridors can often support both high-quality transit and HOV facilities. Requirements for all day bi-directional traffic can justify conversion, expansion, or construction of lanes for BRT/HOV use. Comprehensive BRT networks can incorporate HOV facilities for at least part of the network. Intermodal centers common at BRT facilities can serve to collect and distribute both transit passengers and HOV participants. There are also challenges in coordinating BRT and HOV. Design of regularly-spaced stations requires additional right-of-way for station sites, pedestrian access facilities, and bus pull-off facilities. High frequencies of buses require lower volumes of HOV traffic in order to maintain speed and reliability.

- The Alternative Analysis process can be used as a strategic document to jump-start initial BRT initiatives. The process identifies enablers and barriers to implementation. It can also help coordinate procurements and identify potential partners. Other qualitative benefits should also be considered. Possible benefits may include land use integration, community linkages, accessibility, and property value impacts.

- BRT's qualities bring new imperatives to the Alternatives Analysis process. BRT allows for accelerated development of the operating plan. More than one BRT alternative can be analyzed to capture the full range of options. The combination of building blocks should be defined for each alternative in detail. Potential benefits should be accounted for when they accrue and qualitative benefits should be included. The process should consider synergies with other modes, but should be cognizant of different needs and requirements. The Alternatives Analysis process can be used as a strategic document to jump-start initial BRT initiatives.

Managed Lanes Track

Introduction to Managed Lanes

Carlos Lopez, Texas Department of Transportation, Moderator

Managed Lanes – A "New" or a "Renewed" Idea?

Robert Spillar
Parsons Brinckerhoff

Mr. Robert Spillar discussed the managed lanes concept and provided examples of managed lane projects in North America. He summarized the WSDOT Puget Sound Managed Lane Study, which was conducted by Parsons Brinckerhoff. He noted the assistance of Mr. Robert Fellows, Parsons Brinckerhoff, and Mr. Charles Prestrud, WSDOT, with the presentation and project. Mr. Spillar covered the following points in his presentation.

- Managed lanes are a dedicated lane system for one or more user groups. Managed lanes provide tools to optimize lane throughput. The intent of managed lanes is to provide unimpeded travel during periods of peak demand. Managed lanes may provide benefits to both users and to the roadway system as a whole. Possible user benefits include more reliable travel times, reduced delay, and more choices. Potential system benefits include increasing throughput, opening up mainline capacity, encouraging transit and carpool use, preserving options in corridor, and enhancing emergency response.

- In many respects the ideas and concepts associated with managed lanes are not new. The I-5 and I-90 express lanes in Seattle, the Dan Ryan Expressway in Chicago, and the HOV lanes in Northern Virginia, Seattle, Houston, Los Angeles, and other areas all represent examples of managed lanes.

- While these projects and other similar facilities have been in operation for many of years, significant interest has recently focused on the managed lanes concept. There may be benefits to thinking of managed lanes as a renewed concept rather than a new concept. Public agencies often perceive risks associated with new concepts and new technologies. Change may also be uncomfortable for public agencies. There may be a perception of displaced traffic to arterials or general-purpose lanes with the managed lanes concept. Tolls may be controversial in some areas and the public may react negatively to perceived government management.

- The WSDOT Puget Sound Managed Lane Study was conducted for a number of reasons. The existing HOV system in the area is mature and well used at the 2+ occupancy level. Express lane networks have been operating on I-90 and I-5 for a long time. There are also arterial street HOV lanes and business access transit lanes in the area. To some extent, the HOV system in the area is at a crossroads.

- A number of criteria have been used to measure the success of HOV facilities in the region. These measures include travel time savings, person throughput, transit operations, modal shift, and vehicle volumes. A balance must be achieved with use of HOV facilities. Too little demand, with use levels lower than 800 vehicles an hour, can lead to political failure. Too much demand, with 1,800 more vehicles an hour, can result in operational failure.

- A broader management objective or theory may be appropriate in attempting to optimize throughput by managing the lanes. Other management objectives may address person throughput, transit speed and reliability, travel time savings, carpool incentives, maximizing revenues, and coordinating with land use and development.

- Vehicle eligibility, occupancy levels, access control, and pricing may all be used to manage a facility. Management by eligibility might focus on vehicle-occupancy levels, transit-only, vehicle type, and authorization by permit, time-of-day or destination. Examples of management by access control include express lanes with limited general-purpose entrances, additional HOV access, and reversible lanes by time-of-day. Management by pricing might include variable pricing by time-of-day, by vehicle type, and by occupancy levels.

- Automated tolling can greatly enhance access to managed lanes by reducing delay typically associated with toll booths. Automated tolling allows registered vehicles to travel through toll plazas at posted speed limits, bypassing delays at toll booths.

- Managed lanes can encourage HOV use through pricing. The SR 91 project initially allowed 3+ carpools to travel free of charge. Preferential pricing is now provided for 3+ carpools on the facility.

- The Puget Sound region has a number of existing facilities that can be categorized as managed lanes. These facilities include the I-5 and I-90 express lanes, the I-405 2+ HOV lanes, the SR 520 3+ HOV lanes, the Ferry Fast lanes for registered vanpools, the SR 522 transit-only lane, the SR 99 business access, arterial transit only lanes, and HOV pass lanes at metered freeway on-ramps.

- There are a number of new managed lane options that might be appropriate for further consideration in the Puget Sound region. One option would be to combine HOV and other user groups. This approach might involve pricing single-occupant vehicles and 2+ HOVs, while allowing 3+ HOVs to travel for free. Managing access by selected user groups represents another option. Arterial applications may also be appropriate. Dynamic user group restrictions, such as allowing HOVs in the peak periods and trucks or single-occupant vehicles in the off peak-periods, represents still another possible option.

- Many of the elements of the managed lanes concept have been in operation in Seattle and other areas for many years. There appears to be advantages to considering further application of the managed lanes concept to address congestion, mobility, and air quality concerns.

Life-Cycle Graphical Representation of Managed HOV Lane Evolution
Myron Swisher
Colorado Department of Transportation

Mr. Myron Swisher, described a graphical tool developed to help represent the evolution of HOV lanes into managed lanes. He noted the assistance of Dr. Bill Eisele and Ms. Ginger Goodin, TTI, and Mr. David Ungemah, UrbanTrans Consultants, Inc., in the development of the tool and some of the applications presented. He provided a definition of managed HOV lanes and described some of the concerns and opportunities with managed HOV lanes. He described the development of the life-cycle graphic and provided examples of its use. Mr. Swisher covered the following points in this presentation.

- The managed HOV lanes concept is to utilize any excess capacity on an HOV facility without jeopardizing travel speeds. Managed HOV lanes use a combination of design and operating strategies to maximize roadway capacity, while maintaining freeflow conditions and achieving corridor and community goals. Managed HOV lanes provide flexibility, as operational modifications may be made in response to changing conditions.

- While the HOV traffic grows over time, the vehicle capacity of an HOV lane is consistent. Managed HOV lanes can be used to address this problem by maximizing available capacity by allowing different user groups over the life of an HOV project.

- The graphical tool was developed by the Colorado Department of Transportation (CDOT) to address concerns about the managed HOV lane concept from local transit agencies and HOV advocates. Concerns were raised by these groups over the possible loss of travel speeds as non-HOV volumes grow. There were also issues raised that allowing other user groups to use the HOV lanes would be viewed by the public as a permanent change.

- The graphic tool was developed to demonstrate the concept of HOV lanes evolving into managed lanes. The tool shows how the vehicle-occupancy levels and vehicle eligibility can be raised and changed as vehicle volumes increase on an HOV lane. The tool has been tested using vehicle and person volumes from HOV facilities in Colorado, Texas, and California. It also highlights alternative management strategies that can be used to accomplish different goals. The graphic tool illustrates outcomes based on different alternatives.

- The use of the life-cycle graphic tool has a number of benefits. First, it helps explain the reason and the timing for possible single-occupant vehicle use of an HOV facility. It also helps illustrate the "Empty Lane Syndrome" and how to avoid it. The tool can be used to describe evolving operating scenarios for an HOV facility. It can help transportation officials establish user priorities and critical operating thresholds for managed HOV lanes.

- The life-cycle graphic tool appears to be appropriate for application in a number of scenarios. It could be used in an Alternative Analysis to examine the impact of the "no-build" option. The tool could be used to examine geometric alternatives, including access and enforcement locations. It could also be applied to consider operational alternatives, such as vehicle eligibility and operating hours. Finally, the tool may be appropriate in performance measurement, including examining person throughput and revenue maximization.

A Legislative Framework for Operating Managed Lanes
Beverly Kuhn
Texas Transportation Institute

Dr. Beverly Kuhn discussed legislative issues related to the implementation and operation of managed lanes. She highlighted the results of recent research conducted by the Texas Transportation Institute (TTI) for the Texas Department of Transportation (TxDOT). The multi-year project is examining a number of topics related to planning, designing, funding, and operating managed lanes. She noted the assistance of Debbie Jasek, TTI, in the development of the legislative analysis. Dr. Kuhn addressed the following points in her presentation.

- Managed lanes have been defined in this research project as "a facility that increases freeway efficiency by packaging various operational and design actions. Lane management

operations may be adjusted at any time to better match regional goals." Managed lanes may be a lane or group of lanes with a combination of operating and design strategies that maximize person moving capacity, optimize vehicle carrying capacity, provide travel options and increase flexibility, and achieve corridor and community goals. Managed lanes are designed for flexibility so service options can be modified over time.

- Examples of managed lanes include HOV lanes, HOT lanes, value-priced lanes, express lanes, bypass lanes, dual facilities, and lane restrictions. One of the first questions to be considered in the planning process for a managed lane project is what user groups should be served.

The focus of the TxDOT managed lanes research project is to develop a better understanding of how managed lanes can improve mobility for people and freight. The two major project objectives are to investigate the complex and interrelated issues surrounding the safe and efficient operation of managed lanes and to develop a comprehensive manual to help TxDOT make informed decisions.

- The research project involves a number of tasks. A literature review has been completed. A symposium was held to initiate discussion of the major topics related to managed lanes. Issues related to marketing, designing, planning, estimating demand, funding, and enforcing managed lanes were examined. Upcoming tasks focus on travel information needs, incident management, interoperability, traffic control devices, interim use, and monitoring and evaluating managed lanes.

- The legislative framework needed to support managed lanes was explored. Legislation at both the federal and the state levels was examined related to designing, operating, and enforcing the various types of managed lanes.

