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16. Abstract

The Texas Department of Transportation and its agency partners have implemented various forms of lane management and pricing over the past three decades, including HOV lanes, managed lanes, and toll roads. As more of these complex transportation facilities are planned and constructed throughout the state, there is a need to understand how these facilities may operate over time. Ideally, the long-term operations should be based on metrics that are agreed upon in advance. By defining what metrics can most effectively measure the performance of a facility and outlining what thresholds trigger a change in operation, policy-makers and the public can anticipate and appreciate how a facility's operation may change over time. This understanding allows the facility operators to focus on the tasks of efficiently operating a smooth transportation network rather than focusing on how to get the necessary changes made in a timely manner. This study provides a framework in which operating decisions for priced facilities can be made and can guide the changes in operational strategies for a facility over time. The research process was initiated with a literature review and targeted interviews of toll and managed lane operators to assess the state of the practice in performance measurement for pricing and other operational changes. The research team then developed guiding principles for identification, selection, and communication of performance measures and targets. A conceptual framework was formulated and data collection infrastructure needs were also documented. The conceptual framework was then developed into a more detailed version in a web-based format. This report documents the research findings and results and provides guidance on the use of the web-based framework tool. In addition, several outreach products were developed under this study to assist agencies in communication of performance management principles for proactive management of priced facilities.

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OPERATIONAL PERFORMANCE MANAGEMENT OF PRICED FACILITIES

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DISCLAIMER

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation. The engineer in charge of the project was Ginger Goodin, P.E. #64560.

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- Kori Rader.
- Flor Tamez.

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CHAPTER 1. INTRODUCTION

Over the past several decades, the Texas Department of Transportation (TxDOT) has implemented many transportation innovations to meet the mobility needs of a growing population and economy. These innovations have included High Occupancy Vehicle lanes (HOV), High Occupancy Toll (HOT) lanes, managed lanes (ML), and toll roads. These types of projects are being considered or implemented in several urban areas of the state. Whenever these projects are considered there are a range of policy decisions that must be addressed, some of which can be controversial. Moreover, the operating characteristics of a project are likely to change over time, requiring additional policy decisions to adjust operating strategies to match the new operating characteristics.

Managed lanes, HOT lanes, and even HOV lanes are more complex, both from a policy and an operational standpoint, than traditional roads or toll roads. As more of these complex transportation facilities are planned and constructed throughout the state, there is a need to understand how these facilities may operate over time. The operations should be based on metrics that are agreed upon in advance, ideally before the opening of the facilities. There needs to be an understanding of how changes in certain metrics impact the performance of a facility. By defining what metrics can most effectively and efficiently measure the performance of a facility and outlining what thresholds trigger a change in operation, policy-makers and the public can anticipate and appreciate how a facility's operation may change over time. This understanding allows the facility operators to focus on the tasks of efficiently operating a smooth transportation network rather than focusing on how to get the necessary changes approved in a timely manner.

PURPOSE OF STUDY

The purpose of this research is to develop a framework in which the performance measures with identified thresholds are used to initiate pre-determined changes in managed lanes and toll road operations. The flow diagram in Figure 1 illustrates the framework as a performance management cycle, beginning with a mobility pledge that defines the desired performance of the facility, followed by a process of performance measurement, verification that performance is meeting expectations, and activation of changes as needed.

The research also supports the application of the framework in the following ways:

- Explains how the framework will allow for flexibility to achieve maximum efficiency.
- Demonstrates how the framework will incorporate the appropriate involvement by all affected.
- Provides guidance for selecting meaningful performance measures for managed lanes and toll roads.
- Explains the different methods of collecting needed data and defining what infrastructure is necessary to collect that data most cost effectively.
- Demonstrates how the development of the frameworks ensures transparency and accountability.

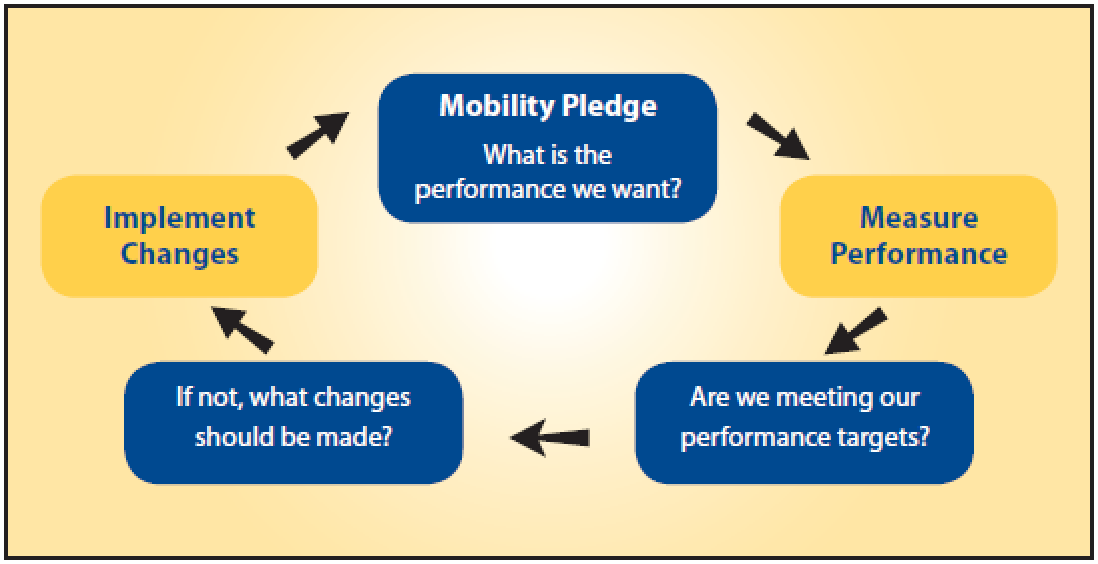

Figure 1. Performance Management Framework.

METHODOLOGY

This study provides a multi-faceted framework in which operating decisions for priced facilities can be made and can guide the changes in operational strategies for a facility over time. The research process was initiated with a literature review and targeted interviews of toll and managed lane operators to assess the state of the practice in performance measurement for pricing and other operational changes. The research team then developed guiding principles for identification, selection, and communication of performance measures and targets. With the assistance of a project advisory committee comprised of TxDOT representatives and regional planning partners, a conceptual framework was formulated. Data collection infrastructure needs were also documented. The conceptual framework was then developed into a detailed version in a web-based format.

This report documents the research findings and results and provides guidance on the use of the web-based framework tool. In addition, several outreach products were developed under this study to assist agencies in communication of performance management principles for proactive management of priced facilities.

CHAPTER 2. BACKGROUND

RATIONALE FOR PERFORMANCE MEASURE-BASED DECISION MAKING

Texas has a long-standing tradition of using variable operating strategies to meet the needs for mobility. Toll roads were first initiated in the Dallas-Fort Worth area with the completion of the Dallas-Fort Worth Turnpike in 1957. This facility and others operated by the North Texas Toll Authority in the Metroplex, toll roads in the Houston area operated by the Harris County Toll Road Authority, and more recently, the Central Texas Turnpike Project in the Austin area and Loop 49 in Tyler operated by TxDOT, all operate as traditional toll roads with a toll rate determined by vehicle type, regardless of occupancy or time of day.

The advantage to this methodology is its simplicity. It is easy to communicate to the user. However, it may not truly reflect the impact the vehicle has on the entire system at any given time. Furthermore it does nothing to mitigate congestion on the facility and does not fully utilize the limited resource that capacity represents. The difficulty in moving from such a system to one that is more complex was readily observed when Harris County Toll Road Authority (HCTRA) attempted to change the toll rates on the Westpark toll road. In 2007, HCTRA asked for, and was briefly granted, permission to charge higher peak hour toll rates to improve traffic flow. Public and political backlash was swift, and HCTRA was forced to abandon this operational change, despite the peak period congestion on the Westpark facility.

To address urban freeway congestion, transportation planners have looked to HOV lanes for the past three decades. The theory being that by carpooling, more people are moved in fewer vehicles thereby reducing congestion. TxDOT and its partnering agencies have been planning, designing, building, and operating HOV lanes since the late 1970s. Beginning with the I-45 Contraflow Demonstration Project in Houston, HOV facilities in Texas have proven to be an effective mobility strategy by offering a reliable high-speed option with travel time savings for bus riders, carpoolers, or vanpoolers.

Texas has also had unique experience in addressing operational concerns by modifying vehicle eligibility requirements in HOV lanes and evaluating the impacts, particularly on the Katy HOV lane in Houston. When the Katy HOV lane was opened in 1984 only authorized buses and vanpools were allowed. Gradually between 1984 and 1987, 4+ carpools, then 3+ carpools, and then 2+ carpools were allowed, and with each step the change was evaluated from an operational standpoint (*1*).

By 1988, morning peak hour vehicle volumes on the Katy were frequently approaching or exceeding capacity, thus degrading travel time savings and trip reliability. A policy decision was made in 1988 to increase vehicle occupancy to 3+ during the morning peak hours. By eliminating 2-person carpools during the morning peak hours, carpool volumes dropped 65 percent, peak-hour person volumes declined by 33 percent and congestion was eliminated (*2*).

Houston is the only location where 2+ HOV lanes have been successfully converted to a 3+ HOV facilities. There are scores of congested HOV lanes across the country in cities such as Los Angeles, Seattle, Long Island, and Atlanta where life-cycle operating frameworks were not put in place to identify the performance thresholds that would trigger a change from 2+ to 3+

occupancy. As a result, one of the most pressing issues facing HOV operators today is how to address growing congestion in HOV lanes through increasing occupancy requirements given the absence of an operating policy framework.

The QuickRide program, initiated in January 1998 as Texas' first HOT lane operation, allows 2-person carpools into the HOV lane during the 3+ restricted time periods at a flat toll rate of $2.00 per trip. The program is an effort to recover the person-movement benefits of the lost 2-person carpools, better utilize HOV lane capacity, and yet maintain high-speed operation to preserve the travel time savings for buses and other users. The program was expanded to the Northwest (US 290) HOV lane in 2000. Currently, Houston METRO is examining converting several of Houston's HOV lanes to HOT lanes and is dealing with many of the policy and operating threshold issues this research project will address.

Currently there are over 155 lane miles of HOV lanes in Houston and Dallas. Many more have been planned in those cities as well as other Texas metropolitan areas. However, within the last several years TxDOT has recognized that using price to ration existing HOV capacity can improve lane efficiency. Furthermore, with the growing cost of highway construction and the declining buying power of the gas tax, a new way of looking at project implementation is warranted. There is now interest in converting existing HOV lanes to HOT lanes, expanding existing HOV corridors into managed lane corridors, and developing new managed lanes in corridors where HOV facilities were once planned.

Managed Lanes

The term managed lanes evokes different meanings and connotations depending on the public agency or individual project. There is no nationally recognized definition of managed lanes. TxDOT has developed the following definition for managed lanes as part of its managed lanes research program, and it serves as the official definition of the concept for TxDOT:

> A managed lane facility is one 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 (*3*).

HOV lanes certainly fit within the managed lane definitions described above, although the HOV application is only one of many managed lane approaches that currently exist, or are proposed to exist, on preferential roadway facilities. The following facility types could be considered managed lanes in the broad sense of the definition above, if they are designed and operated to preserve enhanced travel conditions:

- HOV lanes or HOT lanes.
- Value priced lanes.
- Express lanes.
- Separation or bypass lanes, primarily for commercial vehicles.
- Dual roadways (physically separated inner and outer roadways in one or both directions where operation can be managed on at least one of the roadways).
- Separate tollways or toll lanes constructed within freeways.

FHWA views managed lanes in the same broad sense as TxDOT, but further defines the principle that operational strategies are proactively (real-time) implemented and managed in response to changing conditions. Under this philosophy, the operating agency proactively manages demand and available capacity on the facility by management strategies such as variable pricing, vehicle eligibility restrictions, or access control (*4*). Variable pricing has been demonstrated in practice as the only strategy that has the ability to truly manage demand on a real-time basis.

The introduction of pricing on HOV lanes in the mid-1990s was tested as a means to address underutilization of HOV lanes, such as the I-15 project in San Diego, or over-utilization of HOV lanes, as in the case of the Katy HOV lane in Houston. The growing use of pricing as a means to readily manage demand is facilitated by the development of electronic toll collection (ETC) technology as an increasingly practical and inexpensive tool. Pricing helps maximize the use of available pavement and still prioritize operation for HOV use. The introduction of pricing into the HOV operation is seen by some as an opportunity to manage the facility by allowing other users into the lanes as capacity allows (*5*).

In the last few years, however, the concept of pricing as solely a demand management tool has evolved, in Texas in particular, to a dual-purpose strategy of revenue generation and demand management. Given the prospect of funding shortfalls and the need to recover operations, maintenance, and capital costs where possible, any added lanes TxDOT is pursuing are being evaluated for tolling. These are being referred to, in most cases, as managed lanes, with consideration of some level of active management using variable pricing under consideration. A list of some of the managed lanes now under development or consideration in Texas is provided below:

- Katy Freeway (I-10) in Houston.
- Northwest Freeway (US 290) in Houston.
- North Tarrant Express in Fort Worth.
- LBJ Freeway (I-635) in Dallas.
- Tom Landry Highway (I-30) in Dallas/Fort Worth.
- Loop 1604 in San Antonio.
- Northeast Corridor (I-35) in San Antonio.
- Loop 1 in Austin.
- I-35 in Waco.
- I-10 and Loop 375 in El Paso.

Given the evolution of HOV facilities to managed lanes over the last decade, the level of activity in development of managed lane projects in Texas and nationally, and the need to use toll financing to implement managed lanes and/or build new facilities, questions arise as to how best operate these facilities. Typically, detailed traffic and revenue studies are used to determine initial toll rates and even ranges of toll rates based on users' willingness to pay, but very little study has been done on how performance measures may be used to impact price or operational changes on facilities over time.

Setting Performance Measures

As more priced facilities come online, motorists are presented with more choices. There is the possibility that many facilities within in the same region may have different operating strategies. A literature review reveals that very little study has been conducted on using performance measures to set toll rate policy.

Much research has been done and methodologies documented on toll rate setting. Ideally, traffic and revenue studies conducted during project development determine appropriate tolls to attract enough traffic to maintain the financial viability of the road. Often what is not accounted for is using price variability to keep traffic free flowing.

Section 1604(b)(7) of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) authorized the Express Lanes Demonstration Program. Part of the authorization requires the publication of performance goals for each project. Performance goals, monitoring and reporting program requirements for the I-635 project in Dallas and the North Tarrant Expressway in Fort Worth were published in the January 22, 2009, *Federal Register* (*6*). These proposed goals and monitoring program along with the 19-point Managed Lane Policy established by the Regional Transportation Council set a framework for how these types of projects may operate in the North Texas area (*7*). However, the operating policies in North Texas may differ significantly from the operating policies in East Texas or West Texas; thus it becomes necessary to establish a multi-faceted framework within which to manage various types of facilities.

Moreover, managed lane facilities may start with a particular operating policy and find that over time the policy must be adjusted. This may be referred to as a project's *life-cycle operation*, as depicted for an HOT lane in Figure 2 below. The figure shows how operations are expected to change over time due to conditions on the facility (*8*). In this scenario both price and occupancy are used as adjustment mechanisms. The question is: at what point does the change in operation occur? To answer these questions it is necessary to establish thresholds of certain metrics and priorities for several possible goals. This research will assess the most appropriate metrics, the collection of data to support the metrics, how to use those data to make operational changes, and how to communicate that information in a way that is meaningful to the general public and policy makers—the ultimate goal being a seamless transition from one strategy to the next based on pre-determined thresholds.

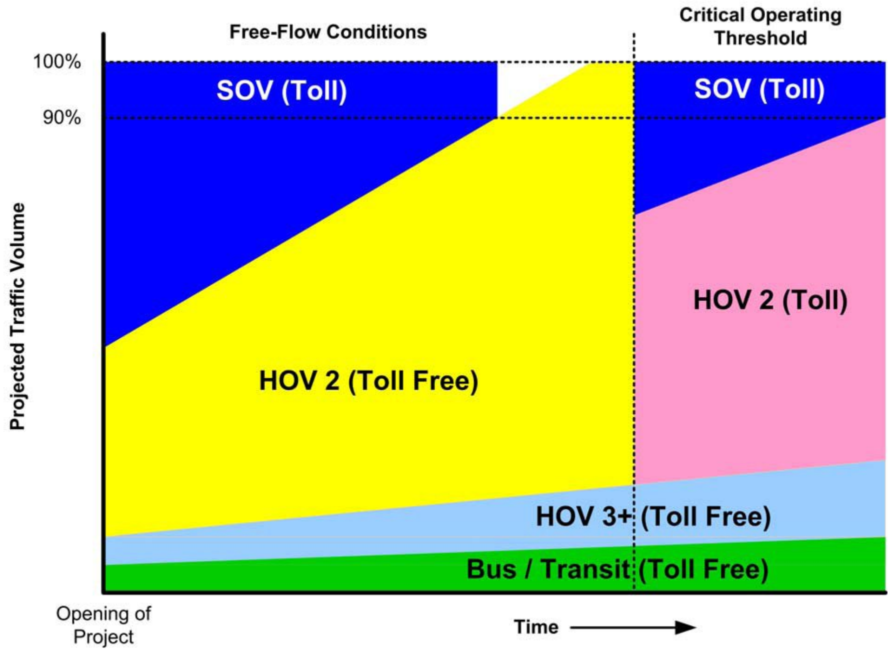

Figure 2. Life-Cycle Graphic of a HOT Lane (*8*).

Without these policies and thresholds in place, adjustment to the operating procedures can be a difficult and time-consuming process. During this time the lanes will not be operating efficiently and the public will likely be getting mixed messages regarding operating policies and prices. If a framework, like the one developed in the research, is in place, then the agency can plan for, and advertise the upcoming change in policy, as it will not hinge on a vote. Decision-makers still have a say in operations during the initial development of the policies and framework details for the facility. Communication with stakeholders and the public at the development stage coupled with ongoing performance reporting and public notification of changes is important to public acceptability of the framework.

A simplified example of an operating framework is the 91 Express Lanes in Orange County, California. Figure 3 illustrates the measures and thresholds for congestion management pricing in the super peak time periods on the variably-priced express lane facility (*9*). Based on defined toll adjustment goals, the framework lays out the method by which the super peak toll rate is determined using performance measures based on specified traffic volumes and pre-defined performance thresholds. The framework stipulates that the operator's board of directors, which is the body that approved the framework, and express lane customers will be informed of a toll adjustment 10 or more days prior to that toll adjustment becoming effective.

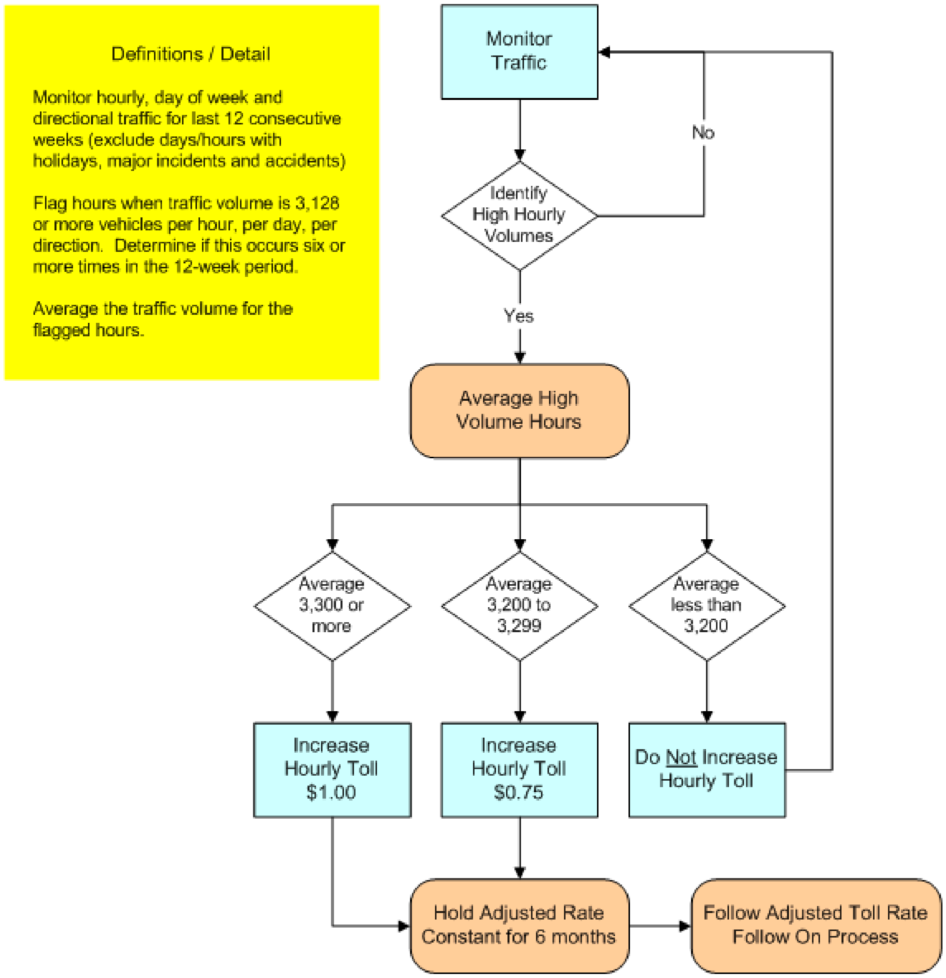

Figure 3. Toll Policy Decision Process for the 91 Express Lanes (*9*).

STATE OF THE PRACTICE REVIEW

A state-of-the-practice review was conducted through phone interviews of key personnel in agencies with operational projects plus website exploration of individual managed lanes projects across the country. Data and information were collected to answer questions such as:

- How do projects address toll rate changes?
- Is there a policy framework for the operation of the facility? How was it developed? Who was involved?
- How are the changes communicated to the public and other stakeholders?
- What is the reaction to policy or toll rate changes?
- Have there been changes in policy? If so, what caused them?
- What performance data are collected?
- How are performance data collected?

The research team gathered information from 20 projects. These projects included HOT lanes, express lanes, a priced queue jump, conversions from HOV lane to HOT lane, and traditional toll roads. Among them, 12 were via phone interview and the rest through exploration of project websites and other sources.[1] For each project, we tried to obtain as much information as possible to answer the questions listed above. Below is a list of projects explored through the literature review efforts by the team.

- SR 167 HOT Lanes Pilot Project.
- Express Toll Lanes on I-30/Tom Landry in Dallas.
- SR 91 Express Lanes in Orange County.
- MnPASS HOT Lanes on I-394 in Minneapolis.
- I-35W Corridor in Minneapolis.
- HOT Lanes on I-15 (San Diego).
- HOT Lanes on I-15 (Salt Lake City).
- 95 Express (Miami).
- SR 73 Toll Road in Orange County.
- C-470 Corridor in Denver.
- Queue Jumps in Lee County.
- Toll Roads in Illinois.
- Pennsylvania Turnpike.
- Regional System of Variable-Priced Lanes in Washington Region.
- Inter County Connector (ICC) & Express Toll Lanes (ETL) on I-95 in Maryland.
- Potential Managed Lanes on I-75 South in Atlanta.
- Conversion of HOV lanes to HOT Lanes on I-85 in Atlanta.
- Projects in Texas under the ELDP Tolling Agreement.

Existing and Future Policies of Managed Lanes Projects across the Country

There are over 130 freeway HOV facilities in metropolitan areas in the U.S. (*10*). According to the *Federal-Aid Highway Program Guidance on High Occupancy Vehicle (HOV) Lanes*, the vehicle-occupancy requirements for carpools have evolved over time from initially a 3+ occupancy level used on many projects to a two-person per vehicle (2+) carpool designation currently on most facilities (*11*). There are some instances in which changes in the designated vehicle-occupancy restrictions occurred over the life of an HOV facility. For example on both the I-10 West and US 290 HOV lanes in Houston, the HOV lanes using a 2+ requirement have experienced congestion resulting in reductions in trip time reliability and slower travel times. As a result, the vehicle-occupancy requirements were increased to 3+ during the morning and afternoon peak-hours (morning only on US 290). As indicated in Chang's study, in terms of HOV eligibility, 185 of the HOV facilities in the inventory (54 percent) are purely 2+. There are 14 facilities (4 percent) that are purely 3+ (*12*). Facilities, such as the El Monte Busway on the San Bernardino Freeway in Los Angeles, the I-10 West, the Nimitz Highway in Honolulu, Hawaii, and US 290 HOV lanes in Houston, require three or more occupants during specific peak-hours and a 2+ requirement at other times (*11, 12*).

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[1] Matthew E. MacGregor at TxDOT provided the source for information of projects in Texas under the Express Lane Demonstration Program.

As indicated in the *High-Occupancy Vehicle Guidelines*, in the State of California, the predominant occupancy requirement for existing HOV facilities is 2+ and it is expected that most new HOV facilities will be 2+ as well (*13*). Caltrans would consider increasing the occupancy requirement if adding a second HOV lane is inappropriate. Research studies have shown that in going from HOV2 to HOV3+, vehicular demand may reduced by 75 percent to 85 percent (*13*). Such adjustments may be too severe if only a moderate reduction in demand is necessary to maintain free-flow conditions.

The *Federal-Aid Highway Program Guidance on High Occupancy Vehicle (HOV) Lanes* suggests[2] a minimum average operating speed to be maintained as defined in Section 166(d)(2)(A) as 45 mph, for an HOV facility with a speed limit of 50 mph or greater, and not more than 10 mph below the speed limit for a facility with a speed limit of less than 50 mph. Section 166(d)(2)(B) provides that an HOV facility is considered degraded if it fails to maintain a minimum average operating speed at least 90 percent of the time over a consecutive 180-day period during morning or evening weekday peak hour periods (or both for a reversible facility). A minimum average operating speed can ideally be obtained by collecting data at multiple locations. Data collection points can either be spaced uniformly at equal distance apart from one another or at strategic locations. The monitoring should be conducted, at a minimum, during peak periods. Though the FHWA has provided recommendations on vehicle occupancy requirements and performance standards for HOV/HOT lane projects in the United States, the operating characteristics of a project are determined by local factors that are likely to change over time as well. In the following sections, we will describe existing and future operating policies of those projects selected in our review.

SR 167 HOT Lanes Pilot Project

Washington State's first HOT lanes opened on SR 167 on May 3, 2008. The HOT lanes were converted from existing HOV lanes and now offer single-occupancy vehicles (SOVs) the option to pay a toll for using the lanes. The two general purpose lanes, as before, remain toll-free and open to all traffic in each direction. To ensure the traffic in the HOT lane always flows smoothly, the toll paid by the SOVs is adjusted every five minutes. It ranges from $0.50 to $9.00 based on real-time traffic data, including vehicle speeds and traffic volumes, which are collected by loops underneath the pavement. The toll rates vary with traffic such that the toll rate is higher when traffic slows and lower when traffic is high speed. The managed lane is separated by a solid double white line and access in and out of the HOT lane is restricted to access zones (six in the northbound direction and four in the southbound direction) (see Figure 4). Though there are no explicitly stated goals of the project, important issues considered include improving freeway efficiency (speeds and volumes) and safety (crashes, etc.) plus the ability to finance improvements (reconstruction and operations costs) through tolls. Performance data, speeds in this case, are collected by loops located every half mile and the Traffic Operation Group in Washington State Department of Transportation (*14*). Collected tolls are used to finance construction, operation, and improvements costs in this corridor.

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[2] The FHWA does not require use of a specific procedure or methodology for states to use in determining if the operational performance of an HOV facility is degraded.

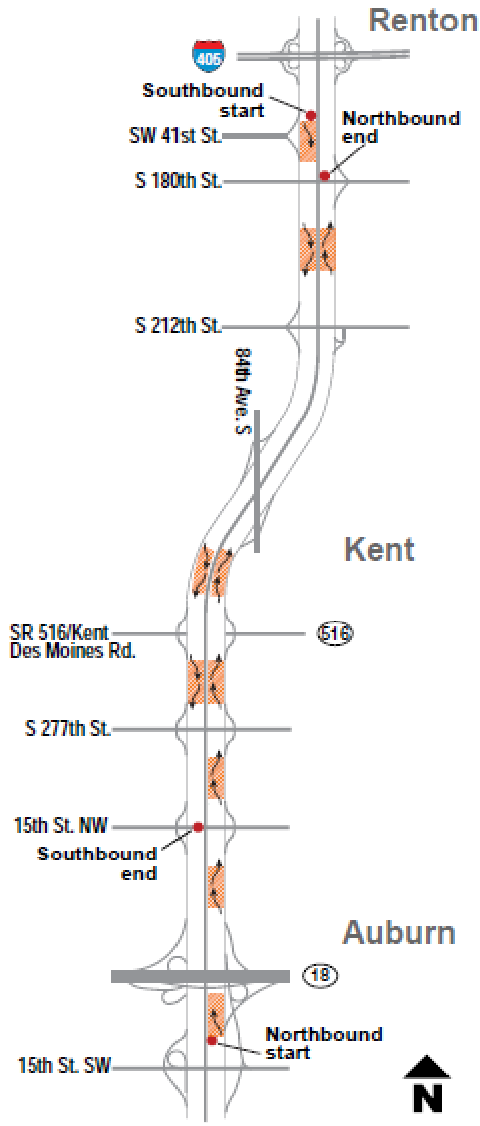

Figure 4. SR 167 HOT Lanes Pilot Project Area Map and Access Zones (*14*).
Source: Washington State Department of Transportation (WSDOT)

In the SR 167 HOT lanes pilot project, WSDOT allows carpools of two people or more, vanpools, transit, and motorcycles to use HOT lanes toll free (*14*). In the State of Washington, the required number of people on most HOV lanes is two. There are only three exceptions (*15*). The first exception is on SR 520 (west of I-405). It is the one place on the HOV system where three or more people are currently required. The second exception is on the segment in SR 167 discussed above, where, if there is capacity, SOVs with a transponder may pay a toll for using these lanes. The third exception is on the I-90 HOV Reversible Express Lanes between Rainier Avenue and Island Crest Way. Currently, SOVs are allowed on this segment of the facility without paying a toll (*16*). However, a 1976 Memorandum of Agreement anticipated that the reversible express lanes might someday become congested. If this becomes the case the agreement establishes a hierarchy of users (*17*).

Our phone interview[3] with the tolling engineer at WSDOT indicated that the Transportation Commission,[4] a state wide body composed of seven citizen members appointed by the governor and confirmed by the senate, sets the toll rates based on a range suggested by WSDOT. WSDOT proposed an initial range with a price cap of $9.00. Once the cap is reached then the HOT lanes will be reverted to HOV-only lanes. The $9.00 price cap was partially selected by looking at Minneapolis's I-394 price range. The Washington State Legislature (WSL) requires the Transportation Commission to periodically review the toll charges to determine appropriate toll rates which maintain travel time, speed, and reliability on the highway facilities (*18*). WSDOT annually reports to the Transportation Commission and legislature on operations and findings. The report includes data of facility use, a review of the impacts of the HOT lanes on several areas including freeway efficiency and safety, effectiveness for transit, throughput and vehicle movement by mode, if collected toll revenue is sufficient to finance improvements and transportation services, and the impacts on all highway users.

As stated in the Revised Code of Washington (RCW 47.56.403), the commission may offer toll discount to inherently low-emission SOVs (*18*). The department is also responsible for, through modifying the pilot project, addressing identified safety issues and mitigating negative impacts to HOV lane users. The pricing algorithm was designed to maintain speeds of at least 45 mph for 90 percent of the time during rush hour in the HOT lanes. If deemed appropriate, the Commission may vary the toll by time of day, level of congestion, vehicle occupancy, and other criteria. Combining the traffic volume and lane speed, the software based on the pricing algorithm calculates the corresponding toll rates to manage the number of single occupant vehicles entering the HOT lanes. The interviewee also indicated that there is no change to the price/occupancy guiding policy so far. Algorithm tweaks that varied the toll rate have been discussed at public meetings but received little reaction.

WSDOT utilizes a price setting algorithm[5] to dynamically adjust the toll rate every five minutes and the toll rate ranges from $0.50 to $9.00. The average toll paid was $1.00 per trip for the period between May 2008 and April 2009. Figure 5 presents the performance averages by month from May 2008 to April 2009. Notice that the highest toll paid ($9.00) occurred in June and July in 2008. There is no pronounced evidence that the highest toll paid is positively related to the number of daily tolled trips. After WSDOT refined the price-setting variables, the highest toll paid dropped to $2.75 in April 2009. To ensure carpools and buses premium service during the first few months while drivers were adjusting to the new HOT lane system, engineers intentionally adjusted toll rates to a relatively higher level ($9.00 in this case) to test the sensitivity of the pricing algorithm settings. As a result, engineers made minor refinements to decrease the sensitivity of the algorithm in late summer and fall 2008.

After a year of operation, WSDOT stated that the HOT lanes are working by saving people time, providing commuters with more options, and improving the use of SR 167 (*14*). The HOT lane

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[3] The phone interview with Tyler Patterson from WSDOT was on December 5, 2009.
[4] The Transportation Commission works with the Washington State Department of Transportation and elected officials to define the state's transportation plan, transportation investment plan, and transportation policy.
[5] The Transportation Commission is responsible for setting the toll rates in Washington.

commuters typically save 5 or 10 minutes on each trip and more than an hour of valuable time in peak hour over a five day work week. During the one year of operation, the project did not cause an adverse effect on safety, but additional data will be needed to be conclusive regarding safety impacts. From May 3, 2008, through April 30, 2009, the HOT lanes generated gross revenues of $316,600. The monthly average revenue grew from $25,500 in the first 6 months of operation to $28,200 in the second 6 months of operation.

	May 08	Jun 08	Jul 08	Aug 08	Sep 08	Oct 08	Nov 08	Dec 08	Jan 09	Feb 09	Mar 09	Apr 09
Average toll paid	$1	$1.25	$1	$1	$1	$0.75	$1	$0.75	$1	$0.75	$0.75	$0.75
Highest toll paid	$5.75	$9	$9	$8.50	$4.25	$3.50	$6	$4	$6.50	$3	$3.25	$2.75
Average number of daily tolled trips	1025	1080	1210	1250	1250	1270	1510	1160	1560	1610	1700	1710
Highest number of daily tolled trips	1220	1260	1390	1460	1390	1555	1740	1910	1850	1820	1880	1860
Average peak-hour northbound tolled trips	140	140	160	180	180	190	200	160	230	250	250	270
Average peak-hour southbound tolled trips	100	100	120	110	120	120	140	100	150	150	160	160
Max. peak-hour tolled trips	170	210	180	240	230	240	260	260	260	280	310	310

Figure 5. Performance Measures: SR 167 HOT lanes (*14*).
Source: WSDOT

In case of emergency situations, WSDOT installed a monitoring system that automatically sends out a mass e-mail to the entire operations team. A traffic management center monitors the HOT lanes using remote control cameras and by analyzing traffic data (speeds and volume) collected from loops every 1/2 mile. When an emergency appears, the management center has the authority to manually override the pricing system. In addition, incident response team (IRT) vehicles on SR 167 assist drivers in response to needs and clear traffic-blocking vehicles. The average response time for IRT vehicles ranges from 9.3 minutes to 10.3 minutes per incident.

Express Toll Lanes on I-30/Tom Landry in Dallas

As possibly the first value pricing project in the Dallas area along the I-30 Tom Landry Freeway corridor, the express toll lanes on I-30 are managed HOV lanes in the median of a general purpose freeway (see Figure 6). The I-30 corridor serves as the region's test bed for value pricing so that potential strategies can be examined and adjusted before being applied in other corridors. In accordance with approved regional policies, SOVs will be allowed to use the HOV lanes by paying a fee. The facility initially opened as HOV-only lanes in the first phase and is proposing to shift into "Express Lanes" in later phases once the tolling equipment installation projects are completed (currently anticipated to open sometime after 2012). In the first phase, a 5-mile segment was opened to the public in July 2007 and the extension, past Loop 12, was opened in the spring of 2009, which resulted in a total length of 11.9 miles of the managed lanes (see Figure 3).

The current HOV-only hours of operation are weekdays from 6:00 to 10:00 a.m. and 3:00 to 7:00 p.m. The HOV facility is closed for the rest of the day and during weekends. Hours of operation will be extended in both a.m. and p.m. peak periods (5:00 to 11:00 a.m. and 1:00 to 11:00 p.m.) in the value pricing phase. During the HOV-only phase, HOV2+, vanpools, motorcycles, and transit vehicles are allowed to use the facility for free. Variable pricing will be applied in the second phase and certain users (HOVs and motorcycles carrying a valid transponder) will receive a discount during peak hours (6:30 a.m.–9:00 a.m. and 3:00 p.m.–6:30 p.m.).

During the value pricing phase, two stages are planned: fixed schedule mode and dynamic mode. As indicated by Poe and MacGregor, "*a fixed-fee schedule will be applied during the first six months of operation; dynamic pricing will be applied thereafter. The toll rate will be set up to a $0.75 per mile cap during the fixed-schedule phase. Toll rates will be updated monthly during the fixed-schedule phase and single-occupant vehicles will pay the full rate. During the dynamic-pricing phase, tolls will be rebated if the average speed drops below 35 mph*" (*19*). Macias et al. pointed out that in the fixed schedule mode the toll base rate schedule is manually calibrated to maintain the desired level of service (average speeds greater than 50 mph) (*20*). The toll base rate schedule serves as the basis to calculate the tolls. The frequency of the calibration cannot be more than once every 30 days. The dynamic mode will start operating after the initial 180 days of operation in the fixed schedule mode. The dynamic pricing algorithm is currently under development and the dynamic mode rates can adjust from the base toll rate not more than as frequent as every five minutes. The maximum toll rate cap is $0.75/mile. Figure 7 shows an example of how the toll rates dynamically vary with the real-time traffic flow pattern (*21*). The functioning of the dynamic pricing strategy renders itself the capability of managing traffic demand to achieve targeted throughput and efficiency level.

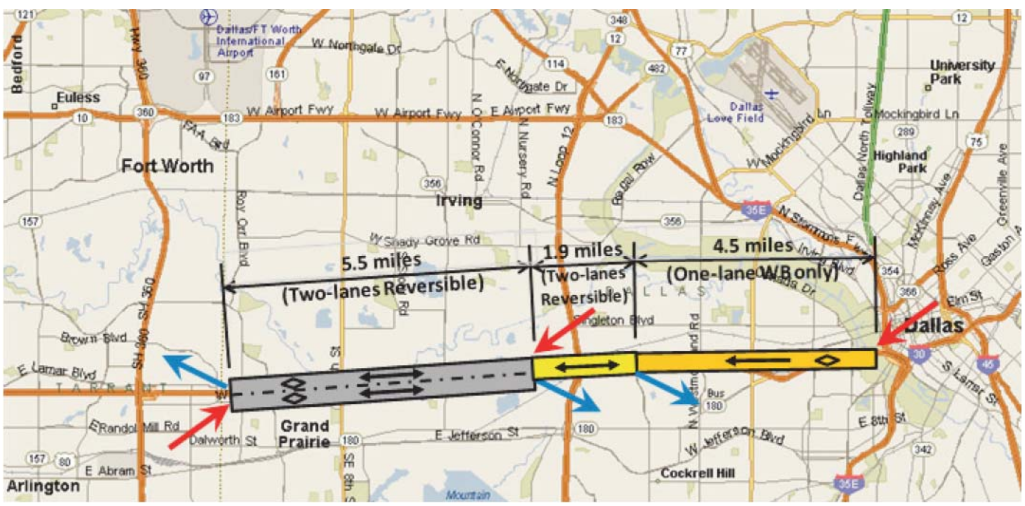

Figure 6. I-30W MLs Eastbound and Westbound Segments (*20*).

Dynamic pricing, applied in this managed lane project, is a strategy that the toll rates are dynamically adjusted to real-time traffic performance so that the targeted performance level can be reasonably achieved. This strategy will be very helpful in tackling reliability problems experienced in the I-30 corridor that are prone to high incident rates and special event traffic.

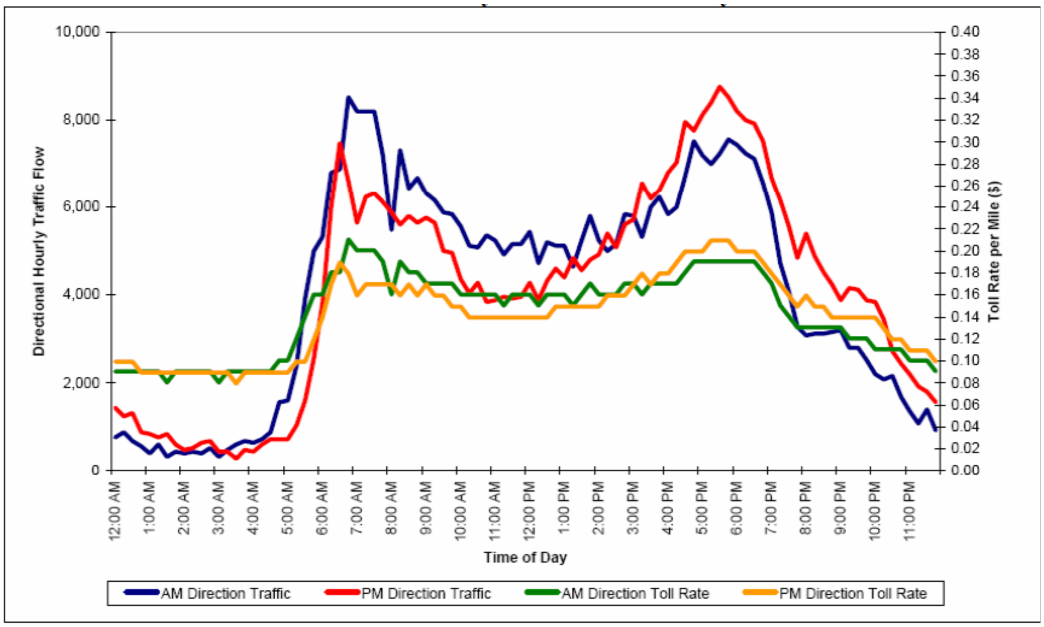

Figure 7. Traffic Flow Pattern-Dynamic Time-of-Day Toll Rates (*21*).

SR 91 Express Lanes in Orange County

As California's first modern, privately owned toll road, the 10-mile, four-lane and fully electronic toll road 91 Express Lanes facility was purchased by the Orange County Transportation Authority (OCTA) in 2003. As the operating agency, the OCTA sets the toll policies aiming to optimize the traffic flow at free-flow speeds. The toll adjustment serves several goals such as: 1) reducing congestion through diverting traffic to non-peak period, 2) maintaining free flow speed on the Express Lanes and travel time savings, 3) meeting increasing travel demand in the future, and 4) generating sufficient revenue for the operations and maintenance of the toll lanes.

Data collected as a measurement of performance are hourly, daily, and directional traffic volumes. This project defines the peak period "Super Peak" as the hourly period, per day, and per direction when traffic volumes meet or exceed the designated Trigger Point. The trigger point is defined as 92 percent of the maximum optimal capacity (3,400 vehicles per hour, per day, and per direction). OCTA has undertaken the Performance Monitoring and Pricing Pilot Project (PMAP), which is a progressive system and dynamic pricing assessment effort. To accomplish their objectives, the project will review options of speed and travel time sensor technology, approaches to dynamic pricing, and impacts of dynamic pricing policy.

The determination of toll rates for the 91 Express Lanes follows the OCTA toll policies (*22*). The toll policies include the concept of congestion pricing for the 91 Express Lanes. To implement this concept, the operating agency continually monitors hourly traffic volumes in the 91 Express Lanes. The policies require continually monitoring the directional traffic volumes on a rolling 12 consecutive week period. The hourly, daily, and directional traffic volumes of 3,128 or more will be flagged for further review. An increase of $1.00 and $0.75 in the toll should be carried out if the average flagged vehicle volume is 3,300/more and between 3,200 and 3,299, respectively. If the average flagged vehicle volume is less than 3,200 then the toll shall not be changed. The current minimum toll is $1.00 ($0.10/mile) and the maximum is $9.90 ($0.99/mile). Figure 8 shows the toll policy decision process for congestion management pricing during the Super Peak. A toll increase might be triggered if the hourly, daily, and directional traffic volume remains at a level of the Super Peak.

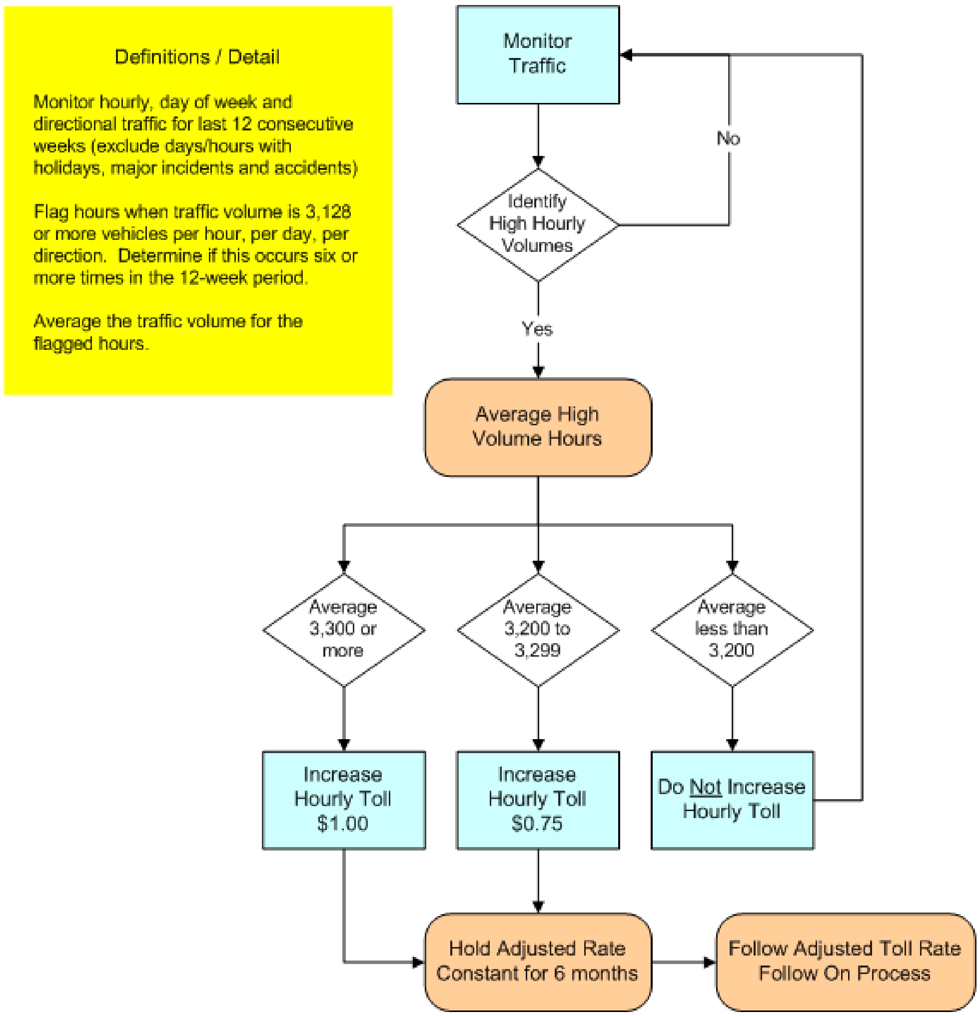

Figure 8. Toll Policy Decision Process (*22*).

A review will be conducted 6 months after a toll increase for the most recent 12 consecutive weeks (weeks that a major traffic anomaly occurred due to a holiday or an accident/incident are not counted) of the hour, day, and direction. If there are six or more weeks that the traffic volume is less than 2,720 vehicles per hour, day, and direction, then the traffic volumes for the corresponding 12 consecutive weeks shall be averaged. If the average turns out to be less than 2,720 then the toll shall be reduced by $0.50 to encourage more demand and subsequently better use of 91 Express Lanes. Figure 9 presents the follow up process after the toll rate is adjusted. There is at least a 10-day notice period to the OCTA's Board of Directors and customers prior to a toll adjustment becoming effective. Tolls for non-super peak hours remain stable at the levels of November 2001 except for annual inflation adjustments.