- From a federal perspective, authorization is either explicitly authorized or implied for most types of managed lane facilities. The need to remove “pilot” wording from the federal value-price/HOT lane program was identified as important. At the state level, additional legislation or changes to existing legislation may be needed to advance many types of managed lanes. There may be a need to define managed lanes in legislation and to authorize transportation agencies to operate all types of strategies to make operational changes. For example, ILEV authorization following federal regulations may be needed. Legislation related to lane restrictions, such as allowing full-time operation or restricting vehicles from designated lanes, may also be needed.

- Enforcement is another area where it appears further legislation is needed. Topics to be addressed include ensuring the appropriate agencies have the authority to enforce laws, making it illegal to violate the regulations of managed lane facilities, and allowing enforcement methods to change as technology becomes available.

- It appears that legislation broadening the powers of state departments of transportation and other transportation organizations is needed to fully realize the managed lanes concept. Legislation provides the tools needed to implement managed lane facilities effectively.

Telling the Managed Lanes Story

Bill Stockton, Texas Transportation Institute, Moderator

Concept Marketing of Managed Lanes

Tina Collier
Texas Transportation Institute

Ms. Tina Collier discussed approaches for marketing managed lane projects. She summarized the results of recent research conducted by TTI for TxDOT. The multi-year project is examining a number of topics related to planning, designing, funding, and operating managed lanes. She recognized the assistance of Ms. Ginger Goodin, TTI, in the study. Ms. Collier covered the following points in her presentation.

- Managed lanes have been defined in this research project as "a facility that increases freeway efficiency by packaging various operation and design actions. Lane management operations may be adjusted at any time to better match regional goals." Managed lanes may be a lane or group of lanes with a combination of operating and design strategies that maximize person moving capacity, optimize vehicle carrying capacity, provide travel options and increase flexibility, and achieve corridor and community goals. Managed lanes are designed for flexibility so service options can be modified over time.

- The marketing and public education efforts associated with 10 managed lane case studies throughout the country were examined. The case studies explored the methods used communicate with the public, the messages, the techniques for gaining public support, and the perception of the public toward the project. The types of messages and the techniques that appeared to have the most influence were examined. The appropriate groups and individuals to deliver the messages were also identified

- A number of common themes or messages were found with successful managed lane projects. These themes included focusing on providing mobility choices, improving travel choices, and enhancing the efficient use of roadway capacity. Communicating how the facility will operate, how it would be enforced, how the revenues will be used, and how it will be funded was also identified as important.

- Marketing efforts for managed lanes focus on a number of different audiences. These audiences include elected officials, community and business leaders, special interest groups, neighborhood groups, the media, commuters in the corridor, and the general public.

- A project champion was also identified as an important element of successful marketing efforts. It appears that an individual or individuals, often not associated with the transportation agency, is the most effective spokesperson for a project.

- Numerous market research techniques and marketing approaches have been used with managed lane projects. These approaches include surveys, focus groups, stakeholder interviews, media coverage, Internet sites, mailings, and exhibits.

- The information obtained from the market research activities indicates negative and positive reactions may be common with the managed lanes concept. Common negative reactions focus on concerns over double taxation, inability to actually improve traffic conditions, and

short-term approaches. Positive reactions focus on improving mobility, increasing revenue generation, and encouraging transit and ridesharing.

Telling the Managed Lanes Story – San Diego's North I-15 Corridor
Dave Schumacher
San Diego Metropolitan Transit Development Board

Mr. Dave Schumacher discussed the I-15 managed lanes project in San Diego. He noted that the project represents the joint efforts of Caltrans, the North County Transit District, the Metropolitan Transit Development Board, and the San Diego Association of Governments. Mr. Schumacher covered the following points in his presentation.

- The North I-15 Corridor is located to the northeast of downtown San Diego. It is characterized by suburban land use patterns with long travel distances. I-15 is the only continuous north-south artery along the 20-mile corridor. The facility is currently congested. The existing freeway does not meet current demand and will not meet future demand.

- The existing HOV lanes were opened in 1987. They are eight miles in length. The facility is a two-lane, one-way reversible operation and is barrier separated. The FasTrak value pricing demonstration began in 1997. It includes dynamic pricing, with no tolls for carpools or transit.

- The FasTrak program developed out of a local elected official's interest in improving transit services in the corridor. He saw the excess capacity on HOV lanes as an opportunity. The FasTrak demonstration program was successfully implemented due to a number of factors. It addressed the under utilization of the HOV lane and has support from local elected officials willing to try a demonstration program.

- The development of the North I-15 Corridor HOV/managed lanes project examined a number of issues. These issues included the need to ensure freeflow conditions for BRT, the desire to extend the FasTrak value pricing program, the need to respond to traffic emergencies, and the need to design for long-term demands. The recommendations included three main elements. The first element recommends pursuing a four-lane managed lanes facility with a moveable barrier. The second component was extending the FasTrak value pricing program. The third element was incorporating direct access ramps and BRT stations as integral parts of the project.

- A number of techniques were used to provide for community involvement in the project. Venues included meetings with established community groups, hearings with public officials, community newspaper articles, one-on-one communications, and multiple agency participation. Key elements of the strategy including developing first-name relationships with community leaders, developing elected officials as champions, and maintaining ongoing contact with community newspapers. One-on-one communications with community and business leaders played a key role. These approaches helped present a united front of coordinated agencies to the public.

- There was also extensive public involvement in examining extending the value pricing program. The key objective of these activities was to assess attitudes and concerns related to both the existing and the proposed projects. The community outreach program included

focus groups, stakeholder interviews, intercept surveys, and a telephone survey.

- Focus groups were conducted with FasTrak users, transit users, and motorists in the general-purpose lanes. The focus groups results showed strong support for the managed lanes concept among all users. Equity was not an issue with the groups. The provision of transit was key in this perception, as was the feeling that the project did not take anything away from the various user groups. Pricing was viewed as fair in terms of paying for premium service.

- Stakeholder interviews were conducted with elected officials, local agency representatives, and members of public interest groups. The results of these interviews indicated that most people viewed the project as a transportation solution. The "Lexus Lane" stigma was muted by inclusion of BRT. Most people saw the project as offering ongoing congestion relief. Many business groups emerged as champions for the project. Support from elected officials was also key, especially during the demonstration phase.

- Carpoolers and transit users were interviewed at park-and-ride lots and bus stations in the corridor. Of the transit users, 84 percent considered pricing fair and saw a need for additional services. Of the 70 carpools interviewed, 92 percent considered pricing fair and 70 percent said that HOV lanes were a factor in their decision to carpool. Thus, the impact of the HOV lanes on carpool formation is noteworthy.

- The results of the qualitative research were used to develop a quantitative telephone survey. The telephone survey was conducted of 600 general-purpose lane users and 200 FasTrak users. The results indicated that 92 percent like the time-saving option, 77 percent agree on allowing single-occupancy vehicle use for a fee, 71 to 75 percent consider value pricing fair, and 84 percent favor the managed lanes project. There was little variation in responses across ethnic and income categories.

- The results of the community involvement were used to develop recommendations for the next steps. The recommendation included speeding up project delivery, enhancing marketing of services, providing transit tied to local needs, addressing long-range issues, considering operational flexibility, and enhancing public education.

- A number of conclusions emerged from the community involvement process. First, it appears FasTrak benefited from previous outreach efforts that forged close community ties. Second, the initial demonstration program benefited from having a local elected official as the project champion. Third, value pricing was woven into the overall multimodal transportation solution in the corridor. Fifth, research provided multi-faceted insight to the value-pricing concept. Finally, the multi-agency cooperation between the MPO, highway department, and transit agencies presented a united front to the public.

- The future pricing strategy focuses on the use of a skewed rate strategy to address value pricing with multiple access points. This strategy offers the best demand management tool, although the complexity of the approach will need to be addressed with motorists through ongoing education.

- The project budget includes funding of BRT stations and transit vehicles. One example of the BRT components is the direct access ramp BRT station at Rancho Bernardo. The Transit Plaza Median Freeway Station at City Heights provides another example of the BRT

elements. It includes a freeway median station with elevator and stair access to arterial streets, an arterial street plaza with widened bridge decks, and dedicated transit lanes. Community and business groups have provided support and funding for station improvements.

- The first stage of construction is scheduled to begin in 2003 and should be completed by 2007. The success of the I-15 Corridor has lead to system-wide coordination of HOV and transit plans.

Public Attitudes about Managed Lane Concepts in the Puget Sound Area
Bruce Brown, Pacific Rim Resources
Mark McCourt, SCR

Mr. Bruce Brown and Mr. Mark McCourt discussed the results of recent surveys conducted in the Puget Sound region and Los Angeles County on public attitudes related to managed lanes. They summarized the research methodology and the results related to perceptions of congestion, HOV use, HOV support, and support for managed lanes and pricing options. Mr. Brown and Mr. McCourt covered the following topics in their presentations.

- In the Puget Sound region, a statistically valid telephone survey of 1,116 adults was conducted using random digit dialing. The survey had a margin of error equal to 2.93 percent at the 95 percent confidence level. The surveys were conducted in May of 2001. The respondents provided an accurate demographic representation for the Puget Sound region and Sound Transit sub-areas, including Snohomish, King, and Pierce counties.

- The Los Angeles County survey focused on all Los Angeles County residents 18 years of age or older. It was distributed by sub-region in proportion to population. The target was 3,200 completed surveys. A total of 3,273 surveys were actually completed. The results had an accuracy of ± 1.0 to 1.7 percent at a 95 percent confidence level.

- In the Puget Sound region, 76 percent of the respondents reported driving alone at least some of the time. Almost a third carpool some of the time, and almost a tenth use transit.

- In Los Angeles County, 74 percent of the respondents indicated driving alone as their normal commute mode. A total of 19 percent reported carpooling, five percent normally take the bus, and one percent each reported taking the train, vanpooling, and walking.

- Almost three-quarters of the respondents in the Puget Sound region reported traveling during the peak hours. Approximately 84 percent of the respondents in Los Angeles County reported commuting on a regular basis, with 64 percent indicating they normally travel during both the morning and afternoon peak periods.

- Most of the respondents in the Puget Sound region reported experiencing some degree of congestion on the freeways, with about a quarter experiencing extreme congestion most of the way. Some 52 percent of the Los Angeles County respondents reported experiencing extreme congestion during the peak hours, while 26 percent experienced congestion most of the time.