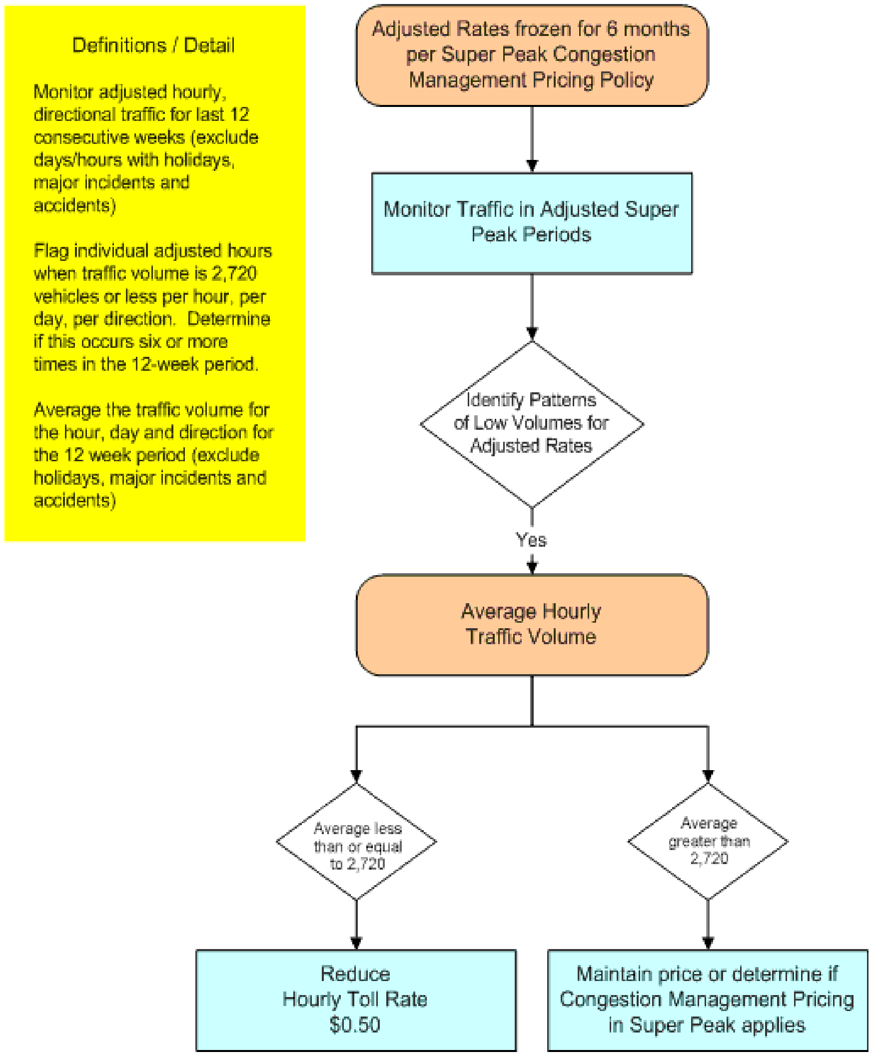

Figure 9. Adjusted Toll Rate Follow on Process (Super Peak Adjusted Rates Only) (*22*).

To encourage carpooling, there are discounts for vehicles with three or more persons (HOV3+). Such HOVs can ride free in the 91 Express Lanes during most hours except from 4:00 p.m. to 6:00 p.m. weekdays in the eastbound direction. They pay 50 percent of the toll during this two-hour peak-period. The exception will remain in effect unless the debt service coverage ratio is projected to be 1.2 or greater for a 6-month period. In that case, HOV3+ will travel completely free every day.

The 91 Express Lanes 2009 Annual Report indicated that the "Three Ride Free" trips accounted for 22 percent of total 91 Express Lanes trips and this "Three Ride Free" policy turned out to be effective in encouraging "*more people to ride together and cut their travel time and save money during tough economic conditions*" (*23*). Like many other toll roads where cameras are used to monitor the facility for toll violators, surveillance cameras are used along the 91 Express Lanes to improve customer safety. Specialists in the Traffic Operation Center can use the surveillance cameras to identify incidents and resolve them quickly. The report also states that apart from being used for operations, maintenance, and debt payments, excess revenues will be used for improvements along the SR 91 corridor. A customer satisfaction survey by OCTA in 2009 revealed 87 percent of those respondents indicated that they are satisfied with the service and this number shows a growing overall satisfaction (*23*). Customers who were most satisfied said it was because the express lanes save them time.

MnPASS HOT Lanes on I-394 in Minneapolis, Minnesota

The conversion of the original I-394 HOV lanes to HOT lanes was authorized by the Minnesota Legislature in 2003 and the first phase of the project was opened in May 2005. The HOT lane is the first of its kind in the state of Minnesota, which imposed new and significant changes to the way highway traffic is managed. The project was developed through a public-private partnership (PPP) and partners include the state of Minnesota and service vendor Wilbur Smith Associates. These lanes are known as the MnPASS Express Lanes, which allow the SOVs to pay a toll to access the HOV lanes, however, carpools and bus still have priority and use the HOV lanes toll-free.

As stated in the provisions of the toll lane legislation, the Commissioner of Transportation is responsible for the implementation of user fees on HOV lanes in Minnesota (*24*). The commissioner could also adjust the occupancy requirements to HOV3+ to ensure traffic flows freely. However, it is likely that the legislature would want to be involved in that decision. The goals of the legislation are to improve operating efficiency in trunk highway corridors and provide travelers with more options. Moreover, the legislation defines the way collected fees are to be used: "*1) repay trunk highway fund or other fund source for cost of equipment and modifications in the corridor, 2) costs of implementing and administering the fee collection system,*" and excess revenues shall be spent half on capital improvement in this corridor and the other half transferred to the Metropolitan Council for expansion and improvement of bus transit services in this corridor.

Our interview[6] with the value pricing program manager in the Minnesota Department of Transportation (MnDOT) indicated that the I-394 project goals are: 1) to improve the efficiency of I-394 by increasing the person- and vehicle-carrying capabilities of HOV lanes; 2) maintain free flow speeds for transit and carpools, 3) use excess revenue to make transit and highway improvements in the I-394 corridor, 4) use electronic toll collection and 5) employ new Intelligent Transportation System (ITS) technologies such as dynamic pricing and in-vehicle electronic enforcement. The source of revenue to construct the HOT lane came from the ABC garage account (about $7 million) and use of the revenue is directed by the authorizing legislation: first to cover operating costs, then if excess revenue, to make transit and highway improvements in the I-394 corridor.

Our survey revealed that the policy for changing the occupancy requirements on HOV lanes was set in state statute. The I-394 project is designed to better use the capacity in the corridor. The traffic speeds are maintained at or near posted limits by a dynamic pricing strategy that adjusts the toll rates based on the demand and use of the lanes. Travel speeds and traffic density in the lanes are collected by loop detectors located every 1/2 mile on the highway, and a program

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[6] Kenneth Buckeye at MnDOT responded to our survey via email on November 19, 2009.

named IRIS is used to immediately sense bad detectors. Every couple of years the data from IRIS will be compared with actual traffic counts.

According to the legislation, the toll rates may adjust by time of day or vary with congestion. The lanes remain free to HOVs and motorcyclists during peak hours and are free to all users in off-peak periods. The toll rates are dynamically adjusted every 3 minutes to manage the traffic at free-flow speed. The average peak period toll varies between $1.00 and $4.00 depending on the level of congestion in the MnPASS Express Lanes, and the rates were set between $0.25 per segment up to a max of $8.00 for use of the entire corridor. This ensures that traffic in the MnPASS Express Lanes continues to flow at 50 to 55 mph. The average toll paid increased from $0.55 in September 2005 to $1.10 in September 2006 due to the modified toll schedule instituted in January 2006, which kept the range of tolls constant but it triggered the increase in toll levels at lower congestion levels. Revenue generated exceeds its cost of operation.

URS Corporation's study indicated that since the conversion of the I-394 HOV lanes to HOT lanes in 2005, the performance of the whole facility has been improved significantly and it received wide public satisfaction and support (*25*). MnPASS has been very successful since its opening and a number of benchmarks have been achieved in several areas. The project adopted non-barrier separation tolling and it turns out to be working effectively. The amount of traffic being served on the MnPASS lanes has increased up to 33 percent, specifically the total peak hour volumes have increased by 5 percent, while the HOT lane still maintains constant targeted levels of service. The goal of maintaining 50–55 mph on the MnPASS lanes has been achieved for 95 percent of the time without compromising the safety. Actually, comparison of crash rates over the last three years shows there has been a 12 percent decline since MnPASS began.

I-35W Corridor in Minneapolis, Minnesota

As part of the Urban Partnership Agreement,[7] the conversion of the HOV lane into an HOT lane on I-35W allows single occupant vehicles to enter the HOV lane. The MnPASS system installed in the HOT lane is to allow the unused capacity of the HOV lanes to be used by SOV drivers paying a toll and meanwhile maintain the service (free flow traffic at 55 mph) to carpools and transit on the managed lanes. To maintain such goals, the number of SOVs entering the managed lanes must be properly controlled by dynamically adjusting the toll rate based on the level of congestion and demand in the HOV lanes. The "Minnesota Urban Partnership Agreement (UPA), Concept of Operations" utilizes a dynamic pricing strategy in the management of the I-35W Corridor (*26*).

The pricing strategies incorporated in the toll setting algorithm are summarized as 1) goal of the algorithm (same as the one currently used on I-394, but with different maximum and minimum toll rates) is to maintain a speed of 50 mph for 90 percent of the time when the lane is tolled, 2) minimum price per zone is $0.25 and the maximum price per zone is $8.00 for use of 1 zone, 3) maximum price per directional trip is $8.00 if both zones are used, 4) entry point prices based

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[7] Through a combination of transit, road pricing, technology, and telecommuting, UPA includes projects that will improve traffic and reduce congestion on Interstate 35W, Highway 77/Cedar Avenue and in downtown Minneapolis. As of date, the project is not yet completed so that no impact and performance reports are available.

on worst points downstream of entry point and 5) prices will change no more frequently than once every 3 minutes. Rates will increase as traffic demand increases in the HOV lane until the rate reaches a level high enough to discourage users from entering (or the maximum is reached) and conversely, the rate will decrease as the congestion is alleviated in the HOV lane to allow more SOV motorists into the lane. The level of congestion in the HOT lane is determined by examining the accumulated traffic data (traffic density and level of service) from within the HOV lanes.

The operators also have authority to override the current state of the HOT lane. Three defined override conditions of the HOT lanes are: "*Closed to all traffic in either direction; Open to HOV traffic only northbound or southbound ($0.00 rate for HOV, all others are violations; Open to all traffic ($0.00 rate for all, no violators)*" (*27*). In emergencies or special situations, the override state will be functioning to reflect the state of a lane and it is independent of the rate information.

HOT Lanes on I-15 (San Diego): Previous and Current Policy[8]

The FasTrak pricing program in San Diego was implemented in April 1998. This program allows SOVs to pay a toll each time they use the HOV lanes and the toll rates vary with time of day and traffic flow in the I-15 MLs. These managed lanes extended from SR 56 in the north to SR 163/I-15 split in the south. This is the south segment in Figure 7. It is currently (January 2010) open as a two-lane reversible facility but is being widened and will be 4 lanes in 2012. Fees were adjusted in $0.25 increments as frequently as every 6 minutes to help maintain free-flow traffic conditions on the HOT lanes. The toll varied between $0.50 and $4.00, and it could be as high as $8.00 during very congested periods. Pricing is based on maintaining a Level of Service (LOS) "C" for the HOT facility (*28*).

Primary goals of the project were to maximize the use of the existing I-15 Express Lanes and to fund new transit and HOV improvements in this corridor. According to the Value Pricing Project Quarterly Report from the FHWA approximately 75 percent of the traffic on the HOT lanes traveled for free during weekdays (HOV2 or more for free) and the rest were FasTrak SOV customers. The collected toll was used to begin Express Bus Service in the corridor, HOV enforcement, operations, and maintenance costs of the Electronic Toll Collection (ETC) system and customer service center. In 2002, about $2.2 million in toll revenues were collected; approximately 50 percent is/was used to fund the Inland Breeze Express Bus Service operating in the corridor and the other 50 percent went to the enforcement by the California Highway Patrol and operation of the ETC system and customer service center (*29*). Survey results of public response to the concept indicated that both users and non-users of the dynamically priced HOT lanes strongly support the use of price as a strategy to improve traffic. Additionally, equity was not considered an obstacle to implementing pricing and it is surprisingly interesting to observe that the lowest income group expressed stronger support than the highest income group (80 percent vs. 70 percent) (*29*).

[8] Policies implemented before March 2009 in this report are defined as previous, and those after March 2009 are current.

In their report, results of an evaluation study by Supernak et al. indicated that the I-15 pricing project appears to have met most of its primary objectives (*30*). Their evaluation was based on a wide range of quantitative data such as traffic volumes, travel modes, vehicle speeds, travel times, and violations. Their study showed that the FasTrak program was working properly to better use the MLs. They reported an increase of subscriber vehicles and the project generated sufficient revenue to fund transit improvements in the I-15 corridor. At the end of their 3-year impact evaluation program, Supernak et al. also indicated that the FasTrak program did not negatively affect the number of carpools on the MLs and there were substantial increases in HOV volumes during the FasTrak implementation. In addition, due to its good performance in redistributing the traffic from the middle of the peak to the peak shoulders, FasTrak is capable of maintaining free-flow conditions at all times, as required by California law, despite steadily increasing volumes on the MLs.

The extension of the I-15 HOT lanes from SR 56 to Del Lago opened in March 2009. With this opening the entire HOT lane (SR 163/I-15 split to Del Lago) now operates as described below. The lanes are designed to provide a platform for new technology including electronic sensors monitoring the traffic flow, a sophisticated congestion pricing system that adjusts the toll rate based on the level of congestion in the HOT lanes, and a moveable barrier allowing for directional expansion during a.m. and p.m. peak periods. All these innovations provide sufficient flexibility to meet current traffic demand and accommodate projected growth in the future.

The segment opened in 2009 is a 16-mile congestion-free HOT facility as presented in Figure 10 that also shows that by 2012 the HOT lanes will stretch 20 miles from SR 163 to SR 78. Though there are no stated goals, maximizing throughput and efficiency of the system was indicated as one goal in our discussion[9] with an ITS business analyst at San Diego Association of Governments (SANDAG). Carpools, vanpools, and transit have priority to use the managed lanes and the remaining capacity is sold to SOVs. The collected tolls are used in maintenance of back office operations, customer service, operations, and maintenance of the facility, including moving the reversible barrier, and excess revenues go to reserve account. The analyst also indicated that the transit operator received $500,000.00 per year from the excess revenue, if it is available.

[9] The phone interview with Christopher Burke at SANDAG was conducted on December 4, 2009.

Figure 10. I-15 HOT Lanes Project Area Map (*31*).

Contrary to the previous volume-based pricing system, in 2009, the I-15 HOT lanes started a distance-based pricing strategy that dynamically varies the per-mile toll rate every few minutes based on the level of traffic in the I-15 corridor to maintain free-flow traffic in the HOT lanes. The initial rates were developed by Wilbur Smith Associates and approved by legislature and the SANDAG Board. The SANDAG Board of Administration has the authority to set toll rates between $0.50 and $8.00. The current pricing approach on the reversible HOT lanes ensures LOS C by measuring actual volume and comparing that volume to the facility's design capacity.

Density is measured at four toll plazas and is also used for performance data. The toll setting algorithm looks ahead at density at downstream plazas to make adjustments to the current toll rates. However, there is no detector to check if the toll collection equipment is accurate. In a 2006 report to SANDAG, HNTB Corporation indicated that Caltrans installed vehicle detectors at strategic locations along the ML and adjacent general purpose lanes to collect congestion data (*32*). Data (vehicle location, speed, and volume) collected through inductive loop detectors for all lanes and segments in both directions are transmitted to the Traffic Management Center (TMC). With those data, operators in Caltrans TMC can compare the performance of the I-15 corridor freeway system between the managed lane and general purpose lanes (GPLs), and then make effective traffic management decisions.

The HOT lanes provide all travelers of all transportation modes reliable travel. HOVs, motorcycles, transit, and approved hybrid vehicles can continue to use the lanes toll-free. Statistics from SANDAG shows that the average traffic volume on entire I-15 facility ranges from 170,000 to 295,000 vehicles a day and vehicles on GPLs usually are subject to 30 to

45 minutes delay at peak periods. The projected traffic in the corridor is approximately 380,000 vehicles daily by 2020, which necessitated improvements in respect to pricing strategies to meet the growing demand (*33*).

HOT Lanes on I-15 (Salt Lake City) (34)

I-15 in Utah's Salt Lake City metropolitan region has 38 miles of HOV lanes. In September 2006, the HOV lanes were converted into HOT lanes. For a monthly fee of $50.00, SOV drivers could use the HOV lane. All vehicles with two or more occupants, motorcycles, emergency vehicles, buses, and clean-fuel vehicles with a current "C" plate[10] from the Department of Motor Vehicles (DMV) are eligible to use the Express Lanes free of charge. Traffic studies by Utah Department of Transportation (UDOT) show that one lane on I-15 can maintain a minimum speed of 55 mph during peak periods with up to 1500 cars. However, until September 2006, the HOV lanes only served about 650 to 750 vehicles per hour in peak periods (*35*).

To better use the available capacity, UDOT began HOT lane operations with the monthly fee and is now considering another operational adjustment to improve traffic conditions. As indicated in our phone interview[11] in November 2009 with an ITS engineer who is managing the HOT lanes on I-15 project for FHWA, the operating agency is shifting the monthly fee to a pay per trip ETC system in 2010. The interviewee also indicated that toll-related goals of the HOT lane project include: 1) to effectively use the excess Express Lane capacity and support the effective use of the capacity of I-15 as a whole, 2) maintain 55 mph for 90 percent of the peak periods on weekdays by limiting the number of permits purchased by SOVs, to effectively manage and monitor the operation of the Express Lanes, and 3) to clearly define toll rates to the driver. Performance data (speed and volume) will be collected by loops placed at 1/2 mile spacing for most of the 38 miles of HOT lane. Speed and transponder reads will also be collected at several tolling locations.

The future dynamic pricing system uses a traffic-condition algorithm that is based on real-time traffic flow data from the Express and general-purpose lanes. Using data provided by UDOT's TransSuite traffic management system, the algorithm will generate toll rates that optimally manage demand (*34*). Their team is currently reviewing algorithms to determine what speed measurements to use in this calculation. A policy framework guiding occupancy restriction or pricing changes is currently under development. Due to the excess capacity in the lane, it is anticipated, however, that the policy will not consider items such as additional restrictions on the lane or increasing occupancy requirements and the focus will be on the pricing of SOVs. The State Transportation Commission has final say on these guiding policies and sets the toll rates, as well as occupancy restriction level if it becomes an issue, with assistance from FHWA and their consultant who will draft guidelines and rates for the commission's review. The minimum and maximum tolls have not yet been determined.

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[10] C Plate is only available to those vehicles meeting the criteria of clean fuel and clear air. http://dmv.utah.gov/licensespecialplates.html#cleanfuel

[11] The phone interview with Russ Robertson from FHWA was conducted on November 24, 2009. Bryan Dillon from FHWA also responded to the survey and answered some questions via email.

The revenue collected from users is the only dedicated funding source and will be distributed among enforcement, maintenance, and other items for the project. UDOT is developing plans for public outreach and have set aside funds for this purpose. The focus in this current phase is on how the ETC system will work since it is new to the area and the project is a complex 38-mile long HOT facility with four tolling zones.

95 Express (Miami) (36)

In December 2008, the northbound express lanes between I-195/SR 112 and NW 151st Street on I-95 were opened for tolling in Miami-Dade County. Carpools (HOV3+), hybrid vehicles, motorcycles, and South Florida Vanpools can drive toll-free, but they must be registered with South Florida Commuter Services. Motorcycles and emergency vehicles can use the express lanes toll-free and do not need to register.

Our phone interview[12] with the ITS project manager at Sunguide Transportation Management Center and an engineer with AECOM indicated that the goals of the project were 1) maximize throughput, 2) improve operations of HOV lanes that were over capacity during peak periods, 3) increase HOV restrictions from 4 to 24 hours/day and utilize surplus capacity of the HOV lanes, when available, by SOV drivers paying a toll, 4) maintain free flow speed on the Express Lanes and travel time savings, 5) increase trip reliability, 6) incentivize transit and carpooling, 7) reduce congestion through diverting traffic to non-peak period, 8) meet increasing travel demand in the future, and 9) facilitate trip-reducing carpool formations (as opposed to “fampools”). To achieve the goal of maintaining free flow speed on the Express Lanes, balance between the target of maintaining 45 mph speed for most of the time and not setting the toll so high that the 45 mph speed is achieved 100 percent of the time through overly restrictive use of the lane.

To maintain free flow conditions (45 mph) along the express lanes, the operating agency used an algorithm guided by project-specific rules that enable the software (Express Lanes Watcher) to recommend toll changes every 15 minutes. The software collects real-time traffic data from the express lanes, compares them to historical data, and analyzes this information to dynamically generate tolls based on traffic density within the express lanes.

The toll rates were set by the Florida Legislature on the recommendation from FDOT. The congestion-priced tolls vary from $0.25 to $2.65 between the Golden Glades Interchange to downtown Miami, and they can go up to $6.20 when traffic experiences extreme conditions in order to offer trip reliability to those choosing to use the express lanes (the rates are equivalent to minimum $0.03/mile to maximum $1.00/mile). A minimum $0.25 toll is collected for each segment travelled. The phone interview also indicated that the ITS team helped develop flexible operating policies. Toll rates are set based primarily on speeds, though there are other affecting factors such as density and occupancy. Slight changes to operations are under the jurisdiction of

[12] A phone interview with Rory Santana from Sunguide Transportation Management Center and Gregg Letts from AECOM was conducted on November 22, 2009. Rory Santana also responded to some questions via email.

FDOT, however, significant deviations to operating policies have to be approved by the Florida Legislature. There have been no changes to date.

Performance data (speed, volume, and occupancy) are collected every 1/3 mile on the freeway, including the express lanes and general purpose lanes. The operating speeds and LOS in express lanes and adjacent GPLs are collected via microwave sensors (WaveTronix and Electronic Integrated System Inc. EIS) and loops on ramps. All collected data are processed in a central location. If an individual sensor appears not be working properly, it will be taken out of the toll calculation algorithm. Tolls are the sole source of revenue and are used in priority order:
1) operation and maintenance of the lanes, 2) paying back the contractor who put up advance funding, 3) transit, and 4) any state road.

SR 73 Toll Road in Orange County

In November 1996, the San Joaquin Hills Transportation Corridor Agencies (TCA) started operating SR 73 as a toll road that runs approximately parallel to the Pacific Coast Highway and the San Diego Freeway (*37*). The TCA are made up of two separate government entities created between the County of Orange and a number of cities within the areas benefiting from the Foothill, Eastern and San Joaquin Hills Toll Roads. The two agencies are: The Foothill/Eastern Transportation Corridor Agency (F/ETCA Board of Directors) and the San Joaquin Transportation Corridor Agency (SJHTCA Board of Directors). Other toll roads under the jurisdiction of these two Boards are SR 241, SR 261 and SR 133.

SR 73 is not a typical HOT lane system and is not a toll road over its entire length. It is similar to many publicly-run toll roads with the addition of toll rates that vary by time of the day. All vehicles pay the toll as there is no HOV component. It begins tolling only after the Bison Ave. exit in the southbound direction. In the northbound direction, there is a toll in effect after Greenfield Drive, the first ramp north of the highway’s terminus. Figure 11 shows the project area.

Figure 11. SR 73 Toll Road Project Area Map (*38*).

Our interview[13] was conducted with the director of the Design and Construction Division at TCA. He indicated that the variable or peak hour pricing began in 2001 and the peak hours were determined by the existing traffic at the time and have been maintained as such for simplicity to the users of the roads. The peak hours were originally recommended by staff and approved by the Boards of Directors. Peak hours are designated as 7 a.m.–9 a.m. northbound and 4 p.m.–7 p.m. southbound from Monday to Friday. Off-peak hours include all other weekday hours, weekends and holidays. Currently, there is no mechanism for monitoring shoulder hours and converting them into peak hours. In addition, there is weekend pricing in some locations as well. The toll road system does not utilize any pricing incentives for HOV use.

The operating agency addresses toll rates annually and individually without universal guiding policies over occupancy restriction or pricing change. The toll rates are set by the board of directors with dual goals of revenue (at least enough to pay off bonds) and optimizing traffic flow (throughput). There is a minimum toll set by the bond indentures, but may be waived if an equivalent revenue stream can be met by another means. Table 1 lists the current toll rates for various vehicle types at each of the tolled exits, both with and without FasTrak (*38*). The operating agency collects speed data. However, these speed data are rarely used for price setting strategy and currently there is no speed and accuracy check program utilized for verification purpose. Tolls and development impact fees are the two main sources of the revenue.

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[13] David Lowe at the Transportation Corridor Agencies (TCA) responded the survey via email on November 17, 2009.

Table 1. San Joaquin Hills (SR 73) Toll Road.

Location	Vehicle Class					
Catalina View Mainline	2-axle automobile, motorcycles, or truck		3-4 axles		5 or more axles	
	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend
FasTrak Off-Peak	**4.00**	**3.75**	**8.00**	**7.50**	**16.00**	**15.00**
FasTrak Peak	**4.75**	**3.75**	**9.50**	**7.50**	**19.00**	**15.00**
Cash Off-Peak	4.75	4.50	9.50	9.00	19.00	18.00
Cash Peak	5.50	4.50	11.00	9.00	22.00	18.00
Bonita Canyon						
FasTrak	**0.75**		**0.75**		**0.75**	
Cash	1.00		1.00		1.00	
Newport Coast						
FasTrak	**1.75**		**1.75**		**1.75**	
Cash	2.00		2.00		2.00	
El Toro/Laguna Canyon Road						
FasTrak	**2.00**		**2.00**		**2.00**	
Cash	2.25		2.25		2.25	
Aliso Creek Road						
FasTrak	**1.50**		**1.50**		**1.50**	
Cash	1.75		1.75		1.75	
La Paz Road/Moulton Parkway						
FasTrak	**1.25**		**1.25**		**1.25**	
Cash	1.50		1.50		1.50	

Source: www.thetollroads.com

The San Joaquin Hills Transportation Corridor Agency manages the 15-mile SR 73 Toll Road, which stretches from Newport Beach to San Juan Capistrano in southwest Orange County. Officials from 14 cities and county supervisorial districts near the 73 Toll Road are appointed to serve on the agency's board of directors. The board makes major decisions about construction, administration, and finances affecting the toll roads. SJHTCA member agencies are Aliso Viejo (city council member), Costa Mesa (city council member), Dana Point (mayor pro tem**)**, Irvine (city council member), Laguna Hills (city council member), Laguna Niguel (mayor pro tem), Laguna Woods (city council member), Mission Viejo (city council member), Newport Beach (city council member), San Clemente (city council member), San Juan Capistrano (city council member), Santa Ana (city council member), and County of Orange 3rd and 5th Districts.
The Foothill/Eastern Transportation Corridor Agency manages the 241, 261, and 133 toll roads, which links the Riverside (SR 91) Freeway near the Orange/Riverside County border to I-5 in Irvine and to communities in south Orange County.

F/ETCA member agencies consist of the cities of Anaheim (council member), Dana Point (mayor), Irvine (council member), Lake Forest (city council member and mayor), Mission Viejo (council man), Orange (supervisor of Orange County's Third District), Rancho Santa Margarita (council member), San Clemente (council man), San Juan Capistrano (council man), Santa Ana (council member), Tustin (mayor pro tem), Yorba Linda (council member), and County of Orange 3rd, 4th, and 5th Districts.

As mentioned in TCA's 2009 Annual Report, they began to aggressively use social media resources, such as Facebook and Twitter, to expand communication to the communities about TCA activities and news (*39*). The use of aforementioned web-based media resources has proved to be successful and useful as an inexpensive tool for customers to receive the latest news regarding the latest toll road news and updates. This also helped enhance the agency's ability to receive feedback directly through the Internet.

C-470 Corridor in Denver (Currently the Project Is On-Hold from May 2006)

There is projected to be a population growth of 34 percent and employment growth of 44 percent in the C-470 corridor by 2025.[14] In accordance with the FHWA, the C-470 Corridor Project was initiated by the Colorado Department of Transportation (CDOT), through its consultant team of Wilson & Company and PBS&J. As mentioned on the project website, "*the C-470 Environmental Assessment Document was signed by the Federal Highway Administration and the Colorado Department of Transportation in February 2006. It then underwent a three-month public review process including public hearings…Currently the project is on hold until further notification is given by the Colorado Department of Transportation*" (*40*). Quick facts about the Express Lanes revealed that the two alternatives (adding GPLs and tolled express lanes) considered in the feasibility analysis both met the project goals (minimizing congestion, reducing traveler delay, and improving reliability on C-470 between I-25 and Kipling). However, only the express toll lanes can possibly be funded over the next 25 years.

The High Performance Transportation Enterprise (formerly Colorado Tolling Enterprise [CTE]) sets the toll rates. There are seven members in the High Performance Transportation Enterprise that was created by 2009's Funding Advancements for Surface Transportation and Economic Recovery (FASTER) legislation and the members were appointed by the governor. The toll structure will allow for reduced rates in periods other than the rush hours. The variable toll price will be adjusted based on demand, allowing for free-flow traffic in the express tolled lanes. Though the actual tolls has not yet been set since the toll system is still under construction, the estimated price would be approximately $2.50 during peak period to travel the entire 12.5-mile corridor. According to the C-470 Express Lanes Feasibility Study, "*the toll rate used in the financial feasibility calculation was based on a projected toll rate for 2025 and then interpolated to arrive at a potential opening year toll rate. The initial opening year toll rate for the peak hours was calculated to be $0.12 per mile. This was based on a lower value of time of $6 per hour, derived based on existing drivers' perception of existing traffic conditions. As traffic volumes and congestion increase, so does a drivers' value of time.…With the updated value of time, the micro-simulation model was run for opening year conditions and then optimized. A new toll rate of $0.18 per mile (in 2004 dollars) was developed*" (*41*).

Queue Jumps in Lee County

Priced queue jumps (Q-Jumps) allow travelers to pay a toll to go around/over a congested signalized intersection. This concept was initiated by Chris Swenson in Lee County over a decade ago. For many years this was only a concept but recently construction and planning for these Q-Jumps has begun in earnest. One un-priced facility is built and several priced ones are in design or have begun construction.

[14] This is according to a public hearing held on April 4–5, 2006.

Our phone interview[15] with Chris indicated that even though the goal is not written, it is to maximize throughput. With input from local consultants, the Board of County Commissioners (BOCC) of Lee County sets toll rates on the Q- Jumps (except when the Q-Jump is on a state highway). Local consultants also helped develop appropriate, though very limited, guiding policies for occupancy restriction and pricing changes. This includes if the road should be tolled or not, who travels free, bus use only, etc.

For county roads (the vast majority of Q-Jumps) the BOCC has final say on toll rates. For state roads (US 41 only), the Florida Department of Transportation (FDOT) (District 1 and Florida Turnpike) would make the decision on tolling. It is possible to collect performance data (speed) at a point along short segments (usually half mile long), but this has not been tested yet.

The tolls collected will be the source of revenue and the revenue will be used to repay the cost of construction. Surplus revenues, if any, must be used in improvements in the same corridor. This policy can only be changed by a super majority vote of the BOCC. On the toll bridges excess revenues do occur and they must be used for improvements on bridge approaches. Roads or intersections where more than 50 percent of traffic is headed to or came from the bridge are considered an approach to that bridge.

Toll Roads in Illinois

Our survey[16] found that Illinois does not currently have any HOV/HOT lanes in operation. However, there are ongoing studies examining the potential deployment of HOV/HOT lanes in the Chicago area and will likely begin as HOV2+ (HOV3+ has not been discussed). The Illinois Tollway maintains and operates 286 miles of interstate tollways in 12 counties in Northern Illinois. The Illinois State Toll Highway Authority (ISTHA), an independent agency, is currently responsible for managing all existing toll roads in Illinois. The board of directors sets policy for operations and maintenance and construction of the roadways. There are 11 members, including the governor and Acting Secretary of Transportation, on the board of directors. No more than five of the members may be from one political party. The chairman and directors are appointed by the governor and serve 4-year terms. Goals of ISTHA congestion pricing (for commercial vehicles only) include diverting non-essential truck traffic from peak periods of travel. This is primarily done as congestion reduction effort and a safety effort to reduce serious crashes from trucks.

Data (volume/throughput) are primarily collected through the electronic toll collection system at mainline toll plazas and roadside radar detectors (as part of the Intelligent Transportation Infrastructure Program [ITIP]) spaced approximately a 1/2 mile outside of the toll plazas throughout the system. These data are reported to a regional agency and available to the public at a website (www.gcmtravelstats.com). The ISTHA also conducts regular audits to compare data obtained from ITIP sensors, toll collection data, and data from a regular traffic count program conducted by consultants. Those counts are compared on a daily basis, as stated in the survey.

[15] The phone interview with Chris Swenson was conducted on December 4, 2009.
[16] Christopher DiPalma from Chicago Metro Office of FHWA responded to the survey via email on December 8 and 9, 2009.

The ISTHA sets the toll rates, both minimum and maximum. Toll rates for passenger vehicles remain constant while toll rates for commercial vehicles vary by time of day. Table 2 shows typical mainline toll plaza rates that can vary by location (*42*). The tolls are calculated by distance traveled, which is based on a standard per mile charge for each road, so that the rates will be higher for a plaza that is farther from the starting point. Sources of revenue are mainly from toll revenues and ancillary operations such as oases, or rest area concessions, rents, advertising, etc. Revenues go toward retiring construction bonds and paying for improvement and new construction on ISHTA roadways only. The revenues also cover the cost of administration for the ISHTA, but no revenues are shared with the state DOT or transit service, though the state does receive toll credits from FHWA toward their federal-aid program. According to the 2008 Annual Report, toll and evasion recovery ($640 million) accounted for 95.5 percent of the total revenue ($670 million), investment income from tollway funds and I-Pass cash escrow accounts are 3.7 percent, and concessions and miscellaneous are 0.8 percent.

Table 2. Toll Rates for Typical Plazas as of January 1, 2009.

TRUCKS & TRAILERS (Rates reflect typical mainline toll plaza rates that can vary by location.)			
DAYTIME	2 AXLE 6 TIRES	3-4 AXLES	5+ AXLES
I-PASS & CASH 6 AM - 10 PM	$1.50	$2.25	$4.00
OVERNIGHT			
I-PASS & CASH 10 PM - 6 AM	$1.00	$1.75	$3.00

Source: www.illinoistollway.com

As stated in the 2008 Annual Report, the Traffic Operations Center (TOC) played a key role in incident management. A computer-aided dispatch (CAD) system, the Tollway's Central Dispatch is the heart of the traffic operation. The public safety operation is available on a 24/7/365 basis and is responsible for all radio communication with the Illinois State Police District 15 and Tollway Maintenance and Traffic field operations.

Pennsylvania Turnpike

The Pennsylvania Turnpike Commission (PTC) operates and maintains 545 miles of toll roads in the state. Since its inception, the Pennsylvania Turnpike toll rates have changed six times in more than 68 years (see Figure 12) (*43*). The most recent rate increase was in January 2010. The most common rate for passenger vehicles was increased from $0.95 to $1.00 and for commercial vehicles from $7.85 to $8.10. Increases in both 2009 and 2010 are mainly due to the passage of Act 44 of 2007, which changed the mission of the PTC. The turnpike is required by Act 44 to provide a total of $2.5 billion in supplemental transportation funding from August 2007 to May 2010, and consequently a toll increase in January 2009 and January 2010 became a necessity. As the cost to maintain and construct roadways continues to increase, so does the PTC's responsibility to provide new transportation funding for the entire commonwealth of Pennsylvania. An annual increase of 3 percent is considered reasonable to keep pace with inflation so that the PTC is able to provide necessary funding for roads, bridges, and transit throughout Pennsylvania. The small step increase will serve the purpose and also avoid instituting those bigger increases of 30–40 percent every dozen years as was the old practice. Toll-increase generated proceeds will largely be used by the Pennsylvania Department of Transportation (PennDOT) to help finance off-turnpike road and bridge projects and the state's mass-transit operation (*44*).

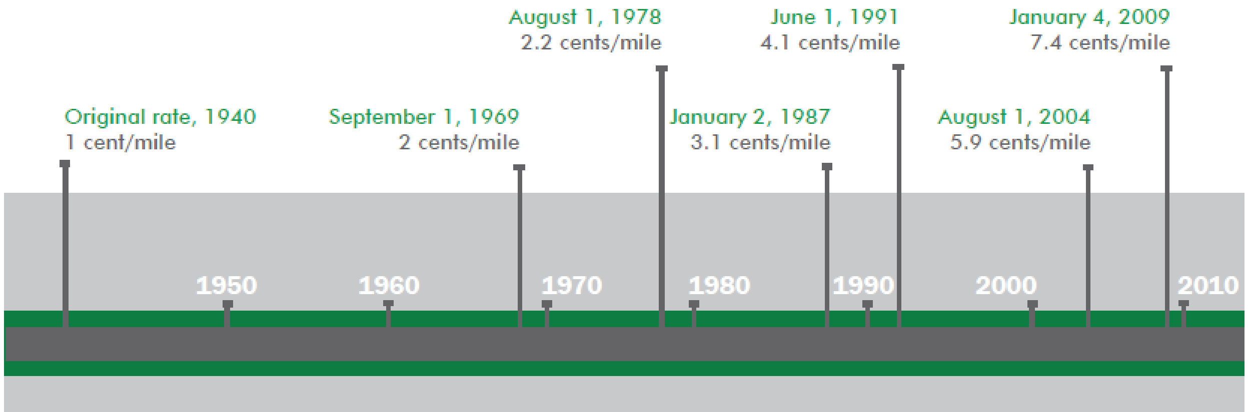

Figure 12. History of Tolls on the Pennsylvania Turnpike.
Source: www.paturnpike.com

The Operations Control Center monitors turnpike activities, such as roadway conditions, construction status, and weather conditions, as well as incident management activities via an extensive radio system. A CAD system renders the center the ability to provide the commission's radio operators with instantaneous access to the closest emergency services. In a situation of emergency, the operator will report the located incident into the CAD system, and the system will then initiate action instantly to handle the situation.

Regional System of Variable-Priced Lanes in the Washington, D.C., Region

An 18-month study by the National Capital Region Transportation Planning Board (TPB) to evaluate the potential for highway pricing in the Washington, D.C., region was completed in April 2005. A Task Force created by the TPB developed a set of regional goals for a system of variably priced lanes (VPL). As indicated by Eichler et al., the goals were designed to "*help guide the regional development of variably-priced lanes that work together as a multi-modal system, while addressing the special policy and operational issues raised by the multi-jurisdictional nature of this region*" (*45*). Toll rates related goals for the regional system of variably-priced lanes include: 1) the toll rates should be adjusted to manage traffic in reasonably free-flow conditions, and 2) integrate transit service as part of the variably-priced lanes system to maximize not only number of vehicles but also throughput (*46*).

The TPB also emphasized the importance of convincing the Congress and the Federal Transit Administration (FTA) to recognize variably-priced lanes as fixed guideway miles so that federal transit funding is unaffected by value pricing projects. Tolls collected from the variably-priced lane would be used to finance construction, service debt, and pay for operations and maintenance of the priced lanes. Excess revenue should be considered for improving transit services. Currently, three major variably-priced highway facilities are being developed as part of the regional system (see Figure 13): the Inter-County Connector (ICC) in suburban Maryland, the

Northern Virginia Capital Beltway (I-495) HOT lanes project, and the I-95/395 HOT lanes project (*45*). The ICC project has six variably-priced lanes with express bus service having direct access to Metrorail stations and is expected to be completed in 2012. The I-495 Beltway HOT lanes project will have four HOT lanes and completion is expected by 2013. The HOT lanes allow vehicles to pay varying rates according to levels of congestion and time of day while HOV3+ as well as transit and emergency vehicles will travel for free. I-95/395 HOT lane project will convert an existing HOV facility to HOT lanes and completion of this project is expected by 2010.

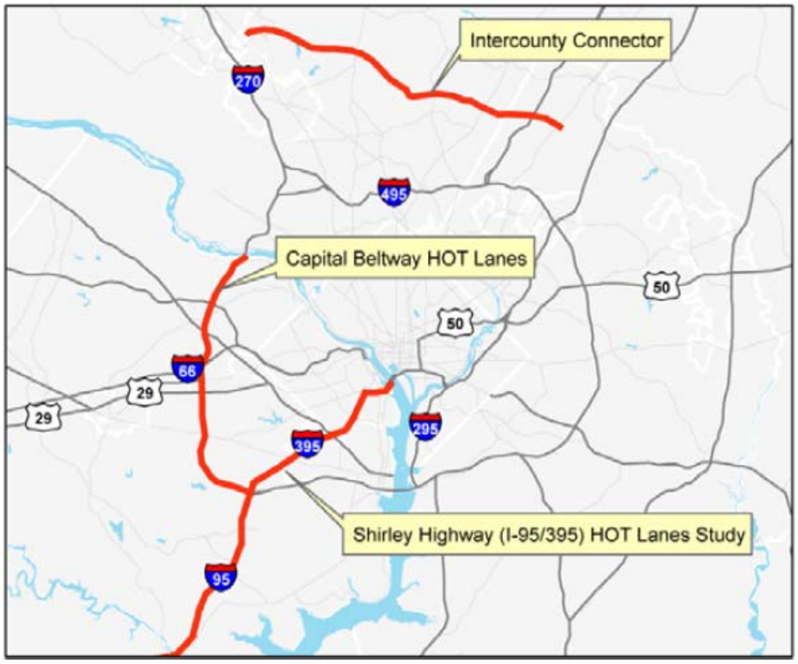

Figure 13. Three Value Pricing Projects under Development (*45*).

Our survey[17] respondent, from the National Capital Region TPB, revealed that all HOV/HOT policies in the D.C. area are made by the states. Regarding the HOV occupancy policy, it was noted that I-66 in Northern Virginia was initially created as a HOV4 facility, but is now operating as an HOV2 facility. That is primarily because of political consideration and reflection of the different needs and desires between the inner-and outer-suburban Virginia residents.

Inter County Connector (ICC) and Express Toll Lanes (ETL) on I-95 in Maryland

The ICC project and Express Toll Lanes on I-95 are being developed by the Maryland (Toll) State Highway Administration (MDTA) (*47*). The ICC will be a volume-based variably priced congestion-managed toll highway. Our phone interview[18] with the acting director in the Division of Capital Planning at MDTA indicated that the volume data will be collected at tolling stations. For the ICC and the ETLs, the goals are: 1) optimizing revenue: to realize at least the revenue

[17] Michael Eichler from the National Capital Region Transportation Planning Board responded to our survey via email on December 7, 2009.

[18] The phone interview with Dennis N. Simpson from Maryland Transportation Authority was conducted on December 4, 2009.

predicted in the most recent traffic and revenue (T&R) analysis, 2) optimizing traffic: to maintain relatively free-flow traffic conditions on the managed lanes and the targeted LOS is between C and D. According to MDTA, "*two types of periodic toll review and adjustment are used in order to meet the stated goals, the Pricing Parameter Review and the Toll Adjustment Review…The Pricing Parameter Review is conducted every year or two and the Toll Adjustment Review is conducted approximately every quarter*" (*48*). The Pricing Parameter Review is used for overall pricing parameters to guide day-to-day operation of the MLs and this review considers many items, such as 1) establish the Mileage Rate Range and Pricing Period Definitions for the coming year, 2) minimum and maximum toll, 3) inflation, and 4) updated T&R analysis. The Toll Adjustment Review is "*for necessary adjustments to the toll levels and pricing period definitions needed to respond to traffic demand variations.*" Items considered include peak, shoulder, and off-peak pricing periods and per-mile toll rates.

The toll rates are set by the "*MDTA executive secretary within the authority-approved ranges and periodically adjusted by the executive secretary with ten days notice of a proposed change in toll rates…Changes in the rate ranges will be made by the board of MDTA after a formal staff proposal and the standard 60-day public comment period*" (*47*). According to MDTA, in addition to generating revenue, the pricing of ICC is designed to encourage travelers to cancel or postpone their trips when congestion levels are higher (*48*). The variable pricing of tolls on the I-95 ETLs is to "*maintain relatively free-flow traffic conditions in the ETLs by encouraging travelers to use the GPLs or to shift travel to a less congested time.*"

As indicated by MDTA, regarding the toll setting policies, due to lack of operation history of both ICC and I-95, the initial toll schedules will be set based primarily on the traffic predictions of each facility's T&R study in projecting the tolls needed to both achieve targeted revenue and maintain LOS (*48*). Moreover, no discount will be offered for any vehicle for any trips on managed facilities. There is, however, a pricing incentive for travelling in less congested periods. Tolls are the source of revenue. They will be used for all MDTA facilities (new construction), pay for bonds, operations, and maintenance for over 20 years, as indicated by the interviewee.

In the initial operation phase, dynamic pricing will not be applied on the ICC. The MDTA in September 2009 announced a toll rates range for ICC that could vary between $0.10/mile and $0.35/mile for cars to manage traffic. The toll rates during peak-hours (6–9 a.m. and 4–7 p.m.) on weekdays excluding federal holidays for cars range from $0.25 to $0.35/mile, off-peak $0.20 to $0.30/mile, night (11 p.m. to 5 a.m.) $0.10 to $0.30/mile, and the minimum toll is the greater of $0.40 or two miles of the toll rate. Motorcycles pay car toll rates but for vehicles over 2 axles, the applied toll rates will be the multiplication of corresponding multiplier with base 2-axle rate. Peak, off-peak, and shoulder pricing periods[19] are determined on actual traffic measurements through the day. For the T&R study, traffic variation over the peak hours were obtained on existing arterials in the area. The actual traffic peak will be directly measured in order to adjust the pricing periods after the project completion.

[19] Shoulder hours are defined by MDTA (2009) as those hours before and after the peak hours during which traffic is rising toward or decreasing from peak, and congested conditions are infrequently occurring.

Table 3 shows the approved toll rate ranges of ICC. The table shows that the minimum toll rate is $0.20/mile and the maximum toll rate is $2.63/mile (*47*).

Table 3. Approved Toll Range of ICC.

Pricing Period Vehicle Class	Mileage Rate Range					
	2-Axle Rate (per mile)	3-Axle Rate (per mile)	4-Axle Rate (per mile)	5-Axle Rate (per mile)	6^+-Axle Rate (per mile)	Motorcycle (per mile)
Peak	$0.25 to $0.35	$0.75 to $1.05	$1.13 to $1.58	$1.50 to $2.10	$1.88 to $2.63	$0.25 to $0.35
Off-Peak	$0.20 to $0.30	$0.60 to $0.90	$0.290 to $1.35	$1.20 to $1.80	$1.50 to $2.25	$0.20 to $0.30
Overnight	$0.10 to $0.30	$0.30 to $0.90	$0.45 to $1.35	$0.60 to $1.80	$0.75 to $2.25	$0.10 to $0.30

Source: tollroadsnews.com

Potential Managed Lanes on I-75 South Corridor in Atlanta

The I-75 facility is ranked among Atlanta's six most congested corridors. In 2006, the State Road and Tollway Authority (SRTA), an agency operating Georgia's toll roads, sponsored a Value Pricing Pilot Program Study of the Potential Managed Lanes on I-75 South Corridor in Atlanta to examine the feasibility of incorporating pricing strategy in combination with other strategies on the I-75 south of Atlanta from I-285 to SR 16. Pricing strategies reviewed include HOV lanes, HOT lanes, Truck Only Toll (TOT) lanes and special use lanes such as express, bus-only, or truck-only.