- Both surveys asked respondents to indicate the solutions they favored to helping improve traffic flow on freeways. In Los Angeles County, 21 percent favored more transit, 17 percent preferred more freeway lanes, 16 percent favored more HOV lanes, 14 percent preferred

more freeways, and 13 percent favored more rail. Respondents in the Puget Sound region favored managing traffic, with many indicating they did not believe that more roads alone was the solution to addressing the congestion.

- A total of 75 percent of the respondents in Los Angeles County indicated they had used the HOV lanes during peak travel periods, while 73 percent reporting using the HOV lanes during off-peak times. Half the respondents reported only occasional use of the HOV lanes, while 26 percent said they generally use the lanes and 21 percent reported always using the HOV lanes. Travel time savings was the reported reason 57 percent of the respondents said they carpool or vanpool. Cost savings, 18 percent, companionship, 15 percent, and improving traffic conditions, five percent, were the next most reported reasons.

- Approximately 82 percent of the Los Angeles County respondents agreed that the policy approving the use of a portion of sales tax revenues for transit-related highway improvements should be continued. Some 88 percent responded that they supported having carpool lanes on freeways in the county. A total of 89 percent said the carpool lane system should be completed so there is a carpool lane on almost every freeway, and 43 percent strongly supported building more freeway to freeway HOV connections.

- Los Angeles County residents were asked their opinion of a variety of alternate uses of HOV lanes. A total of 44 percent of the respondents disagreed that low emissions vehicles should be allowed to use the carpool lanes regardless of the number of people in the vehicle, while 26 percent agreed that these types of vehicles should be allowed to use the lanes. Half the respondents disagreed that single-occupant vehicles should be allowed to use the carpool lanes if they pay a toll, while 23 percent agreed.

- In the Puget Sound region more than two-thirds of the respondents disagreed strongly with converting existing HOV lanes to HOT lanes. Most reported they would not reduce carpooling, vanpooling, or busing if HOT lanes existed.

- In Los Angeles County, 36 percent of the respondents indicated they would definitely continue carpooling if all carpool lanes were converted to regular lanes. While 38 percent said they would probably continue to carpool. Some 17 percent said they would probably stop carpooling and nine percent indicated they would definitely stop carpooling.

- Less than a third of the Puget Sound respondents support the 3+ HOV lane concept. A bit more expressed support for adding a second HOV lane rather than increasing the vehicle-occupancy level to 3+. Less than a third supported charging 2+ carpools while allowing 3+ carpools to use the lanes for free. Respondents in the Puget Sound region believe the HOV lanes save time, with over half reporting quite a bit to a lot of time saved.

- Some 42 percent of the Los Angeles County respondents felt the HOV lanes were under utilized, while 37 percent felt use levels were just about right, 8 percent said they were over utilized, and 13 percent were neutral or had no opinion. A total of 74 percent of the respondents agreed or strongly agreed that the HOV lanes are more efficient than regular freeway lanes. Approximately 61 percent indicated the carpool bypass lanes on-ramps were fairly effective or very effective in encouraging people to carpool.

- Half the Los Angeles County respondents felt that converting the existing carpool lanes to regular lanes would make travel on Los Angeles County freeways worse, while 25 percent

felt conditions would be better and 25 percent felt it would have no impact. Statements receiving the most support from respondents include “carpool lanes are a strong incentive to get people to carpool,” “carpool lanes are more efficient than regular freeway lanes,” and “carpool lanes reduce congestion in all lanes.

- A little more than 40 percent of the Puget Sound respondents reported a willingness to pay tolls for a faster trip. A little more than a quarter are willing to pay tolls one to three times a week. There was no difference in willingness to pay tolls by income level.

- The public opinion findings from the Puget Sound region and Los Angeles County indicate that people believe HOV lanes save time. A majority disagrees or strongly disagrees with converting existing HOV lanes to HOT lanes. Most respondents would not reduce their carpooling, vanpooling, or bus use if HOT lanes existed. Most respondents in the Puget Sound region do not support a 3+ vehicle-occupancy requirement. A little more than 40 percent of the Puget Sound respondents are willing to pay tolls for a faster trip.

Value Pricing, Part One

King Cushman, Puget Sound Regional Council, Moderator

Pricing Status on SR 91

Kia Mortazavi
Orange County Transportation Authority

Ms. Kia Mortazavi discussed the SR 91 Express Lanes in Orange County, California. She summarized the legislation authorizing the project, the development and operation of the Express Lanes, the recent acquisition by OCTA, and the future outlook for the facility. Ms. Mortazavi covered the following points in her presentation.

- The SR 91 Express Lanes are located in the center median of SR 91 in northeastern Orange County. The lanes were developed through special state legislation allowing private toll roads on some state roadways. The legislation represents one approach taken in California to address the demand for roadways in a time of limited funding.

- The privatization concept focuses on the private sector building and maintaining new highway capacity within public roadway rights-of-way. The project includes a 35-year franchise agreement with the California Private Transportation Corporation (CPTC) to construct and operate the toll lanes. At the end of this period the road would be turned over to Caltrans.

- The franchise agreement included a non-compete clause. The non-compete clause created a 1.5 mile protection zone along each side of the SR 91. No improvements could be made in other freeways and roadways in the protection zone.

- This non-compete clause limited OCTA’s and Caltrans’ ability to respond to increasing demands in the corridor. Over the next 25 years Orange County is projected to add 540,000 jobs. Riverside County’s population is projected to increase by 1 million people, or some 85 percent.

- If the non-compete zone was kept in place it was expected that speeds in the SR 91 regular lanes would experience a decrease of 75 percent by 2030. In addition, the non-compete clause raised issues related to planning and funding other transportation facilities in the region.

- OCTA's acquisition of the SR 91 Express Lanes offers a solution. OCTA is purchasing the facility for $207.5 million. OCTA will assume CPTC's $135 million taxable bonds and pay $72.5 million in cash. The acquisition is contingent upon due diligence review, tolling legislation, and dismissal of pending litigation.

- The benefits of OCTA's acquisition of the SR 91 Express Lanes include eliminating the non-compete clause, ending current litigation, and initiating work on other highway improvements in the corridor. Other benefits include optimizing traffic flow for the public good, allowing 3+ carpools to use the lanes for free, lowering financing costs, and returning the lanes to public ownership.

- The acquisition process included a number of steps. First, a technical analysis was conducted of maintaining the tolls or allowing free use. Second, a cash flow analysis was conducted. Third, numerous meetings were held with elected officials and legislators in the area. Fourth, an independent fairness opinion was obtained. OCTA reached an agreement with CPTC and legislation was drafted to allow for the acquisition.

- A number of near-term roadway improvements are being considered in the area. The improvements will proceed once the acquisition is finalized. Anticipated projects include building auxiliary lanes in some sections, adding storage at truck scales, and addressing problems at downstream interchanges. A number of longer-term improvements are also being studied, including adding through lanes, adding capacity in Riverside County, expanding freeway-to-freeway interchanges and access, and adding downstream capacity.

- The next steps in the acquisition process include signing the agreements and completing traffic and revenue studies. A corridor advisory panel will also be established. If the process progresses as planned, OCTA will assume CPTC's debt and takeover operations in January 2003. Refinancing tax-exempt securities will occur by the summer of 2003.

- A number of lessons have been learned from the SR 91 Express Lanes. First, it appears that evolution follows revolution. While the Express Lanes concept was considered revolutionary at the time, the project evolved differently than was originally anticipated. In developing these types of projects, consideration should be given to LOS-based escape clauses. Developing new approaches is not always easy and often involves many unforeseen circumstances.

The New Texas Turnpike Authority and Texas Toll Roads – Evolution or Revolution?
Brett Jackson
Federal Highway Administration

Mr. Brett Jackson discussed the Central Texas Turnpike (CTTP) Project and the TxDOT Texas Turnpike Authority Division. He summarized the project and highlighted the financing, the design elements, and the future options. He also described recent legislation allowing for the creation of Regional Mobility Authorities (RMAs) in Texas. Mr. Jackson covered the following points in his presentation.

- The CTTP consists of 122 miles of new tolled freeway in central Texas. The project cost is currently estimated at $3.6 billion. The CTTP will serve the area around the city of Austin, which is located in the third fastest growing county in the country.

- The CTTP consists of four distinct projects. Separate Environmental Impact Statements (EIS) were completed on each segment in an average of 26 months. The first project is SH 45, a freeway on existing and new alignments. The second project is an extension of Loop 1, which connects to SH 45 and will eventually connect to I-35. The third project is US 183A, a bypass of the heavily congested US 183 around the city of Cedar Park. The fourth project is SH 130, a 90-mile section of new freeway being constructed under an exclusive development agreement. A design, build, warranty, maintain, and operate agreement is being used on the project.

- Innovative financing is being used on all four projects. Funding sources include bonds, a Transportation Infrastructure Finance and Innovation Act (TIFIA) Loan, STIP funds, and contributions of local rights-of-way. The use of short term Bond Anticipated Notes (BANs) will save some $75 million.

- The four projects represent the first tolled highways in central Texas. They will also deploy the first system to use interchangeable electronic toll collection in the state. The projects incorporate state-of-the-art ITS traffic management systems and telecommunications technologies. They also represent the first delivery of state highway improvements through public-private partnerships and a wide range of innovative financing methods. The projects will provide relief to the region's mobility crisis and deliver a safer, more economical transportation system.

- A typical cross-section includes three traffic lanes and three auxiliary lanes in each direction. The center median is reserved for future HOV lanes. Non-continuous frontage roads are provided.

- The anticipated tolls are based on a traffic and revenue study. The study included the examination of demographics, origin-destination pairs, traffic demand, and other factors such as NAFTA use and avoidance of I-35. The toll cost per mile of $.15 is competitive with other major projects in the country. Consideration will be given to use cost increases per year.

- Legislation allowing for the creation of RMAs in Texas was passed in 2001. Williamson and Travis counties are the first to establish an RMA. This approach provides more local input and takes some of the burden off the state's financial and workload deficit. The RMAs first project is US 183A. Legislation to be considered in 2003 would allow the RMA to issue bonds.

- These projects are innovative in many respects. They represent the first use of the design-build approaches in Texas and are one of the largest projects in the country using this approach. Innovative finance is being used to fund the projects. A total of 120 miles of toll facilities will be completed in five years. The average EIS process is taking approximately 2.5 years.