One of the goals of their study was to evaluate value pricing techniques on the I-75 corridor to better manage travel and optimize the use of the corridor. As indicated by HNTB Corporation, managed lanes on I-75 are to serve four main objectives: "*1) increase throughput as well as number of vehicles in the corridor, 2) maintain free-flow speeds in the managed lanes, 3) increase trip reliability, and 4) providing travel alternatives by accommodating transit and/or carpools*" (*49*). Their study efforts included an assessment of existing traffic conditions, a stated preference (SP) survey, public outreach, a traffic and revenue analysis, system alternatives analysis, an assessment of toll collection technology, sensitivity tests, and capital cost estimation. The SP survey is a home telephone-based questionnaire containing two questions that elicit willingness-to-pay information: 1) a set of four stated preference choices, and 2) a "transfer price" question (*50*).[20] Public outreach efforts included development of a public involvement program, steering committee meetings and presentations, distribution of educational materials such as fact sheets, handouts, and website materials.

Seven different managed lanes options[21] with each utilizing different applications of vehicle eligibility, pricing and access control were studied and compared. Among these seven alternatives, Express Toll Lanes (Cars Only) was selected as the most preferred alternative for the corridor based on the combined assessment of revenue potential and estimated costs. This option would provide the most efficient use of public funds.

[20] For detailed information on transfer price, refer to Section 2.1 of the Final Report.
[21] For detailed information of these seven options, refer to the same Final Report.

Conversion of HOV Lanes to HOT Lanes on I-85 in Atlanta

The Georgia Department of Transportation (GDOT) predicts that the HOV lane volumes on I-85 will grow 6 percent through 2011, 8 percent by 2012, and 56 percent by 2031 (*51*). The increases in traffic demand mean that by 2012 the HOV lanes will exceed the effective lane capacity during peak periods. The conversion of the current approximate 15 miles of HOV lanes to HOT lanes is partly because conventional HOV3+ lanes would be 30 percent underutilized (*51*). In contrast, the HOT3+ can increase utilization of the lane and provide reliable travel times while maintaining average speeds above 45 mph in the peak hours. Figure 14 shows the HOV system and Phase I I-85 HOT lane area map.

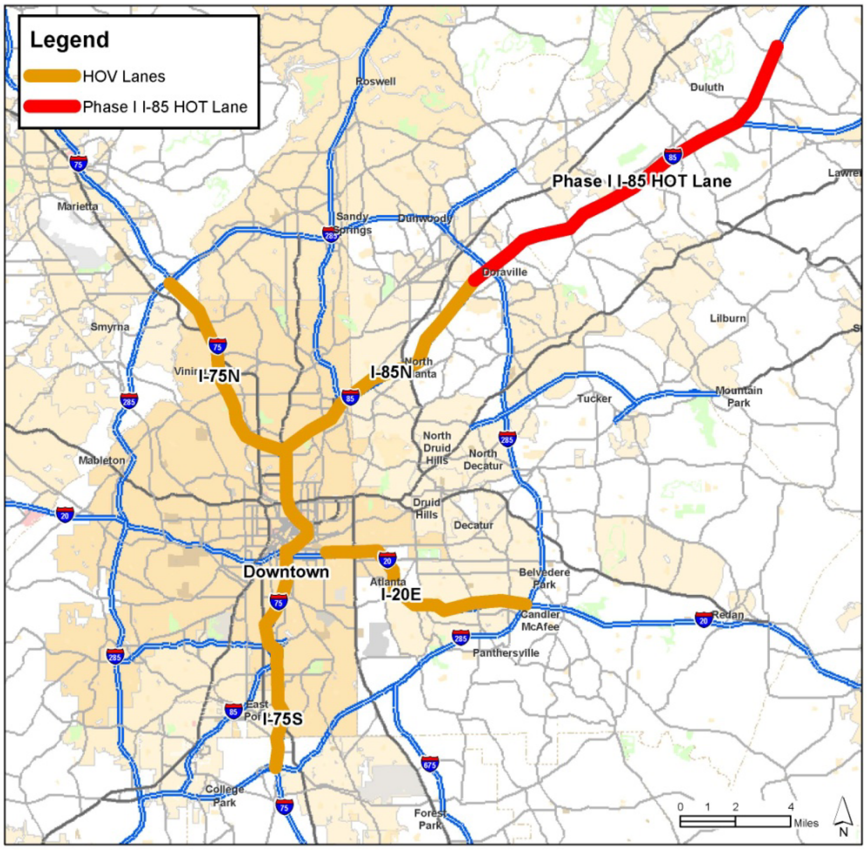

Figure 14. I-85 HOV System and Phase I I-85 HOT Lane Area Map.
Source: http://www.dot.state.ga.us

In November 2008, the USDOT awarded a $110 million Congestion Reduction Demonstration (CRD) Program grant to the Atlanta region. The CRD grant will enable the conversion of 15 miles of existing HOV lanes to HOT lanes on I-85 from Chamblee Tucker Road, just south of I-285, to Old Peachtree Road. Tolls will vary dynamically based on the number of vehicles using the HOT lanes to keep the lane free-flowing and provide reliable travel time. Innovative technologies will be deployed to aid HOT lane operations and enforcement.

CRD funding will also contribute toward expanding express bus services called Xpress. In the I-85 north corridor, the CRD funding will provide new park and ride lots at Hamilton Mill and at Cedars Road. In addition, CRD funding will provide the right-of-way for the expansion of the

I-985/GA 20 park and ride lot and the purchase of 36 new coaches to support the conversion project. Elsewhere in the region, the CRD funding will allow the Georgia Regional Transportation Authority (GRTA) to develop the South Xpress Operating Center, construct eight park and ride lots and purchase 46 new coaches for expanded Xpress service. The total cost for the HOT lane tolling system, civil construction, public outreach, transit improvements, and performance monitoring is $182 million.

All vehicles must register to ride in the HOT lanes and the toll rates will be based on the number of vehicles using the HOT lanes. HOV3+, transit, on-call emergency vehicles, motorcycles, vehicles with alternative-fuel vehicle (AFV) license plate will travel toll free. HOV2 and SOVs will need to pay a toll to use the I-85 HOT lanes. According to GDOT, the impact of HOV3+ and HOT3+ on the travel time is significant (*52*). With HOV3+ requirement, there will be no congestion on the HOV lanes, but only 20 to 30 percent of the lane would be occupied all by HOV vehicles, whereas the HOT3+ policy makes better use of the lane that would be almost fully occupied by HOV vehicles and paying customers.

Our phone interview[22] with the administrator of Strategic Business Development from the State Road and Tollway Authority (SRTA) in Georgia indicated that there is no HOT lane currently in operation in the State of Georgia. They have an HOV law and a Board Resolution that allows for HOV2+ lanes to become HOT3+ registered lanes. The interviewee indicated that the goal is to maintain average speeds 45 mph or more for 90 percent of the peak period. The State Transportation Board can set occupancy levels while the SRTA sets the toll rates. The minimum and maximum rates have not yet been set. In Georgia, they have laws regulating the HOV/HOT/ML lanes and currently there are no performance goals that would trigger the policy or toll rate changes.

The Traffic Management Center (TMC) of the state DOT collects the performance data through loops (for Highway Performance Monitoring System (HPMS) and travel time) and radars (autoscape for vehicle counting, they also use camera for visual identification of incidents). The accuracy of the collected performance data are regularly checked and calibrated by a contractor from Georgia Tech with the contractor's GPS data. The SRTA is in the process of drafting the policies of MLs regulating the use of revenues. The revenue will be used to pay back debt and for operation of the lanes. The FTA anticipates having some portion of revenue to be used on transit improvements.

The policy for HOT3 of the State Transportation Board (STB) approved that certain registered vehicle types shall have preferential use of HOT lanes without incurring a toll charge. These vehicle types are: over the Road Buses, motorcycles, vehicles bearing alternative fueled vehicle license plates issued under Code Section 40-2-76, on-call emergency vehicles, and HOV3+ vehicles. The STB's policy also requires that consistency of occupancy requirement on the whole system. For instance, if 2 or more occupants required on one HOV facility, then the same requirement applies to any other HOV facility within the state.

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[22] The phone interview with Patrick Vu from State Road and Toll Authority was on January 22, 2010.

Projects in Texas under the Express Lanes Demonstration Program Tolling Agreement

Initiated by the FHWA, the Express Lane Demonstration Program (ELDP)[23] is a new pilot program that permits tolling on selected new and existing Interstate lanes (*10*). The ELDP aims to "manage high levels of congestion, reduce emissions in a non-attainment or maintenance area, or finance added Interstate lanes for the purpose of reducing congestion" (*10*). In response to the demonstration program, TxDOT reached tolling agreements with the FHWA for the North Tarrant Express (NTE), LBJ Managed Lanes (I-635), I-30 and I-35E projects under the provisions of ELDP. The Demonstration Program furthers the goals of the National Strategy to Reduce Congestion[24] by allowing states to better manage congestion and improve their ability to finance new or expanded highway capacity through the use of tolling. The FHWA requires that proposed performance goals must include goals related to addressing the "I) Effects on travel, traffic, and air quality; II) Distribution of benefits and burdens; III) Use of alternative transportation modes; and IV) Use of revenues to meet transportation or impact mitigation needs" (*11*). According to the agreements between the FHWA and TxDOT for LBJ, NTE, I-30 and I-35E projects, the four goals listed above have been identified as performance goals for these projects. Apart from being a reflection of the priorities for the project at the state and local levels, these performance goals also reflect the goals of the ELDP set forth in federal law as part of SAFETEA-LU Section 1604(b) (*10*).

The ELDP Agreement for the I-635 project indicates that specific benchmarks have been established for each goal (*53*). Since the specific initial benchmark values are absent before the start of tolling, the results of the first year will be used as the benchmark for future year comparisons. These benchmark values will be compared on an annual basis to those established performance goals. These benchmark values will be considered having been achieved if the current year values meet or exceed the requirements set forth in the related Comprehensive Development Agreement (CDA), or as an improvement from the prior year's values. Table 4 summarizes the measures that are used to assess the achievement of the goals in compliance with reporting requirements as defined in the agreement of I-635 project (*53*).

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[23] The program carries out 15 demonstration projects to permit states, public authorities, or public or private entities designated by States, the authority to collect a toll from a motor vehicle on an eligible toll facility.
[24] The National Strategy to Reduce Congestion on America's Transportation Network was introduced by the U.S. Department of Transportation to set forth several initiatives to relieve congestion.

Table 4. Measures Corresponding to Respective Performance Goals (I-635).

Performance Goals	Specific Goals	Report Items (Measures)
I) Effects on travel, traffic, and air quality	• Average speed in the Managed Lanes is equal to or greater than 50 mph. • Compliance with the CDA for incident clearance requirements. • Compliance with the CDA for lane availability.	• **Traffic volumes** and **speeds** annually, broken into daily averages, for daily total, by a.m. peak, off-peak and p.m. peak for general purpose lanes and Managed Lanes by direction. • Actual **number of incidents** not responded to or cleared and identify the effect of lane availability for both general purpose lanes and Managed Lanes during this time, including whether the availability for each such lane was returned within the time periods established in the CDA. • **Number of declared HOVs** annually, broken into daily averages, by a.m. peak and p.m. peak for the Managed Lanes.
II) Distribution of benefits and burdens	• Facilitate and encourage HOV and vanpool ridership in the corridor and on the Managed Lanes • Facilitate and encourage communication of operations, toll rates and lane availability	• **Number of declared HOVs** annually, broken into daily averages, by a.m. peak and p.m. peak for the Managed Lanes.
III) Use of alternative transportation modes	• Facilitate and encourage bus usage in the corridor and on the Managed Lanes • Facilitate and encourage available rail, bus, HOV and vanpool cross utilization opportunities to improve operations • Facilitate and encourage appropriate bike and pedestrian movements	• **Number of buses** (i.e. registered non-revenue accounts) annually, broken into daily averages, by a.m. peak, off-peak and p.m. peak for the Managed Lanes • **Average toll charged** by vehicle type, broken into daily averages, by a.m. peak, off-peak and p.m. peak for the Managed Lanes.
IV) Use of revenues to meet transportation or impact mitigation needs	• Ensure responsiveness to the usage of any available project funds for specific transportation improvements or required monetary payments for eligible recipients.	• **Average toll charged** by vehicle type, broken into daily averages, by a.m. peak, off-peak and p.m. peak for the Managed Lanes. • **Amounts of revenue share** on an annual basis (if applicable).

Source: Agreement of I-635 (*53*).

In addition to the performance goal of the use of revenues as shown in Table 4, it should be noted that section 1604 (b) (3) (A) of the SAFETEA-LU (Pub. L. 109-59; Aug. 10, 2005) requires that tolls collected under the ELDP shall be used by a state, public authority, or private entity designated by a state for a few purposes: "1) debt service, 2) return on investment of any private financing, 3) covers the operation and maintenance costs of any facilities used for this demonstration program (including reconstruction, resurfacing, restoration, and rehabilitation), and 4) other purpose relating to a highway or transit project under title 23 or 49, United States Code under the condition that the eligible toll facility is being adequately operated and maintained" (*10*).

Two problems are identified in the Dallas-Fort Worth region in Texas under the ELDP: congestion and air quality. As indicated in the application of ELDP to FHWA, the I-35E Managed Lanes project, as one of the 15 demonstration projects under the ELDP, is believed to be the only viable way for TxDOT to provide safe, reliable, congestion-free trips in the area and accomplish its other goals as described previously (*54*). The managed lanes will allow an alternate choice for users to select a priced option to minimize and guarantee their trip time along the corridor.

For the I-35E and I-30 projects, the agreements between TxDOT and FHWA indicate that facility performance will be assessed by referencing baseline values or trends for five core performance measures: "a) Travel-time reliability, volume, speed, and incidents in priced lanes; b) Changes in mode split/ridership/vehicle occupancies of priced vs. general purpose lanes; c) Transit schedule adherence on the project; d) Application of toll revenue reinvestment; and e) Change in criteria pollutant emissions for the region" (*55*, *56*). Table 5 presents the specific reporting items (measures) under these five core performance measures as described in the Performance Monitoring and Evaluation Manual for these two projects. Notice that the roman numerals in parenthesis correspond to the respective goals listed in the first paragraph of this section. These measures provide relevant information on Performance Goals: I, II, III and IV defined previously.

Table 5. Reported Items under the Five Core Performance Measures.

Measure	Report Items (Measures)	Notes	
Travel-time reliability, volume, speed, and incidents in priced lanes (I, II and III)	The percentage of time that the managed lanes are operating at a minimum average speed of 50 miles per hour.	Broken down into daily averages for the a.m. peak, off-peak and p.m. peak periods.	
	The 95th and 80th percentile travel times for the managed lanes.		The 95th percentile represents the slowest traffic day each month. The 80th percentile represents the slowest traffic day each week. This measure is reported in minutes. Broken down into daily averages for the a.m. peak, off-peak and p.m. peak periods.
	The Buffer Index calculated to demonstrate performance in the managed lanes.		The Buffer Index is the extra time that travelers must add to their average travel time when planning trips to ensure on-time arrival.
	Traffic volumes and traffic volume changes on a total and percentage-change basis annually.	Broken into daily averages, for daily total , by a.m. peak, off-peak and p.m. peak for the managed lanes by direction.	
	Traffic speeds and traffic speed differences from the previous year (on a total and percentage-change basis) annually.		
	Verify, validate, reconcile, catalogue, identify and, report actual number of incidents and identify the effect on lane availability for the managed lanes during this time, including the length of time each such lane was unavailable.	Broken into daily averages, by a.m. peak and p.m. peak for managed lanes.	If reasonably available from data sources.
	The speed and travel time differential between the general purpose lanes and the managed lanes.	Broken into daily averages, for daily total, by a.m. peak, 0ff-peak and p.m. peak.	
	Managed lane availability as a percentage of time the lane is available for operations.	Broken into daily averages, by a.m. peak and p.m. peak for managed lanes.	Could include weather, maintenance, problems with operations, opening procedures or special events that could affect the lane availability.

I). Effects on travel, traffic, and air quality; II). Distribution of benefits and burdens; III). Use of alternative transportation modes; IV). Use of revenues to meet transportation or impact mitigation needs

Source: Agreements of I-30 and I-35E (*55*, *56*).

Table 5. Reported Items under the Five Core Performance Measures (Cont.).

Measure	Report Items (Measures)	Notes	
Changes in mode split/ridership/vehicle occupancies of priced vs. general purpose lanes (I, II and III)	Number of declared HOVs for the year and differences from the previous year (on a total and percentage-change basis).	Broken into daily averages, by a.m. peak and p.m. peak for managed lanes.	
	Number of buses (i. e. registered non-revenue accounts) for the year and differences from the previous year (on a total and percentage-change basis).		
	Average toll charged for the year and differences from the previous year (on a total and percentage-change basis), by vehicle type.		
	Ridership volumes for the year and differences from the previous year (on a total and percentage-change basis) , by vehicle type; SOV, HOV2+, HOV3+, Bus, Van Pool and Other.	Broken into daily averages by a.m. peak, off-peak, and p.m. peak for the general purpose lanes, managed lanes and parallel access roads as applicable.	If reasonably available.
	The amount of vehicle miles traveled (VMT) for the year and differences from the previous year (on a total and percentage-change basis), by vehicle type; SOV, HOV2+, HOV3+, Bus, Van Pool and Other.	Broken into daily averages by a.m. peak, off-peak, and p.m. peak on the managed lanes.	
	Violation rates for 1) unauthorized users on the lane, 2) invalid tag/license plate on vehicle, or 3) SOV trying to use the lane at the HOV rate.		If reasonably available.
	Metropolitan Planning Organization (MPO) rideshare payments, HOV subsidy and other disbursements.		
Transit schedule adherence on the project (II, III)	Transit service reliability - percentage of on-time performance of transit service.		If the information is reasonably avaifable.
	Any existing bus transit routes or sanctioned van-pool accounts utilizing the corridor in advance of opening the project for tolling.		This is to be used as a benchmark for added bus transit routes or sanctioned van-pool accounts utifizing the corridor after tolling begins.
Appfication of toll revenue reinvestment (II, IV)	Breakdown of the use of revenues.		
	Percentage of revenue used to mitigate impacts.		
Change in criteria pollutant emissions for the region (I)	Concentrations of six criteria pollutants during the current year and differences from the previous year (on a total and percentage-change basis)		
	Utilize the results of the core performance sub-elements (Travel-time reliability and Changes in mode of priced vs. GPLs.		

I). Effects on travel, traffic, and air quality; II). Distribution of benefits and burdens; III). Use of alternative transportation modes; IV). Use of revenues to meet transportation or impact mitigation needs

Source: Agreements of I-30 and I-35E (*55*, *56*).

For the I-35E project, the Regional Transportation Council's (RTC) managed lanes policy is specifically established to encourage transit usage to improve air quality by reducing vehicle trips. Within this policy, transit buses travel on express lanes for free, vanpools are able to submit eligible expenses for reimbursement from NCTCOG and, while the region is qualified as a nonattainment area for air quality or during any post-maintenance period, HOVs would receive a discount.

The RTC has established policies with regard to use of any excess revenue and tolling policies[25] in their metropolitan planning organization boundaries. According to the application for the I-35E Managed Lanes Corridor, TxDOT, Dallas Area Rapid Transit (DART) and North Texas Tollway Authority (NTTA) will oversee operations, maintenance, and enforcement for the corridor. "The tolling operations and occupancy enforcement will be a collaborative effort between TxDOT, DART ,and NTTA through existing Interlocal Agreements, planned Tolling Services Agreements and anticipated ELDP Tolling Agreements. The tolling framework will provide rates that may vary depending on time of day and day of the week, or that vary depending on the level of congestion. These toll rate schemes will comply with the Regional Managed Lane Policy and Excess Toll Revenue Sharing Policy for Managed Lanes adopted by NCTCOG" (*54*).

RTC managed lane policy defines that the "toll rates will be updated monthly during the fixed-schedule phase and market-based tolls will be applied during the dynamic-pricing phase. The toll rate will be established to maintain a minimum average corridor speed of 50 miles per hour" (*54*). In their ELDP application to the FHWA, TxDOT sets $0.75 per mile as the initial "Base Toll Rate Cap," which shall "be adjusted every year, beginning January 1, 2010, by a percentage equal to the percentage increase in the CPI between the CPI at the beginning of the one-year period and the CPI at the end of the one-year period" (*54*). It is also indicated that "the Base Toll Rates may not exceed the Base Toll Rate Cap during the initial 180 days after the Service Commencement Date regardless of traffic conditions, except with TxDOT's prior written approval in TxDOT's sole discretion." However, after the initial 180 days, meeting some certain provisions the Developer may then increase the Base Toll Rates over the Base Toll Rate Cap.

Trucks will pay a higher rate and "high-occupancy vehicles of two or more occupants and vanpools will pay the full rate in the off-peak period. High-occupancy vehicles of two or more occupants will receive a 50 percent discount during the peak period." Detailed tolling plans for the projects will be available through web sites as that information is developed (*57*).

Findings from State-of-the-Practice Review

In conducting this state-of-practice review, many organizations from around the country were asked to provide any performance promises they might have adopted on their facilities. Although many verbally expressed interest in the idea, only one had clearly defined triggers and actions to ensure performance. This was SR 91 Express Lanes in California where specific traffic volumes, and therefore congestion levels, result in specific price changes. Others, particularly the dynamically priced HOT lanes, had something similar where they raise the toll rate to ensure the smooth flow of traffic every few minutes.

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[25] The RTC Excess Toll Revenue Sharing Policy for Managed Lanes defines the use of any excess revenue, and the RTC Regional Managed Lane Policy defines the tolling policies. They can be found in the attachment 5 & 6 in the I-35 ELDP Application TxDOT (2009). "I-35E Express Lanes Demonstration Program Application: I-35E Managed Lanes Corridor, Express Lanes Demonstration Program."

Similar to a performance promise is the federal legislation that requires traffic speed on HOT lanes to exceed 45 mph for 90 percent of the time during the peak periods. Frequently failing to meet this requirement may force the removal of SOVs from the facility. Fortunately, all HOT lanes have used pricing to avoid this problem. This was the closest any facility came to pre-determined vehicle occupancy adjustments based on performance measures. Finally, the goals and objectives for the many projects proved interesting and insightful. Table 6 summarizes these goals and they will be used in subsequent tasks.

Table 6. Summary of Goals of Investigated Projects in This Study.

Project Name	Project Goals
SR 167 HOT Lanes Pilot Project	• Maintain travel time, speed, and reliability on the facility
Express Toll Lanes on I-30/Tom Landry in Dallas	• Maintain average speeds greater than 50 mph
SR 91 Express Lanes in Orange County	• Reduce congestion through diverting traffic to non-peak period • Maintain free flow speed on the Express Lanes and travel time savings • Meet increasing travel demand in the future • Generate sufficient revenue for the operations and maintenance of the toll lanes
MnPASS HOT Lanes on I-394 in Minneapolis	*Legislation Goals*: • Improve operating efficiency in trunk highway corridors • Provide the travelers more options *I-394 Project Goals*: • Improve the efficiency of I-394 by increasing the person- and vehicle-carrying capabilities of HOV lanes • Maintain free flow speeds for transit and carpools • Use excess revenue to make transit and highway improvements in I-394 corridor • Use electronic toll collection • Employ new Intelligent Transportation System technologies

Table 6. Summary of Goals of Investigated Projects in This Study (Cont.).

I-35W Corridor in Minneapolis	• Allow the unused capacity of the HOV lanes to be used by SOV drivers paying a toll • Maintain the service (free flow traffic at 55 mph) to carpools and transit on the managed lanes
HOT Lanes on I-15 (San Diego)	*Previous Policies:* • Maximize the use of the existing I-15 Express Lanes • Fund new transit and HOV improvements in this corridor *Current Policies:* • Maximize throughput and efficiency of the system
HOT Lanes on I-15 (Salt Lake City)	• Effectively use the excess Express Lane capacity and support the effective use of the capacity of I-15 as a whole • Maintain 55 mph for 90 percent of the peak periods on weekdays by limiting the number of permits purchased by SOVs • Clearly define toll rates to the driver
95 Express (Miami)	• Maximize throughput • Improve operations of HOV lanes which were over capacity during peak periods • Increase HOV restrictions from 4 to 24 hours/day and utilize surplus capacity of the HOV lanes, when available, by SOV drivers paying a toll • Maintain free flow speed on the Express Lanes and travel time savings • Increase trip reliability • Incentivize transit and carpooling • Reduce congestion through diverting traffic to non-peak period • Meet increasing travel demand in the future, and facilitate trip-reducing carpool formations (as opposed to “fampools”)
SR 73 Toll Road in Orange County	• Generate revenue to pay off bonds • Optimize traffic flow (throughput)
C-470 Corridor in Denver	• Minimize congestion • Reduce traveler delay • Improve reliability on C-470 between I-25 and Kipling
Queue jumps in Lee County	• Maximize throughput

Table 6. Summary of Goals of Investigated Projects in This Study (Cont.).

Toll roads in Illinois	• Divert non-essential truck traffic from peak periods of travel • Reduce congestion • Improve safety, such as reduce crashes from trucks
Pennsylvania Turnpike	• Raise revenue
Regional System of Variable-Priced Lanes in the Washington, D.C., Region	• Manage traffic in reasonably free-flow conditions through adjusting toll rates • Maximize not only number of vehicles but also throughput via integrating transit service as part of the variably-priced lanes system
Inter County Connector (ICC) and Express Toll Lanes (ETL) on I-95 in Maryland	*Goals of ICC & ETL:* • Optimize revenue • Optimize traffic *Goals of ICC:* • Encourage travelers to cancel or postpone their trips when congestion levels are higher • Generate revenue *Goals of ETLs:* • Maintain relatively free-flow traffic conditions in the ETLs by encouraging travelers to use the GPLs or to shift travel to a less congested time
ETL on I-75 in Atlanta	• Increase throughput as well as number of vehicles in the corridor • Maintain free-flow speeds in the managed lanes • Increase trip reliability • Provide travel alternatives by accommodating transit and/or carpools
Conversion of HOV lanes to HOT Lanes on I-85 in Atlanta	• Provide users in HOT lanes reliable travel times in this corridor by effective use of the managed lanes along I-85 north of Atlanta through dynamic pricing

Table 6. Summary of Goals of Investigated Projects in This Study (Cont.).

ELDP Projects in Texas	*Goals of ELDP:* • Manage high levels of congestion Optimize traffic • Reduce emissions in a non-attainment or maintenance area • Finance added Interstate lanes for the purpose of reducing congestion *Performance Goals of I-635, I-30, and I-35E:* • Address the effects on travel, traffic, and air quality • Address the distribution of benefits and burdens • Address the use of alternative transportation modes • Address the use of revenues to meet transportation or impact mitigation needs

IMPORTANCE OF EFFECTIVE COMMUNICATION WITH POLICY MAKERS AND PUBLIC

The operations of priced facilities is often complex. Travelers may be unfamiliar with access and egress locations or toll rates may vary by segment. If active traffic management is used on the facility it may become even more confusing to the driver. However, active traffic management is being used by more transportation providers as a way to monitor conditions and make adjustments, as necessary, to provide the best possible service for the traveler. Where active traffic management is being used it is usually being used in the context of providing superior service to the traveling public. To mange expectations of both the public and policy-makers it is necessary to effectively communicate with them.

In most areas policy-makers set goals based on community desires. The goals are reflected in the operational strategies that are available to facility operators. But it is imperative that the public understand how the operational strategies achieve the goals. Some decisions, such as toll increases, can be controversial. Increases are often met with ire by the public so facility operators may be reluctant to increase tolls and policy-makers may even forbid them from doing so. However, if operational changes are communicated to the traveling public well in advance of the changes, the public can gain an understanding of how the change will ensure the continued superior service.

Policy-makers must communicate and the public must understand why a facility uses performance measures, what the measures themselves are, what thresholds trigger a change, and what changes may occur. This makes the process more transparent and efficient.

CHAPTER 3. DECISION FRAMEWORK

The framework developed under this research provides TxDOT and its mobility partners with a tool to aid in operational decision-making over the life of a facility. A web-based tool with users guide (found in the Appendix) has been prepared to assist agencies in applying performance management to projects that incorporate pricing. This chapter describes the premise of the framework and the factors an agency may consider in developing a proactive plan for managing operational performance.

For the application of decision-making, a framework is often described as a set of assumptions, concepts, values, and practices that provides a methodical way of making decisions. The framework devised through this study is designed to address policy options that decision-makers may pursue over the life of their projects. Essentially, a framework establishes a set of guidelines for that decision-making process, allowing inputs from critical operating aspects and making decisions based upon well-defined points. The advantage of having an established framework in place is that the process for changing price or other operational parameters becomes more efficient and transparent, both to policy-makers and the traveling public.

Figure 15 shows a flow diagram that illustrates the general process and the factors that influence the construction of an operational performance management framework. Noted in the diagram are a series of interrelated steps that the operator considers in formulating the framework, including 1) identification of performance measures, 2) development of procedures for calculating the measures, and 3) identification of the solution or actions to be taken when a performance threshold is reached. The remaining sections of this chapter describe the different elements within the flow diagram.

FACILITY TYPE

Identification and description of the type of facility being developed or in-use is an important concept. The description of a facility helps to convey information about how it will operate and its primary goals. “Managed lanes” is a generic term for lanes proactively operated to achieve a pre-determined level of performance; HOV lanes, HOT lanes and express toll lanes are examples of managed lanes.

The following definitions have been developed for this use.

- HOV lanes are primarily reserved for carpools, buses, motorcycles, and disabled veterans in Texas.
- HOT lanes are HOV lanes that also allow lower occupant vehicles to use the lane for a toll.
- Toll roads are priced facilities open to all travelers who pay a toll to use the lanes.

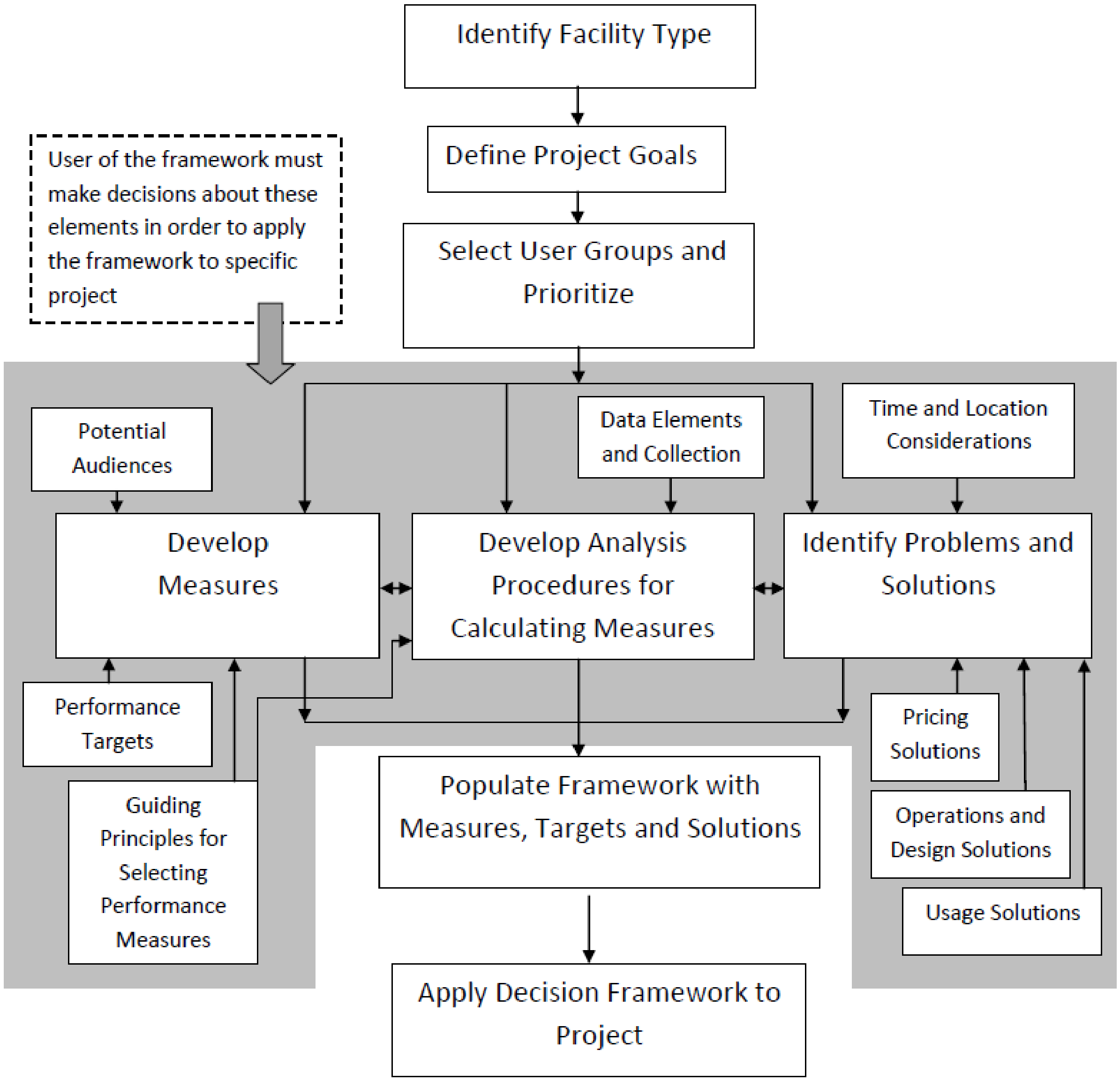

Figure 15. Flow Diagram of Operational Framework Development.

The facility type could change over time. A lesson learned from past projects is that there is a need to better manage and operate roadways as conditions change over time. Changing the type of a facility, say from an HOV to a HOT, allows customers to be better served. Adjusting the type of facility may require a change in some of its operations, such as increasing or decreasing price, changing the number of people required in a vehicles, changing the type of users allowed on the facility, or increasing enforcement.

PROJECT GOALS

The goals are the concrete activity that the agency wishes to achieve by implementing the project. Each goal is essentially a way to manage the facility. If a goal is important, the operations of the facility should be adjusted to accomplish the goal. Based on the research documented in Chapter 2, project goals fell into one of five general areas.

- High-speed travel.
- Maximize revenue.
- Maximize throughput.
- Reliable travel.
- Safe travel.

Within each general goal area, specific objectives were identified. Different objectives can be used in different places and a facility can have more than one goal. Even within the same facility, the goals may change over time, as the population, traffic mix, and acceptance and use of the facility all change. Table 7 lists 18 individual secondary goals, in five primary goal areas, that were derived from the projects listed in Table 6.

Table 7. Goals for Priced Facilities.

Primary Goal	Secondary Goals
High-speed Travel	Improve freeway efficiency Maintain desired level of service Provide travel time savings Maintain free flow speed Reduce congestion Reduce delay
Maximize Revenue	Generate revenue to fund operations and maintenance Fund new transit and HOV improvements Generate revenue to pay off bonds
Maximize Throughput	Increase person- and vehicle-carrying capabilities Effectively use excess capacity Integrate transit service Optimize traffic flow (throughput) Maximize throughput and efficiency Incentivize alternative modes
Reliable Travel	Improve travel reliability Maintain free flow speed for 90 percent of time during the peak periods
Safe travel	Reduce crashes Reduce serious crashes from trucks

Defining clear project goals is an essential step, in that all operational, design, and performance measurement decisions should be based upon the goals that the project intends to achieve.

USER GROUPS

Who Is Allowed?

A wide list of possible user groups can, and has been, developed. This listing of user groups is integrated into the framework and helps to select the operating policies that will be put in place. As the facility changes and the users change, the framework for the facility is flexible enough to allow different user groups. The list of possible user groups includes:

- Transit.
- Vanpools.
- HOV3+.
- HOV2.
- SOV.
- Low-emission vehicles.
- Fuel efficient vehicles.
- Motorcycles.
- On-duty law enforcement/ambulance/fire vehicles.
- Off-duty law enforcement/ambulance/fire vehicles.
- Low income travelers.
- Trucks.

Prioritization of User Groups

While projects may be designed with a set of users in mind, it is commonplace to assign a priority to some user groups and provide toll discounts to those groups. Typically, groups receiving priority will make up either the bulk of the traffic or they are recognized as an important considering in the community surrounding the facility. Establishing priorities is not discriminatory or restrictive; it simply helps in making appropriate decisions about how the facility should operate in meeting the stated goals. The framework recognizes that priorities may change over time and is fully capable of reassessing a facility with different user groups and/or different priorities. In fact, these analyses are encouraged in the use of the framework, so that operators understand how the framework functions and how changes in inputs (such as user groups) can affect the operations.

DEVELOP MEASURES

What Are Performance Measures and Why Use Them?

Performance measurement is the regular and systematic collection, analysis, use, and reporting of data that tracks progress toward a goal. The individual performance measures become indicators that show the agency, and the public and stakeholders, how progress is being made toward achieving the project goals.

If the goal of a facility is to maintain a free flow speed, the performance measurement program would collect speed data over time to track and record speeds to ensure this goal is being met. In a similar manner, if a goal was increasing safety, the performance measurement program would collect and track crash information.

It is important to remember that a performance measurement program does not end simply with collecting and analyzing data. An effective program will also communicate that information to various groups such as the managers and operators of the facility, the stakeholders, and the stakeholders. Performance measurement is a way of being open and transparent and provide for more informed decision-making and solutions to increasing challenges. Performance measurement can also be used to set benchmarks and enhance customer response.

Guiding Principles for Selecting Performance Measures

The overall goal of a performance measurement program is to see if the strategies are working. It is therefore imperative that the performance measures chosen must tell the story of what is happening on the facility. The right measure can help maintain long-term management strategies defined by policy-makers while guiding operators to effectively implement day-to-day changes consistent with community needs.

A good performance measure possesses three important characteristics:

- Repeatable – the application of a measure to a given facility operating under the same conditions should yield the same results. Performance measures should be consistent from year-to-year and location-to-location.
- Valuable – the measures must mean something to the various stakeholders, including the operators. If the measures do not convey how a facility is operating, they are not valuable and cannot identify the decision points upon which the framework and policies are based.
- Sustainable – a measure should be able to be calculated on a continuing basis. If the data collection needs or staff time is too onerous to calculate a measure on a consistent basis, it is not a good measure and will not help to identify transition points in the life of the facility.

A phrase often used in conjunction with performance measurement is "what gets measured, gets managed." Simply put, this means that performance measures are useful only if the data collected and reported are used in a timely, meaningful, and transparent manner.

In addition to the characteristics stated previously, the following list identifies 12 guiding principles to guide the performance measurement process.

1. *Multiple issues mean multiple measures are needed*. No single measure will satisfy all facility or corridor operating and monitoring needs, and no single measure can identify all important aspects. Facility performance optimization is complex and in many cases requires more than one measure, more than a single data source, and more than one analysis procedure.

2. *Pick a set of measures for audiences*. The process for selecting performance measures should identify:
   a. The decisions that will be made.
   b. The alternatives that will be studied.
   c. The audiences for the information.
   d. The accuracy level needed.
   e. The data that are available or can be estimated.
   f. The process should select a set of measures that indicate progress toward the vision for the facility or system.

3. *Use a range of measure subjects.* Vehicle-based and person-based performance measures are useful and should be developed. The physics of speed and volume require a set of vehicle measures; the service component requires evaluations of persons and the value of transportation. Dollar value-based metrics, in some cases, provide a mode-neutral way of comparing alternatives.

4. *Use surveys of people.* Outcome measures such as "How satisfied are travelers with the trip time and cost?" are useful benchmarks. Such market research is basic information in the consumer retail and restaurant industry; priced lanes must adopt this approach. These opinions cannot be directly measured from system monitoring devices. In addition to periodic surveys, the regular performance statistics might be calibrated to traveler satisfaction surveys to find what level of congestion or reliability is deemed acceptable. Automated system monitoring processes provide a rich source of day-to-day performance information that cannot be replicated by user surveys. A combination of the two is the best choice: system performance statistics can be updated much more frequently than surveys, in effect providing very useful user satisfaction information from the same data used to operate the system.

5. *Use travel speed data for mobility measures.* Travel time and speed quantities are useful and understandable to a very broad audience and a wide range of uses.
   a. A complete set of mobility indicators should include an indicator of the variation in travel time. Reliability is a key component of user perception, and is especially important to priced facilities, freight movement and in just-in-time manufacturing processes.
   b. Pricing data and willingness-to-pay information are also key data elements of a performance measures program.

6. *Use the data you have.* Travel time and speed information do not have to be expensive or difficult to collect. Automated data systems (e.g., toll tag detectors), concentrated data collection in problem areas, and sampling methods can be used to estimate travel time quantities. Safety data and disabled vehicle statistics should be gathered from operations centers and enforcement agencies who routinely collect (or should) such data for their staffing and resources allocation purposes. Chapter 4 describes more detail for data collection for performance measurement.

7. *More than one mobility target may be useful.* There is a role for mobility measures based on both free-flow conditions and target conditions. Free-flow-based measures estimate the size or intensity of problems and can be used to estimate the total cost of the problem. Free-flow conditions are also good for mobility comparisons in a national context.

   Targets (for example, 50 mph target speed on a HOT lane) can be used to identify acceptable conditions. The target may vary depending on the adjacent developments (e.g., slower in downtown areas where trips may be shorter, mode options greater, and road expansion limited) or on the facility itself. Target values for key mobility performance measures can be used to identify trip patterns that take more time to complete than travelers' desire. A target can also show segments of the transportation system that are not providing the travel time and/or reliability that travelers expect. Targets also may be designed to illustrate where land use or environmental outcomes are not met. The concept of target travel conditions is the way to link the user satisfaction survey information with the continuous system monitoring data. A matrix of desirable travel speeds can be prepared to represent a combination of community vision and operating efficiency. The expectations for travel conditions vary depending on many factors (e.g., location within the urban area, time of day) that can be included in the set of matrices.

8. *Multimodal measures can be useful.* The Travel Time Index, a ratio between the travel time in the peak-period conditions and the travel time in free-flow conditions or the posted speed limit, can be used as a multimodal transportation system measure. It can be calculated for a range of area sizes, from individual facilities to corridors and regional systems. It can use information on travel time from continuous system monitors or from estimates developed from computer simulation models and empirical formulas.

9. *Delay is a useful measure for economic analyses.* Travel delay, delay per capita, and delay cost are key components of any economic effect analysis. They are also easily communicated to non-technical audiences. They work best in roadway analyses but can be used in multimodal contexts. Annual delay and cost are not typically used as day-to-day decision tools; delay per vehicle may be a measure for individual facilities.

10. *Understand the problems.* Three dimensions of congestion should be tracked with congestion-related performance measures: source of congestion, time of congestion, and location of congestion.

11. *Collect the Whys.* Weather, road conditions, tolls, volume, incidents, special events, and road work data are keys to explaining the outcome of performance measures. If these are not collected, the measures are just numbers; operators and planners will not have the information needed to adjust tolls, operating polices, or designs.

12. *A successful message is one that causes action.* Communication of performance measurement should be done with graphics that resonate with a variety of technical and nontechnical audiences and in real-time, near-term, and planning time frames.

Potential Audiences

One of the significant values of a performance measurement process is that the results can be used for a variety of audiences. Perhaps the most technically inclined audience will be the facility operators who will utilize the results to identify problem areas, potential solutions, and any operational changes that might be required. Another audience for performance measurement information would be agency management, particularly on the statewide level. As facilities across the state are developed and brought on-line, management staff can use the results of the performance measurement process to compare their usefulness and efficiency across the state.

External to the department, the avenues for using the information are as broad. In general, citizens across the state, and certainly within the area served by the facility, should have the opportunity to view information on how the facility is operating and is it meeting its performance goals. In addition to citizens in general, each facility will have any number of stakeholders. These stakeholders may be users of the system, such as carpoolers, transit providers, or commercial entities. The use of performance measurement allows information to be developed that is applicable to all groups. While the level of detail may vary, the process allows all audiences to be served.

Performance Targets

The overall reason for a performance measure process is to assess progress toward a goal. The performance target is essentially a “line in the sand.” If your performance measure crosses that line, the process should trigger a response. Even if it does not cross the line, the comparison of the current value to the target will provide concrete and meaningful information and allow you to gauge how close you are to a trigger point.

The line in the sand or value of the performance target can be used to indicate either good or bad results. In the case of a performance measure that looks at revenue from a facility, a target of a 10 percent increase in revenue from the previous year would be a positive result. However, in the case of a performance measure that examines speed, a target of peak period travel speed less than 45 mph for 20 percent of the time, might be a negative result. The lesson here is that the performance measure itself is not an indicator of good or bad, but rather it is the performance target that in effect, evaluates the performance measure, and compares it to expectations as defined in the project goals. Table 8 offers a range of targets that may be used for developing an operational framework for selected measures of effectiveness.

Table 8. Range of Target Values for Selected Measures Used on Priced Facilities.

Goal	Selected Measures of Effectiveness (MOEs)	Sample Range of Target Values
Safe Travel	Number of crashes	Project dependent (*58*)
	Roadway clearance time	90-155 minutes (*59*)
High-speed Travel	Average Speed	40 mph to 55 mph[1]
	Level of Service	LOS C to LOS D[2]
Reliable Travel	95th percentile travel times	1.1 to 1.5 minutes per mile[3]
	Buffer index	<10% (*60*)
Optimize Revenue	Revenue	Project dependent[4]
	Violation Rate	2% to 10%[5]
Optimize Throughput	Person throughput per hour	1600–3200 per lane[6]
	Persons in HOVs and buses per hour	2400–4200 per lane[7]

(1) Project data, Chapter 2
(2) Project data, Chapter 2
(3) Calculated for 40 mph to 55 mph target speed
(4) The range in revenue values is highly dependent upon individual project characteristics and expectations. The anticipated level of revenue would be developed through the financial analysis for project.
(5) Project data, Chapter 2, and FHWA HOV Enforcement Handbook, 2006
(6) Calculated for 1600 vehicles per hour per lane using occupancy rate of 1.0 to 2.0 persons per vehicle
(7) Calculated for 1200 vehicles per hour per lane using occupancy rate of 2.0 to 3.5 persons per vehicle

DEVELOP ANALYSIS PROCEDURES FOR CALCULATING MEASURES

Concurrent with the selection of performance measures is the identification of data needs to support the identified measures and the procedures for calculating candidate performance measures. Chapter 4 of this report provides detailed information on basic data elements, sources, timeframes, locations, and relative cost for different deployment levels for different data elements that support typical measures of effectiveness. Selection and application of performance measures may require modification based on data availability.

Understanding the analytic procedures and level of effort necessary for the analysis of the performance measures is also important to the final decision on measures. Figure 16 provides an example of the analysis procedure for calculating a buffer index for a specific project (*61*). The operator should identify calculation procedures for each performance measure to ensure clarity of the data needs and application of data.

Buffer Index. The Buffer Index (BI) is the extra time (buffer) that travelers in a corridor need to allow to ensure an on-time arrival for most trips. The BI is equivalent to the extra time travelers must add to their average travel time when planning trips. With continuous data, such as the Mn/DOT RTMC detector data, the index will be calculated for each road or transit route segment, and a weighted average will be calculated using vehicle-miles or, more desirably, person-miles of travel as the weighting factor. The BI can be calculated for each road segment or particular system element using the following equations:

$$Buffer\ Index\ (BI)_{Link} = \left[\frac{95th\ Percentile\ Travel\ Time - Average\ Travel\ Time}{Average\ Travel\ Time}\right] X\ 100\%$$

$$BI_{Corridor} = \frac{\sum(BI_{Link} X\ VMT_{Link})}{\sum VMT_{Link}}$$

Note that a weighted average for more than one roadway section could be computed using VMT (vehicle miles of travel) or PMT (person miles of travel) on each roadway section. The measure would be explained as "a traveler should allow an extra BI percent travel time due to variations in the amount of congestion delay on that trip."