Violations: The Achilles Heal of Electronic Toll Collection

Jerry Hautamaki
HNTB Corporation

Mr. Hautamaki discussed the use of electronic toll collection (ETC) with managed lanes and value pricing. He provided an overview of ETC, the benefits and challenges of ETC, and approaches for violation enforcement. He also reviewed the experience with ETC in the U.S. Mr. Hautamaki addressed the following points in his presentation.

- ETC is an enabling technology for managed lanes, congestion pricing, and other pricing-based strategies for reducing congestion. Using ETC on open-flow, non-stop roads, however, creates the opportunity for violations by driving without a transponder in the vehicle.

- Key components of ETC are the toll plaza with electronic readers and transponder tags on vehicles, which contain pre-paid accounts. The transponders are read as vehicles travel through toll plazas at posted speeds. The toll amount is electronically debited from the transponder account. The toll plazas are also equipped with cameras, which are activated electronically if a vehicle does not have a valid transponder. The license plate of the vehicle is photographed and a citation is sent to the vehicle owner.

- The use of ETC has significantly decreased delays at toll plazas, as vehicles with transponders no longer need to stop to pay tolls. Enrollment in ETC programs has grown dramatically over the past few years. Currently, ETC tag use includes some 8 million in the northeastern states, approximately 2.5 million in Oklahoma and Texas, 1.5 million in California, 1 million in Florida, and .5 million in Illinois. In addition, it is estimated that the trucking industry uses some 5 million tags.

- Enforcing ETC is important for a number of reasons including creating a credible deterrent to violators, recovering revenues, building customer loyalty and trust, and converting violators to customers. Political sensitivity and legal requirements will need to be factored into enforcement strategies. Without a credible and visible enforcement program, violations will increase. Experience indicates that violation rates are typically in the three-to-four percent range with enforcement programs and over 10 percent without programs. Revenues at a typical toll facility are in the range of $50 million to $500 million a year. Thus, every one percent of lost revenue due to non-payment represents between $500,000 to $5 million annually.

- Customer loyalty and trust are key components of a successful toll operation. If customers know that others are cheating and not paying, they will be angry. This anger may spill over and negatively impact the image of the toll operation.

- Most toll agencies try to convert violators to customers. Some agencies allow violators to avoid fines by establishing and maintaining an ETC account. All toll agencies operate within a political environment. Angry customers frequently voice their concerns to politicians. It is very uncomfortable to have to explain to a legislative hearing why people are cheating the toll agency.

- Most toll facilities are financed by the sale of bonds, backed by future toll revenues. Bond covenants typically require accurate and complete accounting of vehicles and revenues, and require that all users be charged. Violations can be interpreted as failure to comply with the

bond covenants.

- Implementing an enforcement program involves a number of steps. First, enabling legislation authorizing violation enforcement must be in place. Second, cameras and other enforcement equipment must be installed. Third, a method must be established for processing the violations and collecting the fines. Processing violation requires staff. Problems may occur with video images due to dirt on license plates, small motorcycle plates, and tandem trailers.

- The experience at three agencies provides examples of toll violation enforcement. The first agency operates 225 toll lanes, of which 53 lanes have cameras. The agency experiences some 1 million transactions a day, with the camera lanes accounting for some 650,000 of these. The agency experiences 28,000 violations a day or about 4.3 percent. About 3,000 are billed to known customers. After three violations in 30 days a letter is sent to the vehicle owner with a $25 per violation fee. Thus, the minimum fine for the first letter is $75. Approximately 1,200 to 1,500 letters are sent a day. Approximately 40 percent of the violators pay upon receipt of the first letter. After 30 days, unpaid fines become a traffic citation and a violator has to go to court. The agency has never lost a case in court. The agency representative is in court one-to-two days a week. Approximately $1.25 million in revenues are generated each year from the fines. The agency employs 21 people in the violation department. The toll agency worked hard to educate courts and District Attorneys about toll violations. Approximately 30 percent of offenders get accounts through the Violation Waivers program.

- The second agency operates 235 toll lanes, of which 39 have cameras. There are 750,000 transactions a day in the camera-equipped lanes. There are 30,000 violations a day or four percent of the total transactions in these lanes. Of this amount, some 37 percent are one-time violators who are not seen again and 23 percent are two-time violators who are not seen again. After the third violation in 12 months a letter is sent to the vehicle owner. The fine is $15, plus $3 in tolls for a total fine of $18. The agency sends 37,000 letters a month or 1,800 a day. Approximately 80 percent of those receiving a letter pay the fine. A violator who does not pay is taken to court. The agency generates some $1.1 million in violation revenue a year from cases taken to court. The agency employs 21 people in the violation department.

- The third agency operates 38 miles of tollways, with all toll collection lanes equipped with cameras. The agency processes some 105,000 transactions a day and 6,700 camera images a day, which account for about six percent of the total transactions. Of these, 3,000 are billed to known customers. Letters are sent to the other violators. The first violation is $7 plus a $40 penalty for a total of $47. The second letter is a $60 penalty, the third letter is a $80 penalty, and the fourth letter is a $100 fine. The agency processes 500 letters a day and receives $2.5 million a year in violation revenue.

- The fourth agency operates 108 kilometers of tollway and has cameras in every toll collection lane. It is an all electronic tollway with no cash collection. Users are billed via transponders or via license plates. Use of the facility is 330,00 trips a day, of which 73,000 a day, or 22 percent, are billed from video images. There is a $1.65 video surcharge on these transactions. The toll collection system costs $55 million. Some $1.5 million in bills are sent each month. The collection staff includes 190 employees.

Puget Sound Regional Council Congestion Pricing Demonstration

Matthew Kitchen
Puget Sound Regional Council

Mr. Matthew Kitchen discussed a GPS-based pricing demonstration project in the Puget Sound region. He described the background of the demonstration, the technology that would be used, the elements of the demonstration, and the potential markets. Mr. Kitchen addressed the following points in his presentation.

- Marginal-cost pricing can address economic, financial, and social goals. It addresses management objectives related to alternatives to traditional road finance. Variable pricing provides a better option that optimizes investments, improves operational efficiency, and respects diverse needs and values.

- The Destination 2030 regional plan includes recommendations focusing on variable pricing. The plan recommendations include introducing variable roadway pricing where and when it is appropriate in the region; exploring and adopting transportation demand modeling improvements that better assess management strategies; planning, designing, and implementing a demonstration program prior to 2006; and developing and funding a detailed outreach effort.

- The FHWA Value Pricing program provides technical and policy support for local projects. It can help finance and organize a regional pricing conference and provides a clearinghouse for information exchange. FHWA awarded a $1.88 million grant for the Puget Sound study. The study will analyze pricing options in coordination with corridor studies. It is part of a broader effort to develop regional transportation financing capacity.

- GPS includes satellites orbiting the earth at an altitude of 20,000 km. The orbital period is 12 hours and global coverage is provided 24 hours per day. At least five satellites are visible at all times. Full operational capability (FOC) was declared by the Department of Defense (DOD) in April 1995 and selected availability was no longer an issue as of May 2000.

- GPS appears to be well suited for value pricing applications. GPS can be used to track the miles a vehicle travels and the time-of-day trips are made. Drivers can be charged accordingly. There are some measurement accuracy issues that will need to be addressed, however. GPS data involves elements of error, so standards of accuracy must be established and measurements verified. Match mapping presents additional challenges due to errors contained in digital maps.

- GPS is an element of a proposed project in Germany to collect freight tolls. The project, anticipated to be implemented in 2003, would provide an example of this approach.

- The Puget Sound study is a hold-harmless pilot project designed to understand user response to road pricing. It proposes using GPS to optimally price the roadway network. The project would test the technology, program design, and behavior. It would also examine broad policy implications and public attitudes.

- The project has two phases – a development phase and an implementation phase. Major activities in the development phase include selecting a price structure and framework, determining GPS utilization technology, and developing evaluation methodologies and participant sample requirements. The main elements in the implementation phase include

preliminary implementation of the pilot study, full project implementation and management, assessment of associated policy issues, a public involvement and a public relations program, and project evaluation.

- A number of outcomes are anticipated from the study. First, the project will help familiarize the public and policymakers with an actual application of road pricing. Second, it will assist in developing an understanding of the technology components and applications of GPS with value pricing. Third, it will generate user response to price data for application in other analytical efforts, such as corridor studies, travel models, and revenue models. Finally, it will better define a set of policy issues to be addressed through actual program design.

- Pre-project planning has been initiated. The development phase activities are anticipated to be completed in 2003. The implementation phase efforts will start in mid-2003 and continue into 2005. The public relations program will run throughout the project.

- GPS provides the potential to manage the transportation system through markets. It may offer a significant contribution to facility and system management through improved performance. It provides a self-financed investment in transportation technology, opens new technology markets, and integrates existing markets. It can also be used for real-time travel and management information. Other ITS applications have increased public acceptance of active management strategies. GPS provides an approach that addresses recurring and non-recurring elements of congestion.

- Electronic toll collection involves a number of elements including in-vehicle, two-way communication and data links. It provides applications for facility management and an avenue for system data collection management. It allows for interface for in-vehicle display of real-time travel information. ITS functions include incident detection, traffic management, travel information, fleet management, route guidance, and planning analysis.

- GPS and other technologies can assist in evolving lane management. They can help manage for value not “values.” These technologies may facilitate markets that allow individuals to choose according to their own preferences. GPS can improve efficiency when managed lanes become the standard not the option. It appears that the best approach may be to let technology evolve as interest rises in system managed level approaches.

Value Pricing, Part Two

Michelle Hoffman, Maryland Department of Transportation, Moderator

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Tel Aviv Fast Lanes – Implementing a Prototype "HOT" Lane in a Middle Eastern Metropolitan Area

Robert Daniel
URS Corporation

Mr. Robert Daniel discussed a proposed HOT lane project in Tel Aviv, Israel. He described the location of the project, the problems being addressed, the proposed solutions, and some of the anticipated challenges with the project. Mr. Daniel covered the following points in his presentation.

- Tel Aviv is located on the Mediterranean Sea coast. Like most metropolitan areas, traffic congestion is a major problem in Tel Aviv. Road 1 from Tel Aviv to Jerusalem experiences an LOS F in the morning peak period and a LOS D in the afternoon peak period. Road 4 in the eastern part of the metropolitan area experiences a LOS F in the morning peak period and a LOS E in the afternoon peak period.

- Approximately 6 million people live in Israel. The Tel Aviv region has a population of 2.5 million, with 350,000 individuals living in the city. There are approximately 330,000 daily commuters in the region. Approximately 60 percent of these commuters travel in private motor vehicles.