Figure 16. Example of Calculation Procedures for Performance Measure (Buffer Index).

IDENTIFY PROBLEMS AND SOLUTIONS

Before measure selection and data collection begins, it is useful to reflect on the potential problem situations, areas, and times and consider possible solutions. The problems may be along the lane or at bottlenecks. They may exist for one or more hours, they may be present in one or both directions, and during one peak commuting period or both. Evidence from the performance measurement process can then be used to determine when solutions should be implemented because the trigger points have been considered from the beginning.

Time and Location Considerations

For each goal, the operator should know the time period being examined and the level of performance that is desired, so it is simple to determine if the facility is not meeting standards. Questions that should be asked include:

- For each goal, are you concerned about deficiencies in performance for peak periods, midday during nighttime hours, during special events, during incidents?
- For each goal, are there different target values for the start-up period of the project and the "mature" operation? These might be aligned with the time-of-day targets (peak, midday, overnight) or with some other set of situations.
- For each goal, are there different target values and solutions for location, corridor, and direction? The operator should know when the facility (and possibly a direction) fails to meet standards and by how much. What are the points of failure along the facility, e.g., access points, in the lanes, at payment points, at bottlenecks?
- When does the project need to be fixed? Is it now? (as in the case of an incident, or failure to achieve a target speed) or later? (next quarter, next month, or next year)

Solutions to Address Performance Deficiencies

Pricing Solutions

For each goal, the operator should define how pricing may be used to address a deficiency. Some typical actions include changing the toll or operating schedules, changing the maximum allowable tolls, changing charges for different user groups, or depending on the facility, to begin tolling operations.

Operations and Design Solutions

In some cases, operational changes or geometric improvements might be required as a solution to problems. In other cases the solution may be as simply as provide clear and transparent information to the affected user groups on items such as toll rates.

- Modify hours of operations, or activate shoulder hours.
- Adjust allowable user groups.
- Increased enforcement.
- Rapid incident removal program.
- Active traffic management.
- Ramp metering.
- Improve design to increase speeds or reduce crash rates.
- Publicity about conditions or toll rates.

Usage Solutions

A number of different solutions can increase or decrease usage of the facility, depending upon the project goals. These include increasing volume of vehicles on the facility, perhaps by user group; increasing transit ridership, if transit is being served; or taking steps to increase the overall person-volume being moved through the facility (maximize throughput). Usage solutions also relate to increasing incentives for lane use and alternate route capacity.

Relationship between Solutions and Performance Measures

The process represented in Figure 17 is not a linear one; it requires review and tradeoffs when developing measures, analytical procedures, and solutions. Questions such as the following should be considered during a comparison of selected measures to potential solutions:

- Is this the appropriate measure?
- Can the effect of all the improvement types be seen in the measures?
- Will the measures be able to illustrate the effect of the improvements?
- Are there aspects of the projects, programs, or policies that will not be covered by the measures? Are the measures understandable to the audiences?
- Are the uses of the measures appropriate, and will the procedures yield reliable information?

CHAPTER 4. DATA ELEMENTS AND COLLECTION

Performance measures require quality data to ensure the integrity of the metric. This chapter identifies several aspects of each basic data element, including items such as sources, timeframes, locations, and relative cost for different deployment levels. Understanding these elements will provide a fundamental understanding of the data requirements for a performance measurement-based framework by which decisions can be made to guide changes in operational strategies for a facility over time.

It is first important to provide context under which a data collection system can be developed to support performance management for a priced facility. Figure 17 provides an illustration of the flow of data for a typical freeway performance monitoring system. For a priced facility, there will also be the tolling system database as a source of data that may be used in performance measurement, either integrated with the Traffic Management Center or provided as a standalone data feed to the data analysis systems.

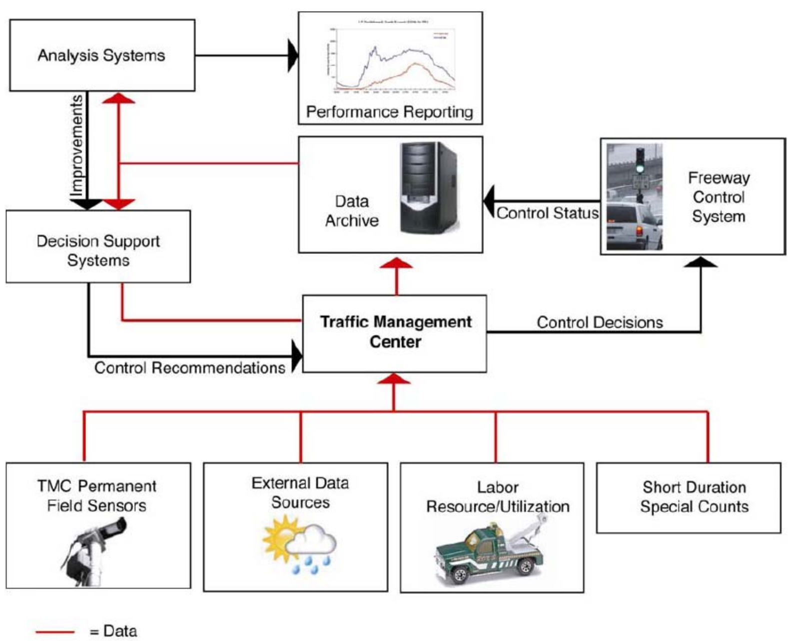

Figure 17. Common Flow of Data for Freeway Performance Monitoring (*60*).

RELATING MEASURES TO THEIR BASIC DATA ELEMENTS

Many useful performance measures can be placed in various categories, such as safe travel, high speed travel, reliable travel, or the optimization of revenue or volume. The same measures may be used to support multiple goals. Many performance measures are not, however, measured directly in the field. As an example, a simple performance measure, such as crash rate, is defined as the number of crashes per 100 million vehicle miles of travel (VMT). The calculation needs are therefore the number of crashes and VMT. VMT is not directly measurable from the field and is calculated from volume. Additionally, a number of pieces of static information, such as links along the roadway and link length, are also required. So to determine a crash rate, two basic collectable data elements are needed, number of crashes and volume, in addition to the static information.

Table 9 identifies the basic data elements associated with each of these performance measures and shows that all of these measures come from eight basic data elements. These elements are:

- Speed.
- Volume.
- Travel time.
- Vehicle person occupancy.
- Incident clearance time.
- Number of crashes.
- Revenue.
- Violations.

Table 9. Basic Data Elements for Performance Measures.

Goal Area	Performance Measure	Basic Data Element
Safe Travel	Crash rate	Number of crashes, Volume
	Number of crashes	Number of crashes
	Incident rate	Number of crashes, Volume
	Incident clearance time	Incident clearance time
High Speed Travel	Travel time	Travel time
	Travel speed	Speed
	Travel Time Index	Travel time, Volume
	Traffic density	Speed, Volume
	Travel delay	Travel time, Volume
Reliable Travel	Number of days per month with speed below a threshold for some period	Speed
	Buffer Index (BI)	Travel time, Volume
	Planning Time Index (PTI)	Travel time, Volume
Optimize Revenue	Monthly revenue	Revenue
	Ratio of actual to forecast revenue	Revenue
	Violation rate	Violations, Vehicle Person Occupancy
	Cost of operation	Revenue
Optimize Throughput	Volume	Volume

The same mapping exercise was done for performance measures in several other key references or studies on the topic, with the same results for the basic data elements (*62*,*63*,*64*,*65*). This served as confirmation that a concentration on collecting these basic data elements will provide the capability to calculate a robust set of performance measures to support the framework process.

INFORMATION ASSOCIATED WITH BASIC DATA ELEMENTS

Although mapping a performance measure to its basic data elements is a start, it is not the complete picture. In fact, it is insufficient guidance to simply say that a basic data element such as speed should be collected on a facility. Discussed below are a number of critical decision points relating to the data collection process that will ultimately affect the capability to provide a rich data source to the performance measurement process.

Types of Infrastructure Used to Collect Data

Infrastructure details the data collection equipment that is used to collect data. For many data elements, a variety of data collection equipment or infrastructure can be used to collect the information. Speed, for example, can be collected using temporary equipment such as traffic counters with road tubes or portable equipment such as radar mounted on portable trailers. Permanent equipment infrastructure might consist of inductive pavement loops or radar stations on items such as light poles. In-vehicle devices such as Global Positioning System (GPS) units can also connect and store speed information. Each of these types of infrastructure will provide for a different level or amount of speed data, which will impact the ability to calculate performance measures at the desired points along the facility.

Sources

For the data elements described herewith, the source of data is either collected in-house, using the infrastructure described above, or purchased externally. The tables in the following sections detail the sources of data as: manual, automatic, or purchased. Manual data collection refers to studies or data collection efforts that are initiated at certain times or based on certain events, in order to capture data to be used for the construction of performance measures. Essentially, manual efforts are planned but not continuous. Automatic refers to the use of the permanently installed infrastructure to collect the data element, typically on a constant and consistent timeframe. Purchased refers to obtaining the data element for the desired locations, from a 3rd party data service provider, such as INRIX, NAVTEQ, or similar vendors.

If not collected in-house, data must be purchased, if possible. Note that not all of the basic data elements can be purchased from an outside source. If data are purchased externally, note that no infrastructure is needed to support data collection efforts.

Locations

Determining the number of locations at which to perform data collection is a trade-off. As the number of locations increase, the cost increases. However, the flexibility and the ability to discern the true performance of the facility also greatly increases. It will be an individual decision for each agency as to where the tipping point between cost and flexibility lies.

For some data elements like speed or volume, the use of temporary infrastructure will probably limit the possible data collection points. This will have a corresponding limitation on the robustness of the calculated performance measures, if for example, speed or volume information can only be calculated at a few points. If the facility is relatively short, this will likely not have a significant impact on the validity of the results. However, as an example, in a lengthy facility, with several access/egress points, measuring volume at only a few points will likely introduce some error into the VMT calculation. Whether or not this error is sufficient to substantially impact the performance measure and trigger points used to change an operational policy must be judged by the individual agency.

The location information for each basic data element is presented in terms of three levels: minimum, preferred, and optimum. Minimum is the absolute smallest number of locations where the data element must be collected in order to provide a calculation basis for performance measures. Preferred is some number of locations above the minimum, to better define the performance measure over the length of the facility. Optimum is the level of data collection that would be utilized to provide the ability to define a performance measure at *each* point along the facility where it could potentially change. For some basic data element, optimum may only be possible with some types of permanently installed infrastructure.

Timeframes

The discussion pertaining to timeframes for data collection is similar to the discussion pertaining to locations. The same descriptors of minimum, preferred, and optimum are used. At a minimum level, data collection must be done is specific time periods critical to the definition of the performance measures, such as the a.m. and/or p.m. peak. Preferred would add in time periods to understand how a performance measure varies over time. For some measures, like travel time, substantial differences may exist between peak and off-peak periods. Collecting data only at the minimal timeframes will not provide a clear understanding of how measures can change over time. Optimum would be data collection being performed on a constant and consistent basis and may only be possible with some types of permanently installed infrastructure or purchased data. The timeframes in question are not always daily. They could be weekly, monthly, quarterly, or whatever time period is necessary for the analysis of operational policies.

Relative Cost for Location Levels

It is not possible to determine an explicit cost for the data collection of each element, as there are too many variables involved that are specific to the facility, the agency, the area of the state or country, etc. However, information pertaining to the relative cost is expressed for the minimum, preferred, an optimum location levels.

For some data elements, there are different types of cost to be considered. As an example, if travel time runs are being performed, the costs involved for minimum levels are largely related to manpower. However, if travel times are being collected via automatic equipment, such as License Plate Recognition (LPR) or Electronic Toll Collection (ETC), the costs associated with data collection are typically more maintenance related. The only manpower costs would be to perform queries on the system data to extract the travel time information. Depending on the programming and setup of the system, this may be a base system capability. In fact, depending on how some agencies organize their budgets with respect to maintenance, there may be no costs associated with the data collection as the maintenance is covered under the collection of fares.

Ease of Collection for Location Levels

General guidance is provided on the ease of collecting data for each of the basic data elements. The levels correspond to the location levels and follow the same classification of minimum, preferred, and optimum. Again, these levels may be highly specific to the facility or agency, and may depend on system capabilities and the ease of extracting and saving information collected from infrastructure on the roadway.

Caveats to Consider

Many of the basic data elements have associated caveats. For example, pertaining to speed, the use of temporary or permanent infrastructure may produce time mean space (instantaneous speed at a point), whereas speed data purchased from a 3rd party provider will likely be space mean speed (average speed over a length of roadway). While the two parameters should be the same or very close in unrestricted flow facilities, they may diverge in timeframes of more restricted or congested flow, such as peak hours. If multiple methods of obtaining speeds are utilized, care must be taken to ensure the consistent use and comparison of data and performance measures.

Another caveat is that some data elements may be necessary to obtain by a particular user group, such as speed or volume for trucks, motorcycles, etc. In some cases, data collection would need to be supplemented with a classification as well, so that data pertaining to a specific class of users or vehicles can be obtained. Some vehicle group classifications, such as carpools versus single occupant vehicles would only be possible with observation.

Basic Data Elements

Table 10 through Table 17 show the detailed information compiled for each of the basic data elements identified earlier in this chapter. Each table corresponds to the information discussion categories explained in the previous section.

Table 10. Information for Basic Data Element – Speed.

Data Element	***Speed***
Performance Measure uses:	• Speed. • Density. • Travel time index. • Buffer index. • Planning time index. • Time periods exceeding thresholds.
Types of infrastructure used to collect data:	• Portable (non-permanent) in the lane traffic counters (lower speeds). • Portable (non-permanent) side-fire traffic counters (can do multiple lanes and directions).

	• Permanently installed in-pavement devices such as inductive loops or similar. • Permanently installed side-fire traffic counting devices. • Instrumental vehicles, such as fleets, with GPS.	
Sources:	Manual	Short term traffic studies with non-permanent infrastructure.
	Automatic	Permanently installed infrastructure.
	Purchased	3rd party data provider, generally obtained by GPS on vehicle fleets or in-vehicle navigation devices.
Locations:	Minimum	One location, not affected by bottlenecks, operational issues, or near access/egress or weaving areas.
	Preferred	Multiple locations with same characteristics as above.
	Optimum	Every *x* miles, such as 1/2 mile spacing if using loops or detectors. Continuous if using license plate or tag readers.

Table 10. Information for Basic Data Element – Speed (Cont.).

Timeframes:	Minimum	a.m./p.m. peak period, Off-peak, at 15-minute intervals.
	Preferred	Multiple time periods above minimum, at 5-minute intervals.
	Optimum	24-hour.
Relative cost for location levels:	Minimum	Fairly minimal cost: manpower plus a simple equipment setup. Traffic control for placement should be considered in cost.
	Preferred	Costs increase for multiple equipment setups.
	Optimum	Installation costs are generally done under construction contracts, but maintenance costs may be significant, depending on type of infrastructure utilized.
Ease of collection for location levels:	Minimum	Relatively simple.
	Preferred	
	Optimum	Becomes more complex. Communications for real-time use needs to be provided as well as an archiving function for historical data analysis.
Caveats to consider:	• Space mean speed vs. time-mean speed. Should be the same for unrestricted flow. 3rd party provider will provide estimated space mean speed. • Investigate formatting and time lag aspects of purchased data. • Speeds may be required by vehicle class, depending on type of facility and operating policies. May want speeds in both tolled lanes and GPLs for comparison, which will increase cost depending on infrastructure.	

Table 11. Information for Basic Data Element – Volume.

Data Element	***Volume***	
Performance Measure uses:	• Volume. • Flow rate. • Corridor counts. • Density. • Time periods exceeding thresholds. • Vehicle Miles Traveled (VMT). • Person Miles Traveled (PMT). • Indexes. • Delay.	
Types of infrastructure used to collect data:	• Portable (non-permanent) in the lane traffic counters. • Portable (non-permanent) side-fire traffic or overhead counters (can do multiple lanes and directions). • Permanently installed in-pavement devices such as inductive loops or similar. • Permanently installed side-fire traffic counting devices.	
Sources:	Manual	Short term traffic studies with non-permanent infrastructure.
	Automatic	Permanently installed infrastructure.
	Purchased	N/A – No known 3rd party companies providing volume data.
Locations:	Minimum	One location, not affected by bottlenecks, operational issues, or near access/egress or weaving areas. Will not satisfy all uses listed above.
	Preferred	Multiple locations with same characteristics as above. Careful placement of multiple counts will allow corridor counts and volumes past access/egress points.
	Optimum	Every *x* miles, such as 1/2 mile spacing.
Timeframes:	Minimum	a.m./p.m. peak period, Off-peak.
	Preferred	Multiple time periods above minimum.
	Optimum	24-hour.
Relative cost for location levels:	Minimum	Fairly minimal cost: manpower plus a simple equipment setup. Traffic control for placement should be considered in cost.
	Preferred	Costs increase for multiple equipment setups.
	Optimum	Installation costs are generally done under construction contracts, but maintenance costs may be significant, depending on type of infrastructure utilized

Table 11. Information for Basic Data Element – Volume (Cont.).

Ease of collection for location levels:	Minimum	Relatively simple.
	Preferred	
	Optimum	Becomes more complex. Communications for real-time use needs to be provided as well as an archiving function for historical data analysis.
Caveats to consider:	• Volumes may be required by vehicle class, depending on type of facility and operating policies. • May want volumes in both tolled lanes and GPLs for comparison, which will increase cost depending on infrastructure.	

Table 12. Information for Basic Data Element – Travel Time.

Data Element	***Travel Time***	
Performance Measure uses:	• Travel time. • Time periods exceeding thresholds. • Percent change in travel time (average, median, peak, 95th percentile). • Travel time index. • Buffer index. • Planning time index. • Delay.	
Types of infrastructure used to collect data:	• Vehicles for floating car runs, using GPS or similar equipment. • Bluetooth readers for data matching on travel corridors. • License Plate Recognition (LPR) equipment capable of performing plate matching and travel time calculation. • Electronic Toll tag Collection (ETC) equipment capable of performing tag matching and travel time calculation.	
Sources:	Manual	Short term traffic studies using floating car.
	Automatic	Permanently installed infrastructure, such as LPR or ETC.
	Purchased	3rd party data provider, generally obtained by GPS on vehicle fleets or in-vehicle navigation devices.
Locations:	Minimum	Studies performed by corridor.
	Preferred	Studies performed by corridor with intermediate points as appropriate, such as different tolling segments.
	Optimum	Studies performed by corridor, but with multiple start points and end points corresponding to access/egress locations.
Timeframes:	Minimum	a.m./p.m. peak period, Off-peak, at 15-minute intervals.
	Preferred	Multiple time periods above minimum, at 5-minute intervals.
	Optimum	24-hour.

Table 12. Information for Basic Data Element – Travel Time (Cont.).

Relative cost for location levels:	Minimum	Fairly minimal cost for travel time studies, resulting mainly from manpower.
	Preferred	For manual studies, slight increase over minimum. For automatic equipment, if not installed at outset of facility, significant costs depending on level of infrastructure and number of locations. May require significant maintenance dollars.
	Optimum	For manual studies, slight increase over preferred. For automatic equipment, installation costs are generally done under construction contracts, but maintenance costs may be significant, depending on type of infrastructure utilized.
Ease of collection for location levels:	Minimum	Relatively simple.
	Preferred Optimum	For manual studies, relatively simple. For automatic equipment, moderate, but algorithms to match plates or tags generally come with back-office operations component.
Caveats to consider:	• Must have travel times in both tolled lanes and GPLs for comparison, which may increase cost depending on infrastructure • GPLs generally do not have LPR/ETC capability	

Table 13. Information for Basic Data Element – Vehicle Person Occupancy.

Data Element	***Vehicle Person Occupancy***	
Performance Measure uses:	• Violation Rates. • Person Miles Traveled (PMT).	
Types of infrastructure used to collect data:	• Manual observation.	
Sources:	Manual	Manual observation, either by location, time period, or constant.
	Automatic	N/A – No commercially available equipment providing such data.
	Purchased	N/A – No known 3rd party companies providing such data.
Locations:	Minimum	For PMT, main entry point to facility. For violation rate, main problem point.
	Preferred	Additional locations over minimum.
	Optimum	Every entry point.
Timeframes:	Minimum	a.m./p.m. peak period, Off-peak.
	Preferred	Multiple time periods above minimum.
	Optimum	24-hour.
Relative cost for location levels:	Minimum	Constant observation becomes costly for manpower. Appropriate and safe locations for observation must be provided.
	Preferred	Costs increase for multiple locations.
	Optimum	Costs for building observation points are generally done under construction contracts, with periodic use for spot studies as needed.
Ease of collection for location levels:	Minimum Preferred Optimum	Moderate – numerous factors such as window tinting, locations, sun angles, vehicle height, vehicle speed, and more affect ability to accurately determine occupants per vehicle.
Caveats to consider:	• Occupancy data may be required by vehicle class, depending on type of facility and operating policies.	

Table 14. Information for Basic Data Element – Incident Clearance Time.

Data Element	***Incident Clearance Time***	
Performance Measure uses:	• Incident Clearance Time. • Percent change in incident clearance time. • Delay due to incidents (correlate with average travel time change at incident time).	
Types of infrastructure used to collect data:	• No infrastructure requirements.	
Sources:	Manual	May require manual data aggregation of incident records.
	Automatic	Automation is possible, depending on sophistication of operations center dispatch and crash records systems.
	Purchased	Depending on company and urban area, some 3rd party providers may have estimates of incident related data.
Locations:	Minimum Preferred Optimum	Throughout length of corridor.
Timeframes:	Minimum	Monthly, by a.m./p.m. peak period, Off-peak.
	Preferred	Monthly, with multiple time periods above minimum.
	Optimum	24-hour.
Relative cost for location levels:	Minimum Preferred Optimum	Costs involved will be for manpower time to determine appropriate records, extract and compile information.
Ease of collection for location levels:	Minimum Preferred Optimum	Moderate. If time information relating to various stages in the incident call is present, assembly of data may be time consuming, but not particularly difficult. If information is missing or difficult to abstract from reports, time requirements will substantially increase. In both cases, time to check data quality may be considerable, depending on the level of detail and quality required for the application.
Caveats to consider:	• All agencies must use a consistent definition of the factors related to clearance time and identical nomenclature for places, times, and attributes.	

Table 15. Information for Basic Data Element – Number of Crashes.

Data Element	***Number of Crashes***	
Performance Measure uses:	• Number of crashes. • Crash rate.	
Types of infrastructure used to collect data:	• No infrastructure requirements.	
Sources:	Manual	May require manual data aggregation of incident records.
	Automatic	Automation is possible, depending on sophistication of operations center dispatch and crash records systems.
	Purchased	Depending on company and urban area, some 3rd party providers may have estimates of incident related data.
Locations:	Minimum	Throughout length of corridor.
	Preferred	
	Optimum	
Timeframes:	Minimum	Monthly, by a.m./p.m. peak period, Off-peak.
	Preferred	
	Optimum	24-hour.
Relative cost for location levels:	Minimum	Costs involved will be for manpower time to determine appropriate records, extract and compile information.
	Preferred	
	Optimum	
Ease of collection for location levels:	Minimum	Moderate. If system is electronic and up-to-date, queries should be relatively simple but results dependant on proper coding of location information by responding units. If system is not automated or up-to-date on data entry, difficulty of finding recent information increases substantially.
	Preferred	
	Optimum	
Caveats to consider:	• Crash rates may be desired by vehicle class, depending on type of facility and operating policies.	

Table 16. Information for Basic Data Element – Revenue.

Data Element	***Revenue***	
Performance Measure uses:	• Monthly revenue. • Actual to forecast revenue. • Cost of operation.	
Types of infrastructure used to collect data:	• No infrastructure requirements that would be additional to systems already in place.	
Sources:	Manual	N/A – No known systems of manual accounting.
	Automatic	Should be a primary output of facility accounting system/back office.
	Purchased	N/A – No known 3rd party companies providing such data.
Locations:	Minimum	Throughout length of corridor.
	Preferred	Throughout length of corridor, with revenue calculated by segment and/or access points.
	Optimum	
Timeframes:	Minimum	Monthly, Weekly.
	Preferred	Daily.
	Optimum	Daily, by a.m./p.m. peak, off-peak.
Relative cost for location levels:	Minimum	Costs involved will be for manpower time to determine appropriate records, extract and compile information.
	Preferred	
	Optimum	
Ease of collection for location levels:	Minimum	Relatively simple. Should be a standard output of back-office operations.
	Preferred	Relatively simple. Should be a standard output of back-office operations
	Optimum	Moderate, if the time period query is not a standard output of back-office operations.
Caveats to consider:	• Revenue collection information may be required by vehicle class, depending on type of facility and operating policies.	

Table 17. Information for Basic Data Element – Violations.

Data Element:	***Violations***	
Performance Measure uses:	• Violation rate.	
Types of infrastructure used to collect data:	• No infrastructure requirements that would be additional to systems already in place.	
Sources:	Manual	N/A – No known systems of manual violation processing.
	Automatic	Should be a primary output of facility accounting system/back office.
	Purchased	N/A – No known 3rd party companies providing such data.
Locations:	Minimum	Throughout length of corridor.
	Preferred	Throughout length of corridor, with violations recorded by segment and/or access points.
	Optimum	
Timeframes:	Minimum	Monthly, Weekly.
	Preferred	Daily.
	Optimum	Daily, by a.m./p.m. peak, off-peak.
Relative cost for location levels:	Minimum	Costs involved will be for manpower time to determine appropriate records, extract and compile information.
	Preferred	
	Optimum	
Ease of collection for location levels:	Minimum	Relatively simple. Should be a standard output of back-office operations.
	Preferred	Relatively simple. Should be a standard output of back-office operations
	Optimum	Moderate, if the time period query is not a standard output of back-office operations.
Caveats to consider:	• Violation information may be required by vehicle class, depending on type of facility and operating policies.	

CHAPTER 5. COMMUNICATION OF FRAMEWORK

RATIONALE

To effectively implement the framework, policy makers and the public must understand and buy into its benefits. Travelers require a fundamental understanding of what measures are being used to determine performance and how changes in those measures affect their daily travel to motivate them to support traffic management projects. Since the general public does not have the technical knowledge that subject matter experts have, this information must be communicated in a way that is easily explained and easily understood. This project created tools that communicate to the policy-makers and the general public what performance measures are, why they are used, and how they may lead to operational changes. The guiding principles and detailed decision framework was translated into reader-friendly, layman's terms. Much as the performance measures must be meaningful to enable successful operation, the communication of the principles must be meaningful to the ultimate audience. The traveler must understand that operations may be altered to ensure the promise of superior performance.

COMMUNICATION TOOLS AND HOW TO USE THEM

This task produced a user-friendly toolkit aimed at educating policy-makers on how to best explain the performance promise and ROI concepts to the general public. The toolkit is designed to be modular so that each individual component may be modified as situations require and individual components may be used independently of one another. Further, to make the purpose of the framework meaningful to the public, the team dubbed it the Traffic Thermostat™ due to the similarity of its function as a regulating tool to the thermostat of a central heat and air conditioning system.

Although for two different audiences, generally speaking, these tools explain the purpose of the Traffic Thermostat™ and its importance to facility operations, as well as provide sample documents for district engineers and others to use in describing the benefits of the framework to policy makers and the general public. The tools developed are:

- **How-to Guide for Using the Traffic Thermostat**™ **Managed Lanes Decision Tool Software.** This document guides users in using the software, which allows operators to input data to determine potential solutions for operational problems. This is the technical piece of the toolkit and most likely will not be utilized by the public. However, it is available for the policy-makers and public should they care to delve deeper into software.
- **Talking points**. These comprise the essential concepts and messages aimed at helping the public understand the value of performance measures, how they help to objectively regulate policy development, and how the public can benefit from policy guided by the Traffic Thermostat™.
- **PowerPoint Presentation**. This presentation emphasizes the rationale behind the Traffic Thermostat™, the need for performance measures, and how these effectively guide policy-making. The presentation is flexible and modular in design, suitable for presenting to policy makers and the public alike.

- **Sample Press Release**. Policy-makers can adapt this sample press release to promote traffic management to the public in their local areas. Core messages in the sample press release coincide with those presented in the Talking Points and PowerPoint Presentation.
- **FAQsheet.** This FAQsheet emphasizes the rationale behind the Traffic Thermostat™, the need for performance measures, and how these effectively guide policy-making.
- **Feedback Framework.** This sample survey of questions will help TxDOT secure feedback regarding the efficacy of the Traffic Thermostat™. The survey is flexible and adaptable to rural and urban environments. It suggests the kinds of questions to ask for use in evaluating how the Traffic Thermostat™ and performance measures are useful in a particular area. Moreover it provides a valuable feedback mechanism to test the public's understanding of the rationale for various policy decisions and their reaction to those decisions.

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APPENDIX . USE OF THE TRAFFIC THERMOSTAT DECISION TOOL

The traffic thermostat decision tool is built to help guide the user through a logical, step-wise, process of examining potential changes to their managed lane/toll facility. The user will need to gather a great deal of information prior to making good use of this tool. The information needed to make the best use of this tool includes:

1. How is the facility currently operating? In the case of planning a future facility this would be how is it expected to operate upon opening. Issues include:
   a) What user groups, if any, are allowed on the facility toll-free? Which are allowed if they pay a toll? Which are never allowed?
   b) Operational characteristics, including average travel speeds, travel time reliability, crash rates, toll revenue, and person movement on the lane.
   c) Design characteristics, including number of lanes, number and location of entry/exit points, and enforcement locations.
2. What are the primary (one or two) goals of the facility?
3. How you plan to measure the lane's ability to meet the goals? What constitutes successfully meeting the goals?
4. What potential changes are possible on this facility to improve performance of the facility? How much will implementing any/all of these changes impact the operations of the facility?
5. Which user groups will be the first to be tolled or removed from the lane? In essence, which user groups will get the most preferential treatment and which will get no preferential treatment?

Once the user has collected the information outlined above, they will be able to examine multiple policy options for their facility. These options will be focused on ensuring the facility meets its operational objectives based on the goals set by policy makers. The tool is available on-line at http://dmgdemo.tamu.edu/6396/. The paragraphs below step the user through the process of using this tool.

SCREEN 1: INITIAL FACILITY TYPE

In the first screen (see Figure A-1) the user must indicate the current (or planned opening day) type of facility. Based on answers provided in subsequent screens the facility type may change, but at this point information on how the facility is currently operating is required. For all screens click Next once you are ready to continue. On subsequent screens there is also the option to hit Back to change your answers on the previous screen.

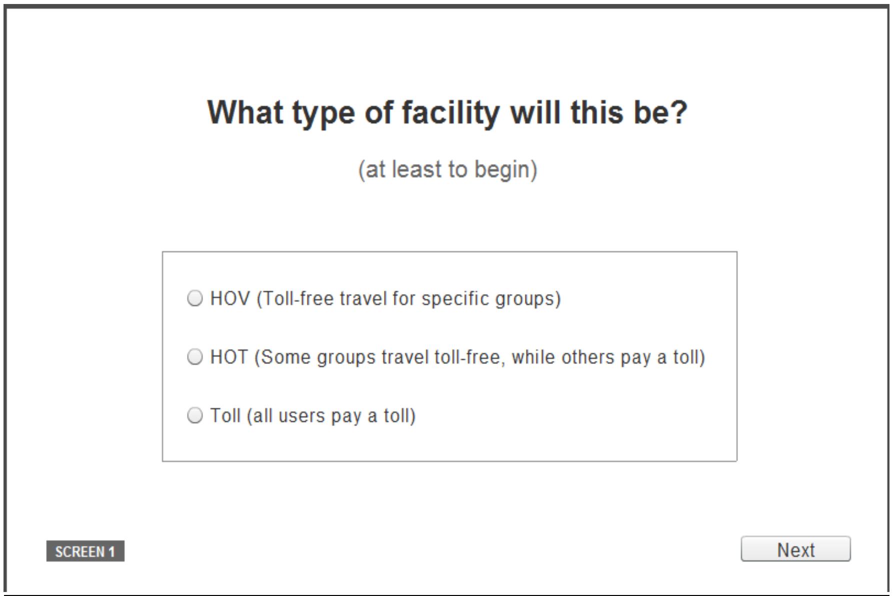

Figure A-1: Opening Screen – Choose Facility Type.

SCREEN 2: PROJECT GOALS

In the second screen (see Figure A-2) the user must select one or two primary goals of the facility. At first glance this would appear difficult as all goals are likely important. Keep in mind that the selection of primary goals will then lead to setting specific measures of effectiveness (Screen 3) that, if not met, force a change in the operations of the facility. Keeping this in mind may help select the appropriate goals. Alternatively, the user could run the tool multiple times, selecting different goals each time. After running these multiple scenarios the user would have multiple outputs detailing the operational changes required to obtain many different goals and to achieve different measures of effectiveness.

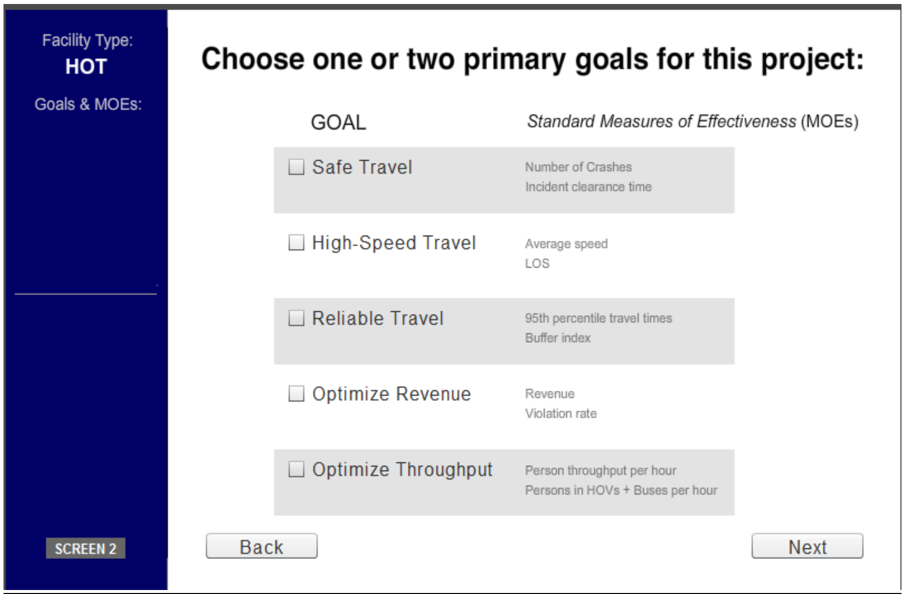

Figure A-2: Choose Facility Goals.

SCREEN 3: MEASURES OF EFFECTIVENESS

Based on the goals selected in Screen 2, the user must now choose how progress toward these goals will be measured. Each goal has two measures of effectiveness (MOE) associated with it. The user can select one or both MOEs for either the peak time(s), or the peak and off-peak period(s) (see Figure A-3). It is left to the user to define what time of day the peak and off-peak periods are, since they are facility specific.

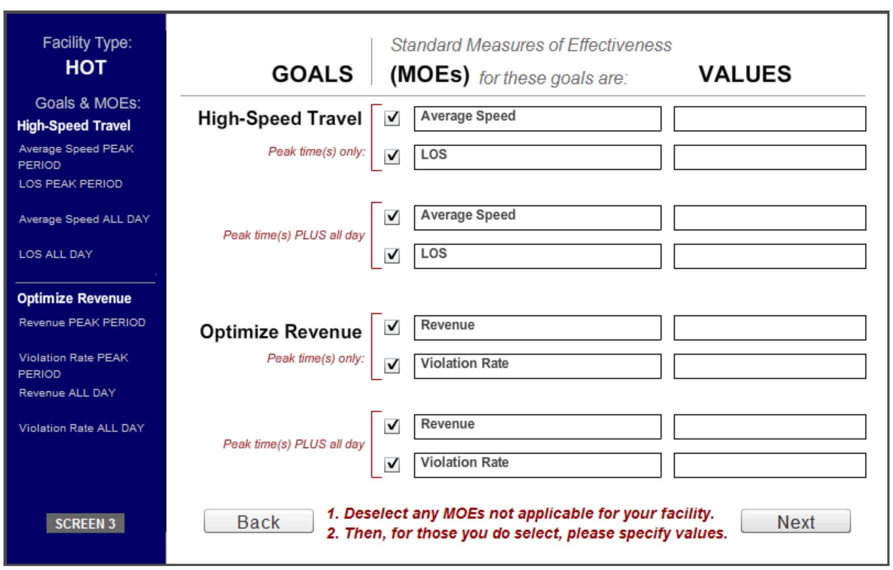

Figure A-3: Enter Measures of Effectiveness.

Each MOE needs a minimum acceptable value associated with that MOE. If this minimum acceptable value is not met then operational or pricing fixes (Screen 4) will be necessary.

Each MOE is facility specific and left up to the user to define. For example, *Number of Crashes* could be:

a) The total number of all crashes on the entire facility (Managed Lanes [MLs] and General Purpose Lanes [GPLs]) in a year).
b) The total number of fatal crashes on the entire facility (MLs and GPLs) in a year.
c) The number of severe crashes on the MLs only in a year.
d) The crash rate per million vehicle miles traveled.
e) Any other definition appropriate for this facility.

SCREEN 4: OPERATIONAL AND PRICING FIXES

The next screen (see Figure A-4) offers the user 10 potential items to change in order for the facility to meet the MOEs detailed in Screen 3. Additionally, the user can enter one or two additional potential fixes for this facility. In the event the facility fails to meet any of its goals then the user will be shown the selected potential fixes as measures to improve performance.

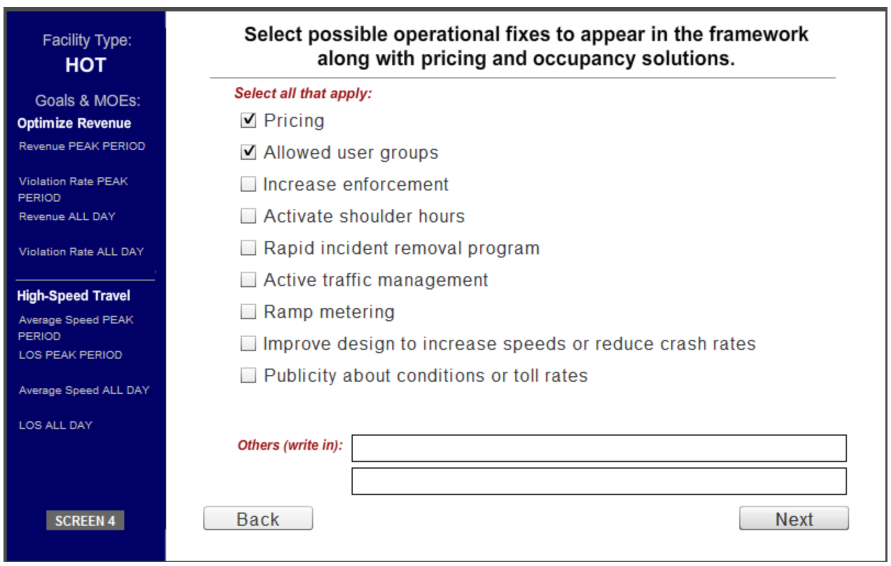

Figure A-4: Potential Operational and Pricing Fixes.

Note the tool does not know the exact extent of the size of the fix or what impact any of these fixes may have on the lane. For example, *increase enforcement* may mean adding one or a dozen enforcement officers, new equipment, or automated enforcement. Its impact may range from negligible to a significant improvement in the operations of the facility. Since this is site specific it is left to the user to define what is meant by the fix (such as *increase enforcement*) and what impact it may have.

The fix "Activate Shoulder Hours" is for a facility that has peak period charging only and during the off-peak period everyone is allowed use of the lane. In the case of the shoulder becoming congested, then restrictions must be extended beyond the peak period and into the shoulder hours.

SCREEN 5: USER GROUPS

Next the user will be asked about the various user groups that may or may not be allowed to use the lane(s). To begin, enter the current (or planned opening day) status of each user group. If they are not allowed then do not check "currently tolled" or "currently free" and the software then knows that group is not currently allowed on the lane (for example: SOVs in Figure A-5). Then rank order each user group based on its given priority level on the facility. A user group priority of 1 is the highest (i.e., transit) and thus would always have use of the lane. Lower priority user groups (2 and higher) would be priced or removed from the lane in order to achieve necessary performance objectives set by the user in Screen 3. Some groups may be of equal priority. In that case they would be given the same rank. Groups that are never allowed on the facility are given a rank of 0 (for example, trucks in Figure A-5).

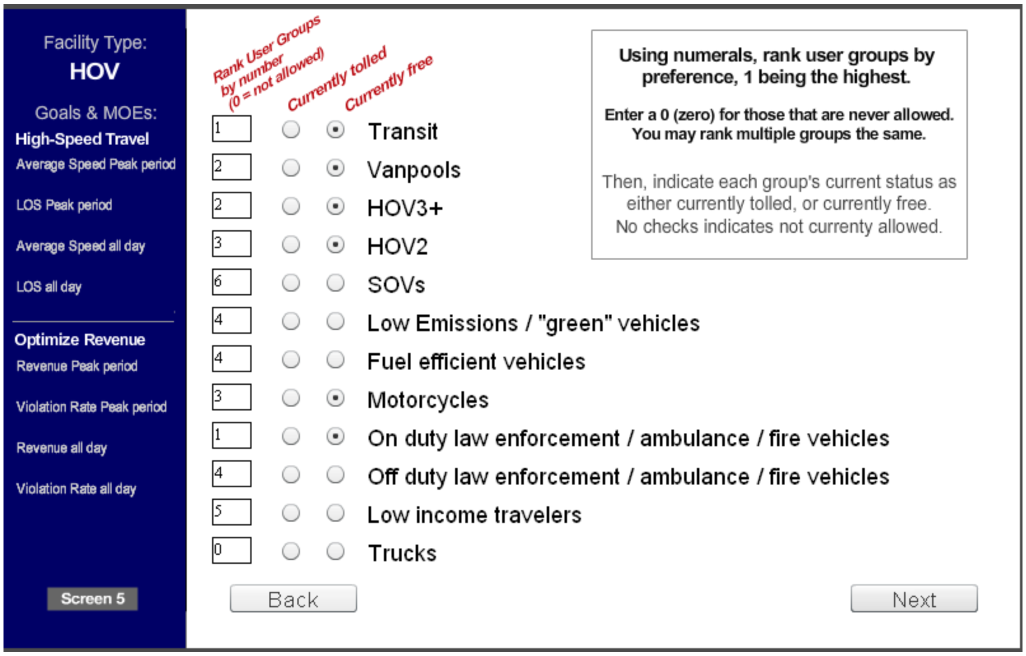

Figure A-5: User Groups.

PROCEEDING THROUGH THE DECISION TOOL

With these inputs the tool now guides the user through the decision/choices that are needed for the facility (see Figure A-6). A good starting point would be when the facility is meeting all of its performance objectives (or MOEs). In this case the user can proceed through each subsequent screen and answer "yes" when asked "With regards to this MOE and value, is the present situation satisfactory?" The end result will then be to make no changes to the facility.

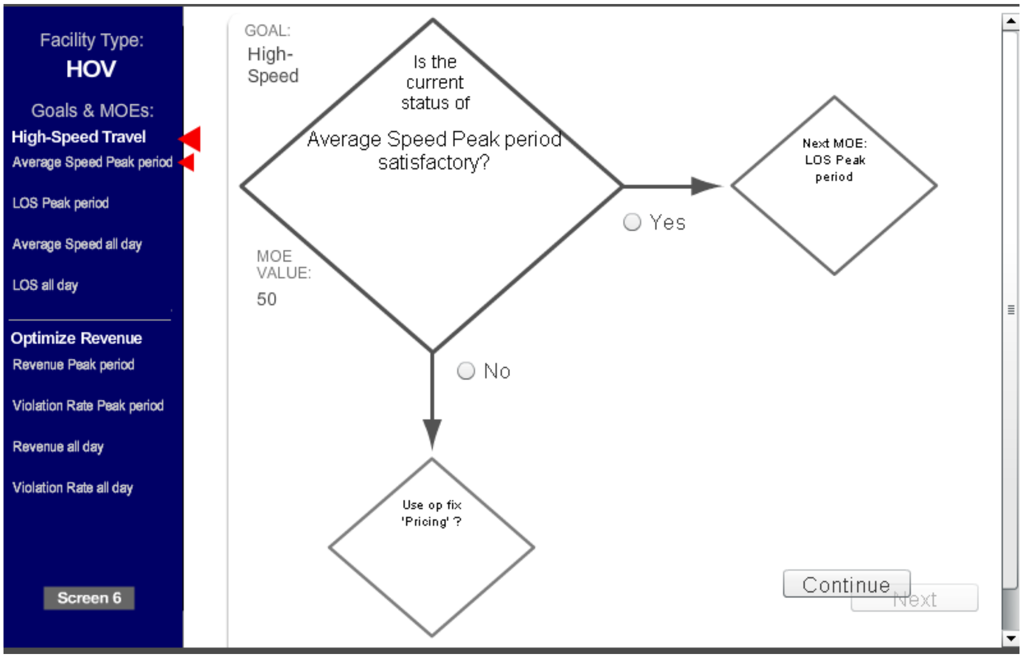

Figure A-6: Decision Framework.

Next the user might examine the facility assuming a future date and increased traffic volumes. During this scenario the facility may no longer meet the minimum MOEs and operational or pricing fixes must be chosen. This second run then represents required changes in the facility as it matures over time. The user might run this future scenario several times, each time trying different operational fixes. Each output from each run then represents a potential policy option that can be presented to decision makers. In this way a governing board is shown a variety of options and can select the preferred one. That provides operational guidance, based on performance measures, for years to come.

The output includes a detailed list of the user groups, MOEs, and selected operational fixes (see Figure A-7). This can be printed or saved.

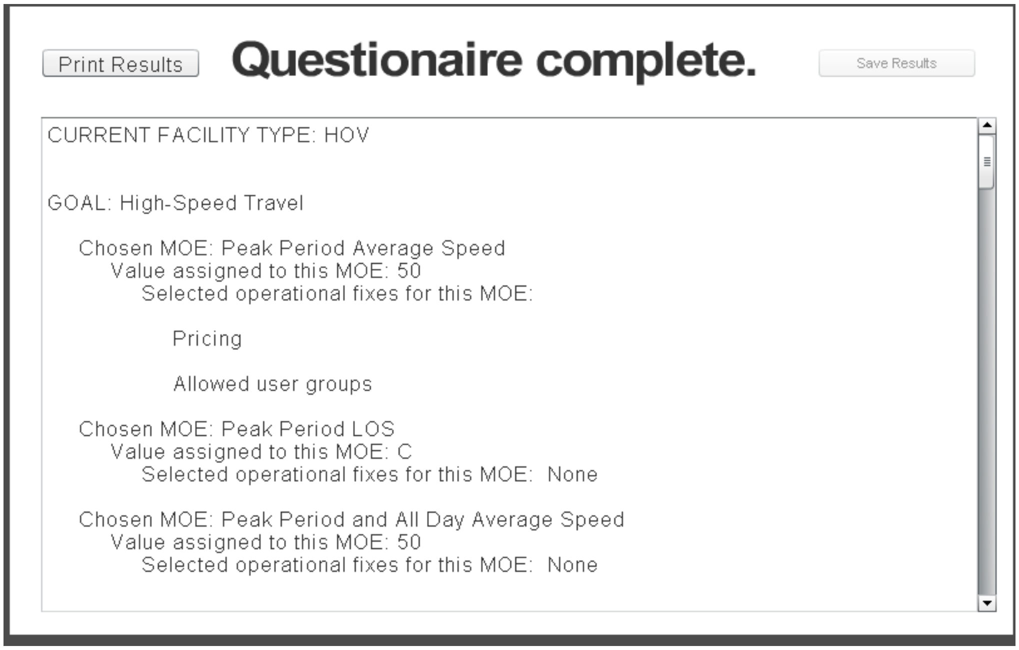

Figure A-7: Text Output.