- Congestion or value pricing represents one possible approach for addressing traffic congestion in the area. Value pricing can be an equitable approach, especially if the revenue from congestion pricing is used for cross subsidization of shuttle bus from park-and-ride lots or bus other services. Other techniques can be used so the wealthy can help to finance travel of those less well off.

- Governmental actions in 1999 and 2002 provide direction for the possible use of value pricing in the region. The Fast Lanes for Public Transportation (Toll Lanes) law was passed by the legislature in 2000. It provided for studies of the value pricing concept and delegated authority for studies and projects among the Cross Israel Highway Company Ltd., Department of Public Works, Ministry of Transportation, and Ayalon Freeway Company Ltd.

- The proposed project on the Road 1 Tel Aviv Jerusalem Highway includes four major components. These elements are Fast Lanes, park-and-ride facilities, free shuttle service to the center city, and intermodal transfer centers.

- The Fast Lane would be approximately 7.5 miles in length and would be added capacity built adjacent to Road 1. The lanes would operate one-way only to the center city. Electronic tolling and variable tolls would be used on the facility.
- Park-and-ride sites along Road 1 have been identified. These facilities would allow commuters traveling to the center city to park and take transit for the remainder of their trip. Direct access ramps would be provided for buses to access the Fast Lane.

- Shuttle bus service would be operated from park-and-ride lots to the center city and other major destinations. A link to the existing rail line in the corridor would also be provided.

- The park-and-ride project has been approved by District Planning Commission. The Fast Lane is in the advanced stage of design. Cabinet level governmental approval of the project occurred in July 2002. Currently there is both political opposition and political support for the project.

Maryland Variable Pricing Study – Lessons Learned
George Walton
Parsons Brinckerhoff

Mr. George Walton discussed the Variable Pricing Study conducted for the Maryland State Highway Administration of the Maryland Department of Transportation by Parsons Brinckerhoff. He provided an overview of the study and his perspective on some of the issues encountered during the project. Mr. Walton covered the following points in his presentation.

- The Maryland Variable Pricing Study was a one-year effort that started in the fall of 1999. It was jointly managed by the State Highway Administration and the Maryland Transportation Authority. The study included proactive and interactive public participation programs that used newsletters and Internet sites. Other federal, state, and local agencies participated on the Steering Committee and various groups participated on the Stakeholder Committee.

- The study had two main goals and a number of objectives. The first goal was to determine the feasibility of a broad range of value pricing strategies to develop a series of recommendations for implementation. The five objectives under this goal were: 1) to identify a broad range of value pricing strategies for the 10 selected corridors and facilities in Maryland; 2) to evaluate the transportation system performance of identified variable pricing strategies; 3) to evaluate the cost and equity implications of the identified variable pricing strategies; 4) to evaluate implementation issues associated with the identified variable pricing strategies; and 5) to identify the next steps leading towards implementation.

- The second goal was to increase public awareness and understanding of variable pricing applications. The four objectives related to this goal were: 1) to identify the audience; 2) to develop and carry out a proactive public involvement process; 3) to provide documentation to the state legislature; and 4) to participate in national discussions of variable pricing.

- The study involved two phases of analysis. The first phase examined qualitative measures. The second phase focused on quantitative efforts, including travel demand and traffic analysis, cost-effectiveness analysis, environmental and equity analysis, implementation requirements, technology and toll collection applications, infrastructure improvement needs, enforcement issues, and legislative needs.

- The study examined the feasibility of variable pricing strategies on six freeways, two tunnels, and two bridges. The study team investigated a range of strategies for each corridor or facility. The effectiveness potential within each corridor or facility was examined. Recommendations for further exploration or implementation were developed for each corridor and facility. The study was to serve as an “off-line” technical assessment of variable pricing and the findings were to have been linked into other ongoing planning studies.

- The results of the phase one study included recommendations to carry forward all the corridors and facilities into ongoing planning studies and to compare the variable pricing

strategies with other options being considered. Moving forward with a demonstration project on US 50 was also recommended.

- The US 50 HOT lane demonstration focused on the 7.5 miles of HOV lanes under construction. The project was to use a 2+ vehicle-occupancy requirement with a 24-hour HOV operation. The demonstration was to examine how to differentiate between vehicles paying a toll and HOVs in the absence of a single point of entry. Human or machine vision would be used to verify occupancy and transponder validity. Alternative enforcement methods that could be put into place to ensure acceptable compliance levels were to be considered. Promoting safety and preventing vehicles from weaving in and out of the HOT lane to minimize their toll charge was considered. The demonstration was also to consider if the additional weaving of general-purpose and HOV traffic into and out of the HOT lane increased safety or operational concerns. The governor ended consideration of the demonstration project and other HOT lane options in the state.

- Others may be able to benefit from the experience with the study. First, the number of corridors selected for study may be been overly ambitious given the timeframe and budget. Second, there may have been too many issues, too many state agencies, and too many county agencies involved in the study. Some of the issues that emerged with the large number of agencies related to different operating conditions, different agency mission statements, existing versus new priced facilities, and competing interests.

- Although interested in examining the variable pricing concept, the agency representatives were cautious about actual implementation. FHWA was clearly interested in having another value-pricing project in place for monitoring and evaluation purposes.

- There may have been missed opportunities with the study. The public involvement plan was well-established, but more aggressive outreach with elected officials earlier in the process may be been beneficial. Early communication may have helped advance the demonstration project. A political champion for the demonstration was also missing. Several project team members championed the study, but could not generate enough support for continuation. There was a need for broad-based support throughout the study areas.

- The study also pointed out that enhancements to regional models are needed to adequately evaluate the demand for variable pricing projects. The tunnels and bridges in Baltimore appear to be more logical candidates for possible projects than roadways.

- Possible equity issues appear to be a major concern among policy makers. Communicating with all groups on the equity issue and other concerns is critical. The media plays a key role in information dissemination, so it is important to spend time with them. It is also important to communicate with local policy makers. Support from top policy makers is critical.

- The timing of grant application processes can also be an issue. It is important that the local decision-making process occurs prior to the federal application process.

- Concerns were raised over how variable pricing fits with Smart Growth. Some groups felt variable pricing would add capacity to a corridor, which did not support their concept of Smart Growth.

- It appears that the study may not have fully identified community perceptions related to

variable pricing. As a result, it may not have been possible to address the local concerns related to equity and other issues.

Six Years of HOT Lanes: What Have We Learned?
Bill Stockton
Texas Transportation Institute

Mr. Bill Stockton discussed the experience with HOT lanes over the past six years. His comments focused primarily on I-15 in San Diego, SR 91 in Orange County, California, and I-10 West in Houston. Mr. Stockton covered the following points in his presentation.

- Concerns over equity are often raised as potential issues with HOT lanes. It appears that equity is a bigger issue in the minds of implementing agencies and elected officials than it is to the public. Survey results and other studies indicate that HOT lanes are used by travelers in all income groups.

- The perception of travel time savings by commuters continues to be much greater than the travel time savings recorded by operating agencies. It also appears that travel time reliability is more important to travelers than absolute time savings.

- It appears to be easier to attract new single-occupant vehicle drivers to a single-occupant vehicle-eligible HOT lane than to attract two-person carpools to HOV/HOT facilities with a three-person requirement.

- An ingenious way of enforcing HOV occupancy has yet to be discovered. Enforcement continues to be an important issue with both HOT lanes and HOV lanes.

- The projects to date indicate that pricing works. The understanding of price elasticity and extension to individual projects is still in its infancy.

- Experience also indicates that the more complicated the geometry of a HOT lane, the more difficult the operations. Both I-15 and SR 91 have one entry point and one exit point.

- In terms of policy implications, political support is still not very predictable, but improving. Having a political champion for a project is very advantageous.

The Current Status of High-Occupancy Toll Lane Applications In the United States: Practice, Politics, and Potential
Benjamin Perez
Parsons Brinckerhoff

Mr. Benjamin Perez discussed the FHWA sponsored *A Guide for HOT Lane Development*. The guide represents a two-year effort of Parson Brinckerhoff, with assistance from TTI. Mr. Perez covered the following points in his presentation.

- The focus of the guide is on educating about HOT lanes, not advocating them. The report identifies what is different with HOT lanes and summarizes the collective experience to date with HOT lanes. The development of the guide included input from technical specialists and extensive consultation with implementing agencies. FHWA personnel provided guidance throughout the process and reviewed the draft report. A peer review process was also used

with the guide.

- The contents of the guide include eight basic sections. These sections are concept and rationale, planning and implementation, organization frameworks, achieving public acceptance, technical issues, operational issues, current experience, and lessons learned.

- HOT lanes are defined in the guide as “managed, limited-access, and normally barrier-separated highway lanes that provide free or reduced cost access to high-occupancy vehicles and also make excess capacity available to other paying vehicles not meeting occupancy requirements.”

- HOT lane management tools are described in the guide. The basic management tools include pricing, occupancy requirements, access points, electronic toll collection requirements, and program participation.

- HOT lane requisites were examined. The elements identified as important included high-density corridors, new managed lanes, and either congested HOV facilities or under utilized HOV facilities. Multi-lane facilities are also preferable.

- There are a number of potential benefits from the use of HOT lanes. HOT lanes provide travelers with a choice of paying for premium conditions. There is no service degradation in managed lanes. They provide travel time savings for users. HOT lanes can improve corridor mobility. HOT lanes can result in improved transit service. Environmental benefits may result from HOT lanes. Finally, HOT lanes may avoid pressure to convert under performing HOV lanes.

- There are a number of policy issues that may need to be addressed in considering HOT lanes. Equity appears to be one of the main issues. There may also be questions if tolls are acceptable to politicians and their constituents. Finally, finding respected project champions willing to lend public support may be an issue.

- Elements to consider in the HOT lanes implementation process include preliminary investigations, detailed planning, and final design/construction. Institutional issues, outreach efforts, and technical studies are needed in all three of these steps.

- Some realities of HOT lanes may be different than perceptions. Political perception of public opinion may not always be accurate. The public may be more willing than their political leaders to support HOT lane projects. Current projects have benefited from political champions. HOT projects that have not moved forward often involved elected officials actively blocking implementation. The importance of educating all stakeholders cannot be understated.

- An 800-person survey of I-15 FasTrack users completed in 2001 demonstrates that motorists of all income levels recognize the benefits of HOT lanes. The results indicated that 91 percent agree that FasTrack is a good idea. Approximately 66 percent of non-users support FasTrack. Some 73 percent of non-users agree FasTrack reduces congestion. A total of 89 percent of users support FasTrack extensions, and 80 percent of the lowest income users support the concept of paying for HOT lane use.

- Surveys in other metropolitan areas indicate there is public support for HOT lanes. A survey

in the Minneapolis/St. Paul area showed 57 percent supported having an option to pay to use an uncongested freeway lane when in a hurry. In Seattle, 41 percent were willing to pay tolls for faster trips, with no statistically significant difference between income and willingness to pay tolls. In Lee County, Florida, 59 percent had a favorable opinion of paying to bypass congestion.

- A study of HOT lanes and value pricing in Maryland was terminated by the governor in 2001. He instructed the Maryland Secretary of Transportation to remove any proposals to study or implement HOT lanes from the Department's overall strategy.

- A demonstration on the I-10 West (Katy) Freeway in Houston was initiated in 1998. The QuickRide project allows 2+ HOVs to use the HOV lane during the 3+ restricted period for a fee of $2.00. The Katy HOV lane is 13 miles long. It is a single reversible barrier-separated lane located in the freeway median. A similar approach was implemented on the US 290 (Northwest) Freeway in 2002. The HOV lane on the Northwest Freeway is approximately 15 miles in length and is a one-lane reversible barrier-separated facility.

- The SR 91 Express Lanes in Orange County, California, provide another example of value pricing. The SR 91 Express Lanes are 10 miles long and include two lanes in each direction. The facility was opened in 1995 and was privately financed through special legislation. HOVs were initially allowed to use the lanes for free under the state law and currently pay half price on the tolls. Currently, toll charges range from $0.75 to $4.75, depending upon the time of day. The project included effective public outreach and extensive data collection activities on pricing and utilization. The private finance added a layer of complexity and the non-compete clause has been problematic.

- The I-15 FasTrack demonstration in San Diego provides another example of a HOT lane project. The HOV lane on I-15 is a two lane reversible facility that is eight miles long. The demonstration started in 1996 allowing single-occupant vehicles to use the HOV lane for a fee. Currently a real-time variable pricing structure is used with tolls ranging from $0.75 to $4.75. The project appears to be popular with users of all incomes, as well as non-users. An effective outreach effort was undertaken with the project. Expansion is currently under consideration. The toll proceeds fund express bus service in the corridor.

- There is current interest in HOT lanes in a number of metropolitan areas. Recent HOT lane studies have been conducted on Route 101 in Marin and Sonoma counties in the San Francisco Bay area and on SR 36/I-25 corridor in the Boulder/Denver region. Possible projects are being examined in Miami, South Carolina, Portland, Seattle, Houston, Denver, Phoenix, Dallas/Fort Worth, and Lee County, Florida.

- A number of lessons have been learned from the current projects and studies. Outreach is critical in gaining public support. The backing of political champions is important in garnering public support. It is not unlikely that the future of a HOT lane initiative will lie in the hands of a single key individual. Surveys prove existing HOT lanes are popular with local drivers. Surveys also demonstrate motorists are likely to support new HOT lane applications and this support is consistent among motorists of all income levels. Support is consistent among motorists who only use HOT lanes occasionally. HOV conversions are often attractive options. A variety of institutional sponsors can be involved with HOT lane projects. Private sector financing adds a layer of complexity. Management tools, including price, need to be flexible. Reciprocity with other tolling agencies is desirable.

- With only four HOT lane facilities operating in the U.S., the concept is not always considered in situations where it might be appropriate. HOT lanes provide a cost effective opportunity to increase use of HOV facilities and highway capacity. There is a need to share the collective experience.

- The *Guide for HOT Lane Development* should be available from the FHWA in late 2002 or early 2003.

Managed Lanes Corridor Planning

Craig Stone, Washington State Department of Transportation, Moderator

Managed Lane Feasibility on I-405 in Seattle

Don Samdahl
Mirai Associates

Mr. Don Samdahl discussed the managed lane Feasibility Study on I-405 in Seattle. The study was conducted for WSDOT by Mirai Associates, Parsons Brinckerhoff, and David Evans and Associates. He noted the participation of Mr. Robert Spillar, Parsons Brinckerhoff, Mr. Ron Anderson, David Evans and Associates, and Mr. Crain Stone, WSDOT, in the study. He summarized the background to the project, the major tasks conducted in the study, and the results. Mr. Samdahl covered the following points in his presentation.

- Addressing transportation needs in the I-405 study area included numerous challenges. There has been strong economic growth in the area resulting in more demand on the transportation system. This growth is out-pacing the existing infrastructure. There are multiple jurisdictions in the corridor. There are also physical and financial constraints, as well as environmental concerns.

- A number of alternatives were examined in the study. A strong TDM program aimed at ridesharing, vanpooling, and transit incentives was one option. The HOV alternative included completing the series of direct access ramps. This would allow carpools, vanpools, and buses to access the HOV lanes without weaving through other traffic. The BRT option would expand transit services up to 100 percent in the corridor. It would implement a BRT-type service for most north-south transit travel and explore automated high capacity transit (HCT) options for the cross-lake (SR 520/I-90) Corridor. The roadway alternative would add up to two general-purpose lanes in each direction between I-5 in Tukwila and I-5 in Lynnwood.

- Managed lanes were also considered. Managed lanes were defined as a dedicated lane system for one or more user groups. Managed lanes provide tools to optimize lane throughput and to provide unimpeded travel during periods of peak demand. Managed lanes appear to be viable if they move more people, improve corridor speeds, increase mode splits, minimize diversion to arterials or neighborhood streets, and provide mobility for freight. Managed lane operational scenarios for short-term and for 2020 were examined. Management by access or user controls and operational variations during the day were also considered. The design implications for various approaches were examined and opportunities for pricing capacity were explored.

- The design concept for the HOV lane and the managed lanes alternatives were slightly different. The HOV alternative required a slightly wider cross-section. The managed lanes alternative included 2+ HOV peak periods, HOV direct access, and allowing all vehicles off-peak at selection locations.

- The analysis of the alternatives examined vehicle and person travel demand, travel patterns, lane utilization, throughput, and speed. The results of the analysis indicated that managed lanes are a viable alternative. The managed lanes option meets or exceeds the throughput provided by the HOV 3+ alternative. It allows HOV 2+ and provides available capacity for

other users. Pricing is an additional management tool that can be used on an on-going basis.

- Potential early action strategies were examined. These strategies included phasing-in managed lanes on a single facility or by a corridor and considering limited pricing with the phased-in segments. The next steps in the process include defining an operational plan, analyzing system needs, and estimating revenues from a priced managed lane.

Monitoring and Evaluation Guidelines for Managed Lanes Value Pricing Project in San Diego
Eric Schreffler
Eric Schreffler Transportation Consultants

Mr. Eric Schreffler discussed the monitoring and evaluation approach for the I-15 managed lanes value pricing project in San Diego. He provided an overview of the I-15 managed lanes project and described the evaluation objectives, the basic evaluation approach, and the performance measures. He also noted the before, during, and after data sets and analysis approach. Mr. Schreffler covered the following points in his presentation.

- Managed lanes are part of the expansion of Express Lanes on I-15. The managed lanes are anticipated to build on the success of the current FasTrak value pricing program on I-15. San Diego Association of Governments (SANDAG) commissioned the value pricing study, Wilber Smith developed the concept plan, and Eric Schreffler Transportation Consultant (ESTC) developed the monitoring and evaluation plan.

- The existing I-15 facility allows 2+ HOVs to use the HOV lanes for free, while single-occupant vehicles pay a toll that varies by the level of congestion in the lane. The future managed lane plan includes four lanes in the center median of the freeway. The lanes would be separated from the general-purpose lanes by barriers. The lanes would be managed through the use of a moveable barrier. Variable value pricing would continue to be used on the lanes. The project also contains a BRT element, which includes direct access ramps and stations.

- The preferred pricing option is a skewed per mile rate with minimum tolls. Distance-based tolls are perceived to be more equitable. The toll per mile would be shown, with users calculating the cost for their trip. The per mile rate would be higher in congested areas. The main disadvantage of this approach is user comprehension.

- The evaluation objectives were to test the managed lanes as HOT lanes and to test the skewed per mile pricing scheme. The evaluation examined the impact of these approaches on users and non-users. Pricing was tested with multiple access points. The use of the movable barrier technology was also examined. The evaluation measured the impact of different alternatives on congestion. It also examined funding options for new BRT and HOV improvements.

- The basic evaluation approach focused on a four-tiered before and after assessment. The four tiers were measurement of system impacts, measurement of utilization, measurement of acceptance, and assessment of operations.

- The evaluation used eight performance measures. These measures were LOS, toll user volumes, changes in mode split, changes in vehicle classification, changes in trip making, changes in park-and-ride usage, changes in emissions, and changes in delay, travel time and

speed.

- The before and after data set used in the evaluation included nine elements. Data on traffic counts, travel time, vehicle occupancy, park-and-ride lot use, HOV violation rates, and accidents were examined. A panel survey of FasTrak users and stakeholder interviews were conducted.

- The analysis focused on a number of key areas. First, utilization of the managed lanes was examined. Second, the impact on the managed lanes and the mixed use lanes was considered. Third, the cost of delay and emissions was analyzed. Fourth, an institutional analysis was conducted and potential equity issues were examined. Fifth, a technical assessment was conducted, which included a cost revenue analysis.

- A number of key recommendations emerged from the study. The first recommendation was to build evaluation into project planning. Assuring that an adequate budget is provided to conduct the before data collection activities was recommended. Including HOV users in the assessment was suggested. Using the results to improve the program on an ongoing basis was also recommended. Finally, providing the results in a straightforward manner that is easy to understand was recommended. More information on the project can be found at www.sandag.org/fastrak.

Planning for Managed Truck Lanes
James Douglas
Parsons Brinckerhoff

Mr. James Douglas discussed potential issues associated with planning managed truck lanes. He described the potential benefits from truck lanes, highlighted four current examples of truck lanes, and outlined issues to be examined in the planning process. Mr. Douglas covered the following points in his presentation.

- Truck lanes separate heavy commercial vehicles from automobiles and other lighter vehicles. Potential benefits from truck lanes include improved operations and improved safety. Operational benefits include eliminating the speed differential between trucks and other vehicles and reducing merging and weaving movements. Truck lanes may reduce crash rates for commercial vehicles.

- Examples of current truck lanes include the New Jersey Turnpike, I-5 in Los Angeles, and the South Boston Bypass. The New Jersey Turnpike includes a dual-dual roadway with automobile-only lanes. I-5 includes barrier separated truck lanes and interchange bypasses. The South Boston Bypass is a separate roadway for commercial vehicles.

- Applications guidelines for truck lanes include consideration of corridors with high truck volumes, high traffic volumes, and major truck generators. Truck lanes may involve extended corridors. Truck merging and weaving should also be examined.

- Potential issues to be considered in the planning process include vehicle restrictions, physical separation, the number of lanes, dual-purpose lanes, key design parameters, and the potential benefits to different user groups.

- Elements to be addressed in the planning process include establishing the need for a project,

articulating the objectives, and addressing specific issues. Although there are only a few truck lanes currently in operation, there is interest in the concept in a number of urban areas.

Using Managed Lanes During Construction
Joel Marcuson
HNTB Corporation

Mr. Joel Marsucon discussed the use of managed lanes during construction. He provided an overview of the managed lanes concept, early adoption strategies, possible benefits of managed lanes, and the use of managed lanes to ease congestion during construction and reconstruction. Mr. Marsucon covered the following points in his presentation.

- The use of managed lanes during construction is a relatively new concept. Managed lanes can expand mobility during roadway construction and reconstruction. Managed lanes can provide better service to travelers during construction. Managed lanes can enhance transit service and HOV use during construction. Possible approaches for use during construction and reconstruction include dynamic managed lanes and reversible tidal flow lanes.

- Numerous benefits may be realized through the use of managed lanes during construction. First, the people moving capacity of a facility is increased. Second, mobility options for travelers are increased. Third, it is a way to provide an early introduction of the managed lanes concept in an area. Fourth, it can build public support for managed lanes.

- Depending on the approach, utilization of managed lanes during construction could increase the capacity of a facility by some 33 percent in the peak hour. The use of managed lanes during construction can provide benefits to HOVs, HOT vehicles, buses, and other users. Implementing managed lanes to help during construction can provide early public acceptance of the concept. The public receives benefits during construction and transportation agencies gain experience in operating managed lanes.

- A number of different approaches, design treatments, and operating plans may be considered. One example focused on reconstructing a freeway with one concurrent flow HOV lane and two general-purpose lanes in each direction. During reconstruction, a reversible managed lane could be operated in the center median. After reconstruction, the facility would include a managed lane, an HOV lane, and three general-purpose lanes in each direction.

Context Driven Design

Don Nelson, Washington State Department of Transportation, Moderator

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I-90 Case Study: Predicting Safety Impacts of Non-Standard Geometric Design Elements

Bill James
HNTB Corporation

Mr. Bill James discussed the I-90 case study in Seattle examining the safety impacts of non-standard geometric design elements. He summarized the I-90 HOV facilities and current corridor design features. He also described the factors influencing crash patterns and the crash projection methodology. He noted the assistance of Mr. Randy Hammond, HNTB, in the study. Mr. James covered the following points in his presentation.

- The current I-90 project is examining two-way transit and HOV operations. The intent is to improve transit and HOV reliability between Seattle and Bellevue. It is also intended to minimize impacts on the environment and other transportation modes. The I-90 project, which is a joint effort between Sound Transit and WSDOT, helps implement the "Sound Move" regional transit program. The project was initiated in 1998. The draft environmental impact statement (DIES) is currently being prepared.

- The current design and operation of I-90 is governed by a 1976 Memorandum of Agreement. This agreement reduced the lane configuration from four general-purpose lanes in each direction and two center reversible lanes to three general-purpose lanes in each direction and the two center reversible lanes. It also set priorities for the center lane users. The priority users are buses, carpools and vanpools, and Mercer Island motorists. The original project design criteria included a 50 mph alignment in Seattle, a 60 mph "minimum" alignment from I-405 to Lake Washington, and standard shoulder widths.

- The I-90 corridor features an urban environment. Some of the unique features include tunnels, the floating bridges over Lake Washington, and Mercer Island. There are a number of context sensitive design elements in the I-90 corridor. First, the footprint is reduced for tunnels and lids, as opposed to open cut proposals. There are three independent roadway alignments. The alignment on Mercer Island included the First Hill lid with active recreation facilities, "community bridges" with mini-lids, and a linear park with a regional trail facility. The architectural design guidelines also incorporated hardscape and landscape.

- There are a number of tradeoffs influencing safety considerations in the corridor. The physical constraints of the corridor limit options. Geometric compromises include lane widths, shoulder widths, and stopping sight distance. There are also policy considerations related to added capacity verses design compromises.

- A comparison of Interstate highway crash rates was conducted. The freeway segments included in this analysis were:
  - I-90, Seattle to Bellevue, current and interim configurations;
  - I-5 segments with standard geometrics, none with HOV lanes (1994-1996);
  - I-5 segments with non-standard geometrics, all with HOV lanes (1994-1996);
  - freeways with HOV lanes and non-standard geometrics in Virginia, Georgia, and California.

- The typical section of I-90 today includes the outer and center travel lanes. The outer roadway is comprised of 12-foot general-purpose lanes and 10-foot outside shoulders. The center roadway includes two 12-foot reversible lanes and eight-foot shoulders.

- The interim I-90 westbound configuration in 1993 had four westbound lanes, three for general-purpose traffic and one for HOVs. The general-purpose lanes were 11 feet wide and the HOV lane was 10.5 feet wide. A two and one-half-foot inside shoulder was provided, along with a six-foot outside shoulder. The interim I-90 eastbound design was three 11-foot general-purpose lanes, a two and one-half-foot outside shoulder, and a two and one-half-foot inside shoulder.

- The I-5 North HOV lanes were added as a retrofit project in the early 1980s. There are three-to-four general-purpose lanes and an HOV lane in each direction. The lanes are 11 feet wide, with a 10-foot wide outside shoulder, and a two-foot inside shoulder. The I-5 South interim HOV lane was developed in the early 1990s. The freeway included four general-purpose lanes and one HOV lane in each direction. The lanes are 11 feet wide with a 10-foot outside shoulder, and a two foot wide inside shoulder.

- Crash data was examined from a number of sources, including the 1995 NCHRP 369 report *Use of Shoulders and Narrow Lanes to Increase Freeway Capacity*. Crash data from California, Virginia, Texas, and Washington was also examined. Crash frequency and severity, including potential rate changes and increases or decreases in crashes were examined. Factors affecting crash rates include geometric standards, the degree of congestion by time-of-day, and traffic volumes. Estimates were developed for upper and lower bounds for standard verses non-standard interstates, and current versus interim I-90.

- A comparison of Interstate highway overall crash rates indicated that the current I-90 and I-5 standard operations are below the average for Washington State urban Interstates, while the interim I-90 operation, the I-5 non-standard, and other freeways with HOV lanes have crash rates slightly above the average.

- A number of safety mitigation strategies were identified for I-90. Speed management strategies included variable posted speeds and speed limit reductions. Improved illumination in tunnels, lids, and other elements were examined. Delineation included pavement markings, guide signs, and lane control signals. Incident management, including improved detection and increases in the number of WSDOT service vehicles and hours of operation were examined. Shoulder rumble strips were also considered.

- Operating strategies being further developed and evaluated include crash reduction measures for all the alternatives, managed lanes, and HOV eligibility requirements. Managed lane alternatives include time-of-day lanes on the outer roadways and value pricing in the center roadway. HOV eligibility requirements being examined include 2+ and 3+ vehicle occupancy levels.

- A variety of additional data needs and areas for research were identified. The influence of congestion relief and accident migration needs to be explored further. The special effects of lane width reductions, shoulder width reductions, and HOV and general-purpose lane speed differential need further analysis. Information on rural two-lane highways is available for many items, but more data is needed for the urban Interstate system.

- The study results indicate that the existing I-90 has some design standard compromises, but has a better than average crash record. In comparison, standard versus non-standard Interstate freeway facilities with reduced width cross-section elements typically have higher crash rates. These rates are within the range of commonly observed rates on urban Interstates, however. Finally, there is a need for better data specific to urban freeways with HOV facilities.

Urban Freeway Context Sensitive Design
Eric Shimizu
CH2M Hill

Mr. Eric Shimizu discussed the application of context sensitive solutions (CSS) with HOV facilities. He described common HOV design issues, presented a hypothetical case study, highlighted the major components of CSS, and explained how CSS could be applied to HOV design issues. Mr. Shimizu covered the following points in his presentation.

- A number of issues may need to be considered in the design of HOV facilities. Mainline design speeds typically govern geometrics and the need to maintain continuity of the corridor. Elevated or depressed HOV ramps may need to be considered in some cases. Other issues related to HOV design standards include the design vehicle used and separation of ramp traffic from mainline through traffic acceleration. CSS can be used to help address some of these concerns.

- CSS was applied to a hypothetical case study. The case study involved a freeway, with a design speed 60 mph, located in an urban setting. The biggest issue was the impact to an environmentally sensitive site north of the proposed HOV interchange, which included a bridge over a river. The accident analysis conducted for the case study showed a higher than average accident rate for a general-purpose on-ramp with non-standard acceleration length. Mainline accidents showed some rear end accidents, but no fatalities. The accident rate was less than the state average for similar highways.

- The case study analysis examined how the environmental and accident concerns could be addressed. The impact of a bridge widening was examined. Reconstruction costs for added piers and girders were examined. The environmental impacts were also explored. The impact to the salmon habitat narrows the construction window and the needed wetlands mitigation complicates the environmental process. All of these issues extends the project timeline and increases project cost.

- The application of CSS was examined to help address these issues. CSS focuses on the purpose and need of a transportation project, and then addresses equally safety, mobility, and preservation concerns. Preservation issues include aesthetic characteristics, historic and cultural resources, and environmental and other community values. Context sensitive solutions involve a collaborative, interdisciplinary approach in which citizens and agency staff are part of the design team.

- There are at least two ways to examine safety as highway engineers, planners, and stakeholders. Nominal safety is examined in reference to compliance with standards, warrants, guidelines, and sanctioned design procedures. Substantive safety is the expected crash frequency and severity for a highway or roadway. When design criteria can not be met, a question is raised if substantive safety is compromised.

- A simple model for meaningful discussion of safety on any project examines nominal safety and substantive safety. Any project or problem can be categorized in one of four quadrants that meet or do not meet these two concerns. The case study described met the nominal safety aspects, but did not meet the substantive safety concerns.

- Substantive and nominal safety drive decisions and projects approaches. When both nominal and substantive safety are met by infrastructure improvements there is no need or justification for geometric revision. When substantive safety is met, but nominal safety is not, reconstruction criteria may be considered to incorporate low cost safety enhancements. Upgrading to full standards may not be cost-effective. When nominal safety is met, but substantive safety is not met, targeted safety improvements may be needed and there may be a focus on cost-effective solutions. When both nominal and substantive safety are not met there is a need to completely reconstruct current criteria or to consider special targeted safety enhancements.

- A context sensitive solution for the case study would need to address mainline and HOV sight distance and grade, and future HOV volumes. Other possible alternative solutions might include narrowing freeway lane or shoulder widths, relocation of HOV interchanges, possible design exceptions, and possible reconstruction of the bridge.

- The conclusions reached from the case study highlights the importance of conducting a thorough risk assessment. It is also important to complete full documentation of the decision process, including the alternative analysis. The close coordination with the public and stakeholders is also critical. Context sensitive solutions are collaborative stakeholder decision processes that should result in balancing safety and mobility with aesthetics, the environment and community values.

HOV Direct Access Guidance for Washington State
Dick Albin and John Milton
Washington State Department of Transportation

Mr. John Milton discussed the development of HOV direct access guidance in Washington State. He summarized the need for revising the access guide and highlighted some of the issues that had to be addressed. Mr. Milton covered the following topics in his presentation.

- The development of the direct access guide was initiated in 1996 in response to interest from Sound Transit in providing improved bus, carpool, and vanpool access to HOV lanes from the left side. At the time, access to the HOV lanes was from the right side. Access to the HOV lanes from the middle or the left was not provided. The existing guidance was limited to right side access to the Interstate system. The HOV direct access ramps would essentially be left-handed on ramps.

- Left access is generally not favored from an engineering perspective. Left access may be appropriate in some cases to provide direct access to HOV lanes, however. A key issue in the development of the direct access guidance was how to revise a commonly accepted standard favoring right side access and provide for left side access to HOV lanes.

- The guidance at the time was focused on access from the right side. The access did not consider the operational effects of left side on-ramps. The new guidance for HOV direct

access connections had to be sensitive to high speed, high volume, high safety, high real estate costs, and high environmental costs. Issues that had to be addressed in the development of the new guidance included parallel on-connections, longer acceleration lengths, longer merging lengths, and longer deceleration lengths.

- The parallel on-connection allows vehicles, including articulated buses, to attain an appropriate speed and to merge into an HOV lane from the left. Parallel on- connections help address possible operational issues associated with merges from the left.

- Longer acceleration lengths are needed to allow 60-foot articulated buses to obtain adequate speed before entering an HOV lane. At the same time, there may be limitations that restrict the ability to provide adequate acceleration, merge, and deceleration lengths.

- Another issue with developing the guidelines was to provide a design that was reasonable and flexible, and which meets federal requirements. It is critical that guidelines not degrade the operation and the safety of the freeway system. Flexibility is provided within the deviation process. FHWA personnel have been very helpful in working through the issues that have come up with the access guidances.

- A number of issues may have to be addressed in considering direct access to HOV lanes. First, acceleration and deceleration gap acceptance may need to be examined. The lengths of the acceleration and deceleration lanes are often a problem in urban areas due to bridges and other limitations on rights-of-way. Ramp shoulders, site distance, and grade may all add to the cost of a structure. Cost is obviously an important factor for all groups, especially the agency responsible for funding a project.

- Access management is another issue. Determining where a ramp starts and ends is more difficult with “T” ramps and other similar facilities. Identifying where a ramp ends and a city street begins is not always easy. This issue influences how full access purchases are measured and if they are 130 feet or 300 feet.

- Access reports are another possible issue. WSDOT is currently receiving a large volume of access reports due to developments along the state system. A different process is being followed for the report on the transit access ramps.

- The HOV direct access guide will become a chapter in the WSDOT Design Manual. Incorporating the guidance into the Design Manual formalizes it as a standard for the Department.

Managed Lanes Design Issues
Bill Eisele
Texas Transportation Institute

Dr. Bill Eisele discussed potential design issues related to managed lanes. He described the results from two research projects sponsored by TxDOT being conducted by TTI. He provided an overview of the managed lanes concept, examples of current projects, possible trends in design and operations, and planning issues associated with managed lanes. Dr. Eisele covered the following points in his presentation.

- The definition of managed lanes used by TxDOT and TTI on the research project is "a lane or group of lanes where a combination of operating and design strategies are used to maximize roadway capacity, maintain free-flow conditions, and achieve corridor and community goals. Managed lanes are designed for flexibility so that operations can be modified over time as conditions change."

- There are a number of examples of operational and design strategies that may be used with managed lanes. These options include variations in user and vehicle group eligibility, time period-based eligibility, pricing, physical control, and operational control. Possible types of managed lanes include HOV lanes, HOT lanes, value-priced lanes, express lanes, separation and bypass lanes, dual facilities, and lane restrictions.

- The I-15 FasTrack project in San Diego provides one example of value pricing. Currently, 2+ HOVs are allowed to use the facility for free while single-occupant vehicles are tolled. Dynamic pricing is used and there is access control through one entry and one exit. Expansion plans include four managed lanes with an interior moveable barrier and BRT with direct access ramps. Single-occupant vehicles would continue to be tolled.

- The I-10 West (Katy) Freeway in Houston provides a second example of value pricing and managed lanes. The project uses fixed pricing with 2+ HOVs paying a toll and 3+ HOVs traveling for free during the morning and afternoon peak hours. Future plans include managed toll lanes with HOV preference. The lanes would be separated from the general-purpose lanes by plastic pylons.

- The SR-91 Express Lanes in Orange County, California, provide another example of the managed lanes concept. This facility uses differential pricing. Vehicle eligibility includes tolling 2+ HOVs and single-occupant vehicles, while 3+ HOV pay a reduced toll of 50 percent the normal rate. There is also access control with one entry and one exit.

- It is important to link design and operations of managed lane projects. Operational components that may need to be considered in the design of a facility include AVI or loop detectors, closed-circuit television cameras, full ATMS, dedicated tow trucks, changeable message signs (CMS), entry ramp metering, significant enforcement efforts, and lower speed limits at constricted points.

- The managed concept may influence future trends in design. Factors that may be considered include greater design consistency on a regional and national basis, greater system continuity, planned conversion to multi-lane managed facilities, and maintaining flexibility. New design standards may emerge with the wider application of managed HOV lanes. For example, efforts are underway in individual states, including Washington and Texas. The AASHTO *Guide for the Design of Managed HOV Facilities* and the *Guide for the Design of Park-and-Ride Facilities* address managed lanes, as does NCHRP *Interim Design Guide for Transit Facilities, Highways, and Streets*. The FHWA-sponsored *A Guide for HOT Lane Development* also addresses design issues.

- Future trends in operations may also influence the design of managed lanes. Technology and interoperability, signing and traveler information, and the use of new tools in managing and operating managed lane facilities represent just a few of these factors. It also appears that there will be continued reliance on on-site enforcement presence. Incident management will need to be considered in the design of managed lanes. The expanded interest in monitoring

and evaluating the performance of managed lanes may also influence design.

- Weaving distances and direct access ramps need to be considered in the design process. Research indicates that weaving distances should be between 500 and 1,000 feet per lane. Direct ramps may be considered when vehicle volumes reach 400 vehicles an hour at an entry point.

- A number of issues may also need to be considered in the planning phase. Like all planning processes, there is a need to involve all relevant stakeholders. Issues to be considered include allowable vehicle user groups, possible pricing strategies, demand estimation, and financing. The need for changes in legislation or new legislation will have to be considered. Public education and outreach are important components of the planning process. Allowable vehicle user groups may include single-occupant vehicles, HOVs, buses, trucks, ILEV, taxi/shuttles, emergency vehicles, and motorcycles. The selection of user groups will depend upon the characteristics of the corridor and project and community goals.

- A hierarchy of vehicle user groups has been identified in the Colorado Value Express Lane study. The highest priority in this study is given to buses and other transit vehicles. Vanpools and 3+ carpools are given second priority. Third priority is provided to 2+ carpools and ILEV are a fourth priority. Toll paying single-occupancy vehicles are the lowest priority group.

- Managed lane systems continue to emerge. Investments in completing managed lane projects and systems will continue to grow, and there are wider applications of new design and operational tools. New design standards that link operations and design are important. Access designs should be examined for managed lanes with different users and vehicles, including freeway within a freeway and management by time-of-day, special events, and incidents. There is also a need to document the state-of-the-practice with HOV interchange areas and left-left ingress/egress.

Transit-Related Design Requirements for Streets and Highways
Steve Schijns
McCormick Rankin

Mr. Stephen Schijns discussed the NCHRP Project 20-7, *Transit-Related Design Requirements for Streets and Highways – Phase I, Interim Guide*. The project was conducted by Parsons Brinckerhoff and McCormick Rankin, International. The interim guide has been completed. Mr. Schijns covered the following points in his presentation.

- The report covers transit-related design requirements for streets and highways. Chapter One is the introduction to the report. Chapter Two provides general guidelines related to functional planning, bus transit capacity, and design controls and criteria.

- Chapter Three focuses on transit facilities on highways. It includes sections on general considerations, transit vehicle facilities, and transit passenger facilities. The section on general considerations covers the various types of transit services on highways, types of transit operation facilities, and the types of passenger facilities. The section on transit vehicle facilities addresses priority lanes, access treatments, enforcement provisions, and signing and pavement markings. The section on transit passenger facilities discusses general site considerations, on-line bus stops, and off-line bus stops.

- Chapter Four examines transit facilities on streets. It includes sections on general planning and design considerations, bus operations in mixed traffic, and bus lane designs. The first section describes the different types of design treatments, the planning and design process, the need and justification process, demand estimation, and bus stop design basics. The section on bus operations in mixed traffic highlights different provisions and intersection treatments. The design section covers bus use of shoulders, curb lanes, second right lanes, left lanes, contraflow lanes on one-way streets, contraflow lanes on two-way streets, and spot treatments. The bus operation on streets section examines enforcement of priority lanes, signing and pavement marking, and ITS provisions.

- Chapter Five covers off-line transit facilities. Topics addressed include planning and design considerations, bus passenger interface, parking and access, and community integration.

- There is a follow up TCRP project to prepare a final handbook. The selected team includes Parsons Brinckerhoff, McCormick Rankin, International, and others. This project will produce a comprehensive guide based on additional research and consultation with practitioners. It is anticipated that the final handbook will be completed in 2004

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